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ANNOTATED BIBLIOGRAPHY ON FIRE SCIENCE

Manuel Torres
Lauren Barsky
Benigno Aguirre
Rita Poteyeva

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This annotated bibliography is a product of the Disaster Research Center's ongoing study of search and rescue (S&R) activity in fires which uses the National Fire Incident Reporting System (NFIRS) data collected by the United States Fire Administration (USFA) to model fire injury and death. It was compiled as part of our examination of civilian death and injury due to structural fires. It focuses on such areas as structural collapse, civilian injury and mortality, firefighter injury and death, causes of fires, behaviors related to injury and death, and the process of search and rescue in fires. It presents a synthesis of several key areas of interest within the emerging discipline. While it is not an exhaustive bibliography representative of all areas of study, it provides an initial overview of several key areas and could serve as a starting point to research. Available findings from various studies could be compared to replicate and augment existing knowledge, as well to develop theories on the effects of the presence of S&R on morbidity and on the causes of civilian injury and mortality.

Research literature in fire science examines factors related to the spread of fires and how exposure impacts civilians and fire fighters. It focuses on the conditions that generate fire, how context of these events lead to injury and fatality for diverse populations, and the efforts to mitigate risk. Agents of fires such as cigarettes and cooking are examined, as well as how time of day or month of year and social characteristics of actors correlate to mortality rates for the civilian population. In addition, those charged with rescuing civilians in fires are studied to understand characteristics of fire response associated with injury and mortality of firefighters. A large volume of work is geared to understand the process of fire fighting and rescue as well as activities to mitigate exposure to risk of civilians and firefighters. The continued presence of fires in the U.S., their destructive outcomes, and the institutionalized activities of professionals ensure the continued relevance of these incidents.

Methodology

The bibliography is limited since it used specific keywords to find articles and may have inadvertently omitted relevant information from the search. Another limitation is that many of the articles found were omitted since they were anecdotal rather than based on empirical analysis of deaths and injuries due to fire. Also, findings on fire fighter fatality may differ due to differences in the concepts and collection procedures used by different data systems. In contrast to the very large amount of research conducted on fire fighter deaths, little research has been conducted on civilian deaths and injuries. Despite these limitations, we believe that this annotated bibliography will assist interested professionals.

A search was performed for articles and studies that used the NFIRS datasets. One source of articles was the United States Fire Administration (USFA). The Fire Statistics web page on the USFA website (http://www.usfa.fema.gov/statistics/) was examined for relevant material. In order to compare these reports to public use of the NFIRS data, searches were made using Google Scholar. Keywords such as "NFIRS," and "report" were used to search for articles. Many reports focused on the following: Location of fire (e.g. campus fires, restaurant fires, kitchen fires); Item first ignited in fire (e.g. mattress and bedding); Demographics of fatalities and injuries (e.g. age was a specific risk factor); Arson and intentional fire; Cause of fire (e.g. unattended or careless cooking, candles, cigarettes); Seasonal trends of fires (e.g. fires sparked by fireworks, barbequing, Christmas trees); Effectives of sprinkler systems; Response time to fires. A literature review was also done on fire science materials focusing on factors that impact the rate of injury and fatality for civilians and firefighters involved in structural fire, along with information on structural collapse. To obtain materials on these subject areas we contacted instructors from fire science graduate programs in the U.S. identified through prior knowledge of key scholars and web-based search of faculty and administrative personnel of graduate programs in Fire Science (e.g., fire training academies; fire engineering schools). We solicited course syllabi, bibliographies, and other documents. Very few responded to our requests, and of those few that did the materials did not materially enhance our knowledge even though a few new sources were identified. A few of the faculty members that responded to our request pointed out that the field is just now beginning to form as a scholarly discipline.

The search for scholarly articles involved using the search engine Google Scholar. Search for articles through this engine was divided into articles focusing on civilians and articles focusing on fire fighters. The key words utilized in civilian web based searches were "civilian" AND "injury" OR "death" AND "collapse" AND "search and rescue" AND "building collapse". The key words utilized in fire fighter web based searches were "fire fighter" AND "injury" OR "death" AND "collapse" AND "search and rescue" AND "building collapse". A total of 374 manuscripts were retrieved, and articles on the web were assessed to gauge their possible relevance (whether or not they discussed morbidity, statistics, and collapse). As well, articles that were anecdotal, only discussed physical aspects of collapse, or focused on aspects unrelated to research goals were omitted. A total of 24 articles were included in our list (see below). The articles found were categorized as dealing with injury and death of civilians and fire fighters; simulation and technology of search and rescue (e.g., use of robots in response); and the collapse configurations of different building structures.

Literature was also found through the use of University of Delaware's Morris Library. Materials such as reports on fire fighter mortality were obtained from the U.S. Fire Administration web site (http://www.usfa.dhs.gov/statistics/). Fire Science instructional materials were searched within this site as well as publications in Amazon.com to understand subject matter taught to students specializing in the fire industry, specifically on how to carry out search and rescue and respond to structural collapse. The National Emergency Training Center's Learning Resource Center (U.S.

Fire Administration) was used to search for materials relevant to our study. The keywords used were "building markings and structural triage" for the years 1990 to 2006; "building collapse" from 1990 to 2006; "building collapse and rescue operations" from 1994 to 2006; and "response times" from 2000 to 2006. Articles available online were printed and documents or books were checked out through Morris Library. Many articles were also accessed through the Morris Library's Interlibrary Loan Online. A subsequent search for literature on civilian fatalities and injuries in fires was conducted to supplement the findings; the Google search engine was used with keywords "Civilian" AND "Injury" AND "Fatality" to uncover relevant items.

In the following sections of this report the articles and other materials are divided into civilian fire fatalities and firefighter fatalities. Within the civilian fire fatalities, articles are separated by causes of civilian fire death, civilian behavioral response to fire, and emergency response to structural fires. Causes of civilian fire death are further broken down into specific subcategories of socio demographic causes of civilian fire deaths by age, population size, personal and situational factors, and structural components in civilian fire deaths. The emergency response to structural fires is also broken down into subcategories including searching for victims, victim removal, structural collapse, search and rescue, and firefighters in search and rescue activities. The section of the text focusing on firefighter fatalities also focuses on the causes of firefighter fatalities and injuries. The conclusion discusses some important discrepancies in the literature.

Civilian Fire Fatalities

Causes of Civilian Fire Death

Previous research has documented how civilian deaths from structure fires in the U.S. vary by many temporal, social, and physical factors. The time of year and day has a great influence over rates of death for civilians. A 2006 National Fire Protection Association (NFPA) report focusing on new requirements for smoke alarms in fires found that 30% of reported home structure fires and 39% of home structure fire deaths occurred in the months of December, January, or February, with the highest number of deaths in the month of January (Moore 2006). These fires and fire deaths reflect the influence of heating equipment. According to the report, 49% of the reported home heating fires and 57% of heating fire deaths occurred during these months. Home fires occurred more often during the dinner hour between 6 and 7 pm, with only 21% of fires occurring during the nighttime hours of 11pm and 7am. Although nighttime fires accounted for only 21% of fires, 51% of deaths resulted from fires reported during these hours (Moore 2006). A study of fatalities in dwellings in London, England, revealed that seasonal variation is a factor in fire ignition; fires caused by smoking and cooking materials were highest during the winter months (Holborn, Nolan & Golt 2003). In London, times of fire ignition were spread throughout the day, with the lowest rates occurring between the hours of 9am and noon.

In examining causes of structure fires in homes, cooking has been found to be a significant risk to fire injury. In 2002 alone, cooking-related fires resulted in approximately 185,600 fires in structures, 3,875 injuries, 80 deaths, and $481 million in property damage **(**U.S. Department of Homeland Security 2005e). According to NFPA, between 1999 and 2002 cooking equipment fires was the leading cause of fire (28%). Heating equipment fires made up 14% of fires, intentional fires 9%, electrical distribution or lighting equipment 9%, smoking materials 7%, candles 5%, exposure to other fires 4%, playing with heat source 4% and clothing washers or dryers 4%. Most civilian deaths were caused by fires due to smoking (29%) followed by intentional fires (19%). Heating equipment fires caused 11% of civilian deaths between 1999 and 2002 and cooking equipment fires accounted for 9% of the cases (National Fire Protection Association 2006). These findings reveal the importance of cooking, heating one's home, and smoking indoors.

Socio-demographic causes of civilian fires

Various socio-demographic characteristics impact the likelihood of civilian fatalities resulting from structural fires. One factor is gender. Specific case studies and national reports on the topic have found that males are more likely than females to sustain both fatal and non-fatal injuries in fire incidents (Hall Jr. 2005; U.S Department of Homeland Security, 2006a). A 2002 report by the U.S Fire Administration found that males are killed more often in fires than females (U.S Department of Homeland Security 2002a). Males, if compared to females, had a higher chance (38%) of dying and of being injured (18%) in home fires (Hall Jr. 2005a). A study conducted by the U.S Department of Homeland Security and the U.S. Fire Administration National Fire Data Center on residential structural fires from 2001 to 2004 found that men were more likely than women to die in residential fires where smoke alarms operated, with 57% of males suffering fatalities compared to 43% of women (U.S Department of Homeland Security 2006a). Likewise, more middle aged men than women were likely to die in residential fires. The risk for fire fatality varies across gender, with males 65 and older 3.1 times more likely to die, compared to females 65 and older who are 2.1 times likely. The risk for fire death increases for females as they age (up to 3.7), the relative risk increases greater for males as they age (6.7) (U.S Fire Administration 2006a). Further analysis on how U.S gendered behavior relates to mortality is needed in fire studies. A possible explanation of these statistics could be that the traditionally dominant roles males play in U.S. families predisposes them to try to protect family members and fight fires, leading to greater risk for mortality and injury.

A United States Fire Administration and National Fire Data Center report looking at fires in 2001 indicated that both African Americans and American Indians had a higher death rate compared to the national average (U.S. Department of Homeland Security 2004a). African Americans were especially vulnerable, with a relative risk of death twice as high as that of the general population. However, a report by the U.S Department of Homeland Security and the U.S Fire Administration National Fire Data Center on residential structural fires from 2001 to 2004 found that racial differences disappeared when smoke detectors are installed and work (U.S Department of Homeland Security 2006a). Further research on the influence of race, gender and age on the presence of smoke detectors in the home, and the risk of death and injury, is warranted.

Social ecological characteristics of communities also impact the survival of civilians in residential fires. Poverty is considered a contributing element to mortality in fires (Tremblay 1994). Residents in U.S. urban areas that require protection from crime use such items as bolts, door locks, and bars on windows that may trap people in burning structures. In one incident leading to fire, candles were burning because the electricity was shut off. An article by the National Fire Protection Association focusing on poverty and fire risk showed that poor households have the greatest risk of fire death mainly because of security bars placed on windows. In addition to preventing intruders from entering the household, security bars also prevent easy evacuation in cases of fire. Other factors including lack of education, leaving children unattended, not having enough money to pay the utilities (so space heaters, candles, or open oven doors are used), lack of communication (such as not being able to afford a phone), and living in an area of high crime were also shown to increase risk of fire death (National Fire Protection Association 1996). A study in London, England found that greater number of fire fatalities occurred in communities that experienced higher levels of social deprivation as assessed by unemployment, low income, health, education, crime and housing (Holborn, Nolan & Golt 2003). Klinenberg's (2002) examination of the social ecological factors that contributed to over 700 heat induced deaths of Chicago residents in July of 1995 confirms how the need to ensure safety in an urban area may increase mortality for many. Socio-economic depressed communities in New Zealand also suffer increased rates of fire fatalities (Duncanson, Woodward & Reid 2002). Since race has been discussed as a possible factor related to mortality, perhaps it, along with socio-economic status, need to be reassessed to disentangle their unique contributions to fire morbidity.

Civilian Fire Deaths by Age

The age of civilians significantly influences the likelihood of sustaining injury and death due to fires, with the elderly and children being most at risk. Children under the age of five were nearly twice as likely to die in home fires while adults age 65 and over are also more than twice as likely to die in home fires (Hall Jr. 2005a). According to a Topical Research Report by the US Fire Administration and the National Fire Data Center, figures from the 2002 NFIRS data found that approximately 2,500 children age 14 or younger were killed or injured in residential fires in 2002. A little more than half (56%) consisted of children age 5 or younger. Of children killed in fires, the majority of fatalities occurred while the children were asleep (55%) with an additional 26% occurred while the child was trying to escape the fire (U.S. Department of Homeland Security, 2005b).

Higher rates of older adult deaths (60 years or older) were found in a London, England study on fatality in fire of dwellings (Holborn, Nolan & Golt 2003). According to a study by the U.S Fire Administration, adults that are 65 years and older are 2.5 times more likely to die in a fire compared to the overall population (U.S Fire Administration 2006a). Earlier, Wolf (1997b) showed that individuals over 65 had twice the national fire death rate. For those older than 75 that rate is three times the national average and at age 85 the rate is four times the average. Smoke is the leading cause of death, and this risk is the highest for those 85 or older. Data from a 2002 NFIRS study found that 34% of deaths in residential structure fires and 14% of the people injured were senior citizens (U.S Fire Administration 2006a). Older adults are more likely to die in fires that occur in the midmorning or early afternoon than are adults aged 18 to 64. An explanation for this is that the elderly tend to be home during these hours while younger adults are at school or at work. Older adults tended to be asleep or trying to escape at the time of their death or injury. Causes of these fires were usually cooking, smoking, and heating.

Fatalities of older adults generally occur more frequently during the winter months of December through February and are primarily the result of heating and cooking (U.S. Department of Homeland Security 2005c). Similar to adults, deaths of children are often highest in the winter months (U.S. Department of Homeland Security 2005b), proving that this time period is an influential factor in human fatalities.

Civilian Fire Deaths by Population Size

Civilian fire death rates by size of community were examined for the 2001-2005 period with the smallest communities (with a population less than 2,500) having the highest rate of death, more than twice the national average (Karter Jr. 2006). Nationwide, civilian deaths for 2005 were 12.4 per-million population. The North Central region had the most civilian deaths with 15.5 deaths per million population followed by the South with 13.8 deaths per million population. The Northeast had 13.0 deaths per million population, and the West had the least amount of civilian deaths with 6.8 deaths per million population. The Northeast had the highest fatality rates for communities of 500,000 or more as well as for smallest communities with populations of less than 2,500. The North Central had the highest rates for communities of 250,000 to 499,999 and for communities of 10,000 to 24,999. The South had the highest rates for communities of 50,000 to 249,999 and for communities of 2,500 to 9,999. These patterns of findings reveal largely unanswered questions about why community size show higher rates of death across different regions of the country. Perhaps an explanation is regional/community variation in the availability, quality and quantity of fire prevention technologies, equipment, training, and services, which are in turn influenced by differences in population size, economic base, poverty and other social and economic factors.

Personal and Situational Factors Resulting in Civilian Fire Deaths

A study by Hasofar and Thomas (2006) using 1993 NFIRS data concluded that civilian mortality was a function of the extent of fire damage; the area of fire origin; the material ignited as well as the form of ignition. The areas of fire origination considered the most prone to fatalities were found to be: lounge areas; sleeping rooms and kitchens. In assessing absolute number of fatalities, the form of material ignited and the form of heat ignition were highly influential characteristics of fires. Such items as sofas, chairs, and bedding were found to be the most dangerous forms of material ignited, while electrical equipment, matches, lighters, and cigarettes were considered the most dangerous forms of heat ignition. Personal factors contributing to a high number of fatalities included: conditions preventing escape---“burning clothes, incapacitation, fire between the victim and exit, and no time to escape”; the condition before injury---“bedridden, too old, drugs and alcohol and asleep” ; the activity at time of injury---“unable to act, sleeping, escaping and irrational behavior”; the location at ignition---“involved with ignition, in room of fire origin, in building of fire origin and floor of fire origin”; and the cause of injury--- “exposure to fire products such as flame, smoke, gas and heat” (13).

Factors that act to mitigate exposure from fires range from social mitigation such as evacuation plans to those of a physical nature (i.e. sprinklers). For certain populations such as the disabled, some structures may prove problematic in evacuation and subsequent rescue. It is often the case that those in wheelchairs are left unattended in a designated area while they wait for rescuers (McGuire 2005). For example, a Maryland woman in a public mall was stranded in an elevator when no effective evacuation plan was available, leading to a successful law suit. There are several initiatives that can assist in preventing life loss to this vulnerable population. A sound evacuation plan for the disabled must encompass a knowledge of building structure, an awareness of who is disabled within the structure, an availability of equipment (i.e. lightweight evacuating chairs), discernible signs of how to evacuate, trained staff on how to implement the plan when needed, and the ability to coordinate with emergency response personnel. These components mitigate harm to this vulnerable population. A study of London's (Holborn, Nolan & Golt 2003) fatal fires from 1996 to 2000 found that one fifth of fatalities in dwellings had some form of disability. Those with physical disabilities are in need of special consideration in times of crisis, and further research is needed on how such impediments inhibit evacuation and protective response.

According to the handbook of the *Society of Fire Protection Engineers* the problems involving fires in occupancies designed for permanently or temporarily disabled persons such as nursing homes and hospitals appear to have declined in recent years (Bryan 2002). However, individuals who have disabilities continue to be more vulnerable to fire incidents. Hall Jr. (2005) found that in 2004, 28% of fatal home fire victims had some type of disability or age-related limitation. A report by the U.S Department of Homeland Security and the U.S Fire Administration National Fire Data Center on residential structural fires from 2001 to 2004 found that physical disability was a substantial factor in fire fatalities, associated with 15% of victim deaths (U.S Department of Homeland Security 2006a).

Other personal and situational factors have been found to influence the risk of injuries in fires as well. Individuals who have age-related limitation or impairment due to alcohol or drug use tend to be more vulnerable in fire incidents (Hall Jr. 2005a). Between 2001 and 2004, possible impairment due to alcohol was a factor contributing to fatal injury in a residential structural fire for close to 28% of all victims between the ages of 18-64 (U.S Department of Homeland Security 2006a).

Role of Structural Components in Civilian Fire Deaths

Structural characteristics of buildings may act to mitigate harm to human life as well as limit physical damage when a fire occurs. Sprinklers, when present, lower the mortality rate and average property loss per fire by one-half to two-thirds, compared to fires where sprinklers are not present (Rohr and Hall Jr. 2005). Sprinkler systems are a useful aide in curbing the impact of fires, although fire fighters must be able to integrate them into their own fire and rescue activities. Sprinklers are able to control fires. However shutting off the automatic system or drawing water away from the sprinklers by operating hoses while on scene may impede the effectiveness of this system (Klaene and Anders 2001). A proper system should have a water supply that supports hose use and sprinklers, and firefighters should connect hoses to an independent source of water. Other factors such as a lack of smoke detectors can promote multiple-deaths in residential fires. Missing or dead batteries are always an issue, as is the location of the smoke detectors (such as the kitchen, which is an inappropriate place) (Tremblay 1994). Holborn, Nolan & Golt (2003) found that a working smoke alarm was correlated with lowered risk of fatalities in London dwelling fires. Stevenson and Lee (2003) also found that the presence of smoke alarms in U.S. households was "significantly negatively associated with residential fire mortality" (47), although the extent of the relationship was minimal. The authors report that although smoke alarms are in a majority of U.S. homes, at least 1/3 to 1/2 may not be functional, leaving in question their influence in saving lives.

Various obstacles which may impede the rescue of victims may result from limitations of structures. Catastrophic fire deaths often reveal the multiplicity of interacting factors that often contribute to the occurrence of multiple fatalities. A 1993 fire at the Paxton Hotel in Chicago caused 20 deaths (Tremblay 1994). This structure was used as a hotel for transients; it was licensed for single- room occupancy. In this four story building, the fire ignited on the first floor, spreading through a stairwell upwards. Its spread was aided by the removal of fire doors which were not replaced. Fire doors on the first floor were blocked, permitting smoke to rise. A delayed alarm impacted notification of the fire. Structural collapses delayed rescuers. Security bars trapped a victim on the first floor while a lack of interconnecting smoke detectors and sprinklers aided growth of the fire. .

The extent of physical damage a fire produces in a structure may impact the deaths of civilians. In board-and-care facilities, fatalities are often associated to the high occupancy of people and the lack of structural components for fire mitigation. A 1997 fire in Pennsylvania at a board and care facility involved the death of 9 of 21 residents and nearly $270,000 in damage. The lack of sprinklers, disabled fire doors, and the slow response to a fire alarm that had been silenced, were factors that contributed to the entire structure sustaining "severe fire damage" (Wolf 1997a) including roof collapse as well as extensive burning of the south side of the second story. The fire was suspected to have originated on the screen porch of this two story facility. It was found that during the renovation of this family home into a board and care facility many stairwells did not comply with the local building code's plans for evacuation. As some of these examples indicate, the social and physical factors correlating with civilian mortality form a complex matrix, where structure, geography, socio-demographic and ignition as well as other characteristics of the fire hazard, interact to impede the ability of many victims to survive structural fires.

Civilian Behavioral Response to Fire

The actions civilians engaged in at the time in which fires occur also appear to be correlated with fire fatality. A study conducted by the U.S Department of Homeland Security and the U.S Fire Administration National Fire Data Center using data for 2001-2004 found that of 3,055 fatalities, most victims (37%) were sleeping at the time of the fire (U.S Department of Homeland Security 2006a). Twenty nine percent were killed while trying to escape the fire and an additional 12% were unable to act because of age, disorientation, or some other reason. Sleeping was more likely to affect children. Of the 37% of fatalities that died while sleeping, children's deaths made up 82% of the cases. Older adults were asleep in 32% of the cases (U.S Department of Homeland Security 2006a). A study on the human behavioral response to residential fires in the United States had similar findings. Interviews with 584 participants in 335 fire incidents in the United States were conducted by fire department personnel using a structured questionnaire at the scene of the fire incidents (Bryan 1977 in Bryan 2002). The study found that 80% of respondents surveyed reported that they evacuated the building and 22.9% attempted to fight the fire. Likewise, the behavior of individuals in both studies varied according to their gender, with females being most concerned with alerting others and assisting others in evacuating the building and males being more active in fire fighting. Females differed significantly from males in the warning and evacuation activities with 11.4% of females reporting that they called the fire department as their initial behavioral response compared to 6.1% of males. Over 10 percent of females reported leaving the building as their first behavioral response action, compared to 4.2% of males (Bryan 2002).

Civilian behavioral response to fire incidents has been a topic of study for approximately 40 years (Bryan 2002). According to Bryan, the response of an individual in a fire is affected by the characteristics of the building the fire occurred in as well as how severely the individual perceives the fire to be at the time of the incident (2002). Research by Wood (1980) reveals that the most important individual decisions and behavioral responses to fire are most likely to involve perceived life threatening situations by the victims and occur prior to the fire departments arrival on the scene. Individuals' perceptions of the seriousness of fire also effects actions to such an event. Individuals who perceive the fire as being more serious are more likely to immediately leave the building and less lightly to engage in fire fighting behavior than those individuals who do not perceive the fire as being a significant threat. A study conducted by Wood found that an individual's familiarity with the building does not affect whether or not an individual will choose to immediately evacuate from the building. Individuals who had previously been involved in a fire incident were more likely to fight the fire or minimize their perceived risk in some way and were less likely to leave the building immediately. Bryan (2002) finds evidence that the presence of fire protection systems in the building may be a factor in an individual's perception of the severity of the fire threat.

The manner in which individuals are alerted to the occurrence of a fire may impact their perception of the threat and their behaviors. A study by Keating and Loftus found that variations in voice quality, pitch, or volume, as well as the content of the message, influence how individuals perceive the seriousness of a fire (1981 in Bryan 2002). Likewise, if verbal messages about what to do are in conflict with other awareness cues, the credibility of the message may be questioned and individuals may disregard them (Bryan 2002). A study by Latane and Darley (1968) found that the behavior of others influences how an individual interprets an ambiguous threat. If these other individuals interpret a situation as being a non emergency, the individual initially questioning the situation is likely to either disregard the initial ambiguous cues or interpret the cues as being a non emergency. This tendency to imitate the behavioral responses of others appears to occur frequently in fire incidents in restaurants, hotels, and other places of public assembly (Bryan 2002).

Bryan (1977 in Bryan 2002) studied 355 primarily residential fires, finding the majority involved in firefighting was between people 28 and 37 years old were more often male than female. Approximately 26% of the male population reported that they fought the fire when they first became aware of the incident compared to approximately 10% of female respondents. The fire fighting behavioral response appeared most likely to occur when individuals were emotionally or economically related to each other or where such behavior was the result of training or an assigned occupational role (Best and Demers 1982 in Bryan 2002).

Best and Demers found evacuation behavior more likely if exits were clear of smoke, or if the smoke was determined by guests to be non-threatening. If smoke was heavy, the guests were more likely to stay in their rooms or move to more suitable rooms in order to protect themselves from smoke (Best and Demers 1982 in Bryan 2002). Wood (1980) made the following predictions regarding fire behaviors: the type of person most likely to evacuate the building as soon as they become aware of the fire is most often female, considers the fire to be a serious threat, does not know a means of emergency escape, has not been involved in previous fires, and has never received any firefighting training. Males between the ages of 30 and 59, in the work environment, and who have been involved in previous fires were most likely to take part in firefighting behavior. Wood (1980) found that general actions of civilians in a fire fell into three categories: "concern with evacuation of the building by oneself or with others;" "concern with firefighting or at least containing the fire;" and "concern with warning or alerting others, either individuals or the fire brigade" (84). Further work by Wood examining 952 fire incidents was conducted in Great Britain. 2193 individuals were interviewed by fire department personnel at the fire incident scenes. The study found that the most frequent behavioral responses to fire were reported as evacuating the building, fighting or containing the fire, and notifying other individuals or the fire brigade about the fire (Wood 1972 in Bryan 2002). There is also evidence of frequent pro-social behavior during fires, which reproduces what is known about the behavior of many people in other crises and disasters.

Emergency Response to Structural Fires

Emergency response to structural fires is a substantial field of study in the discipline of Fire Science. Literature on firefighter initiated search and rescue (S&R) often encompasses discussion of techniques for S&R, victim removal, possible obstacles, physical structure of fire impacted area, types of collapse, voids and areas to search for victims. Much of this literature has taken the form of instructional manuals or texts written by professionals in the fire industry drawing upon years of experience, anecdotal accounts, or involving case studies of specific events which are discussed to highlight proper approaches to S&R for firefighters. The main themes are as follow:

Searching for Victims

The process of searching for victims in a fire often can be broken down into two phases. The first is labeled the primary search. Primary searches involve an initial, rapid search through the structure under fire, where fire fighters investigate possible areas victims are likely to be present. Norman (2005e) contends that a primary search may even take place before hose lines are set up. However it must be stressed those engaged in a primary search should be well equipped, highly prepared and experienced in case they must remove themselves from a precarious or threatening situation during the primary search. As well, a more skilled firefighter will be able to extricate a victim (i.e. dragging) in an environment plagued by smoke and low visibility. The primary search is often considered the most dangerous exploration for victims by firefighters (Dodson 1999). Before beginning a search, firefighters often collect information on the victim from bystanders and family members as to their possible location. In primary searches, firefighters often check the area closest to the actual fire to ensure that victims are removed from this hazardous spot (Norman 2005e).

The secondary search is conducted usually after the fire has been extinguished or is under the control of on scene firefighters. Improved visibility through a reduction of smoke permits search for victims through fallen debris, as well as checking on areas of the inflamed structure that perhaps primary searchers may have missed (Dodson 1999). As well, further extinguishing of areas yet to be completely put out (termed overhaul by firefighters), may occur in this phase of firefighting (Norman 2005e). The search for bodies is a relevant component of the secondary search; they often may be hidden under debris. This facet of search should be undertaken in a slow and careful manner. The area to be searched should include "the perimeter of the building, including any rooftops or setbacks to which people may have jumped, as well as the areas beneath the windows (Norman 2005e; 235). Small children are able to hide or be hidden in small areas (e.g. dresser drawers, cabinets, etc), making it a pressing matter that every area in which a human being can hide should be searched.

The searching for victims is often aided by an understanding of human behavior in fires. Norman (2005e) instructs firefighters to search for possible victims along evacuation routes in structures; people will most often flee a fire yet be overcome by smoke while trying to escape. The main entrance and interior stairway is discussed as an area of high priority to search, as well as behind doors inside a structure. Populations which are more vulnerable (i.e. small children, elderly, handicapped) are often unable to leave quickly in a fire, prompting firefighters to search bedrooms for these individuals. The search for victims in a fire should encompass a VES approach (vents, enter, search); ventilating a structure in a search makes the activity more tolerable. In a multistory building (Hall and Adams 1998), the most important area to search are the floor on fire, the floor above and the highest floor in the structure. Individuals are most likely to be found in these areas; they are often in great danger due to increased heat, smoke and fire.

Victim Removal

The process of victim removal is a highly specialized component of firefighting. Leaving an inflamed structure with a victim is difficult; the purpose "should be to not cause any further injury or aggravation of existing injuries during the rescue process" (Hancock 2000; 433). However in certain situations where danger is high, implementing safeguards to extricating victims (i.e. immobilization) is not possible and retrieving the individual from harm's way takes precedent. There are multiple forms or styles of carries (i.e. Firefighter's carry; Extremity carry; Seat carry) and drags (webbing sling drag; blanket drag; clothing drag; sit and drag method; firefighter's drag) that can be used when finding a victim as well as making use of tools such as backboards and stretchers when removing victims from harm.

Structural Collapse

Structural collapse is often a reality that occurs with many fires. It alters the structure in ways that rescuers must understand. Research in the discipline of fire science has revealed several standard formations of collapse which offer clue to rescuers about where to search for victims. Specific voids develop with each type of collapse. There are five major types of collapses: the pancake, the V-shaped, the A-frame, the supported lean-to, and the unsupported lean to. They are varieties of collapsed structure that fire fighters often encounter (O'Connell 1993a). In the pancake collapse, floors fall upon one another resulting from impact by large loads or failures of the wall itself, creating voids where items within the structure such as furniture and appliances meet the falling floor. These voids permit space to exist for victims to occupy till rescue comes; stairwells are considered the best avenue for S&R. The V-shaped collapse occurs when the floor breaks in the center due to stress, rotting or failing and falling towards the floor below. Voids develop on both sides of the failed floor. The survival rate is high for people below such a collapse as the broken floor prevents falling debris from hurting them. The A-frame collapse occurs when the sides of a floor fail, yet inner beams still support the floor, creating an inverse of the V-shaped collapse as the sides fall to the floor below. The survival rate is apparently highest for victims found near the center of this collapse on the floor below. The supported lean to collapse occurs when one end of a floor weakens due to rotting, failure, or vibrations, causing one end to fall until the weakened side come to rest on some object, creating a void space for individuals who may be found underneath. However, victims may be found on top of the collapsed portion of the lean to. The unsupported lean to (considered to be most hazardous configuration) is the most unsteady collapse site; it involves the weakened ends of floors. However, they are unsupported by any solid objects yet will be suspended (i.e. by pipes or electrical cables). A secondary collapse is possible due to the unstable nature of the fallen structure. Individuals can survive below the fallen floor near the wall where the above hanging floor is still attached, or below the unsupported floor.

Search and Rescue

The process of S&R in a collapse has become a focal point of fire service response. The search for victims in a fire resulting in collapse may involve several components; Collins (2005b) breaks S&R down into five elements: response, size-up and reconnaissance; surface rescue; void-space search; selected debris removal and general debris removal. These are sets of actions needed to complete S&R. Response, size-up, and reconnaissance involve the initial arrival on scene, assessment of what occurred, and developing knowledge of who the victims are, where they are, and the setting up of resources. Surface S&R involves removing people from the exterior, who are easily rescued. S&R in voids occurs after it is determined that no live victims can be found. It is considered the more hazardous phase of search. Such tactics as shoring may begin in this phase of search. Selective debris removal occurs once all survivable void spaces are searched, the layers of the collapsed structure are removed and new areas are searched. Finally, general debris removal occurs when all potential spaces for survival are searched, and no other victims are likely to be found.

Firefighters in Search and Rescue

There are very few studies of the actions of firefighters engaged in S&R and how these actions correlate with the survival of civilians exposed to a structural fire. One rare example illustrates how well intentioned actions of the fire service in the course of S&R may have impacted the survival of civilians. At a 2003 high rise 37th floor office building fire in Chicago, 6 deaths occurred in a stairwell due to smoke inhalation. The fire originated on the 12th floor, where firefighters opened a door which led to smoke filling a stairwell. 80 minutes later victims were found in the 14th floor stairwell. These actions coupled with a lack of sprinklers, and stairwell doors which automatically unlocked when trying to exit the smoke filled stairwell contributed to victim deaths and injuries (Cook County Commission). This is one rare example of a study of specific behaviors of fire service personnel, their actions in S&R, and the negative unintended consequences of these actions on civilians trapped in a fire structure.

Fire Fighter Fatalities

Causes of Fire Fighter Fatalities

There are a lot more studies focusing on fire fighter fatalities than on civilian fire fatalities. Studies on firefighter mortality often focus on causes and duties engaged in by firefighters, revealing how important context is to understanding patterns of mortality. Fahy & LeBlanc (2006) show that firefighter fatalities on duty have decreased nationally; 87 were reported in 2005, the lowest figure since 1993 according to the National Fire Protection Association (NFPA). Deaths occur during many activities associated with fire fighting. Assessing the variety of duties in which firefighters were engaged, roughly 24% of the deaths occurred during fire ground activities---these 25 deaths are the lowest number of fatalities associated with these activities since 1977, the first year such statistics started to be gathered by NFPA (not including the deaths from 9/11). Firefighter training (13%) is a significant activity, accounting for many deaths in 2005. Firefighter training deaths (Fahy 2006) have accounted for approximately 10% of all on duty fire fighter deaths for the past decade (1996-2005). The majority of these deaths are the result of cardiac arrests. Responding to or returning from a fire is the activity in which the largest number (30%) of deaths occurred in 2005 (Fahy and LeBlanc 2006).

The U.S. Fire Administration's (USFA 2006a) analysis of fire fighter deaths in 2005 breaks down the category of fire ground activity to attain a fuller understanding of the types of activities in which these fatalities occurred. The USFA state that 27 deaths occurred (2 more than the NFPA; incidentally USFA reports 115 firefighter fatalities for 2005 while NFPA reports 87; this discrepancy is addressed later on in the manuscript). . Heart attack accounted for the largest number of deaths (11), followed by Search and Rescue (6), Water Supply (2), Incident Command (2), Scene safety (1), and Other (5). The act of search and rescue accounted for very few deaths in 2005.

The leading cause of fire fighter death in 2005 was emotional stress and overexertion, which usually results in heart attacks; being struck by an object (i.e. tree, car, etc) was the second leading cause of injury, followed by becoming trapped within structures, roof collapses or under water. Such incidents as overdoses, being poisoned, or a victim of a gunshot wound, are rare yet contributory factors to death of fire fighters. Social demographic variables such as age can be a contributory factor: of all dead fire fighters over 40, 60% died due to cardiac arrests in 2005 (Fahy and Leblanc 2006). Firefighters in their 50s have a death rate twice that of the average, and those over 60 have a death rate four times that of all fire fighters.

The types of structure also are a contributing factor to fire fighter fatality. Vacant or non-residential structures may be a greater threat. Fahy and LeBlanc (2006) assessed the NFPA annual fire loss studies (from 2000 to 2004) of fire ground deaths per 100,000 structure fires by property use and found residential structures to be less hazardous to firefighters. Although a greater number of firefighters die in residential structure (3.8 deaths per 100,000 residential structural fires), the rate in non-residential or vacant structures is higher (6.9 per 100,000 non residential structural fires). Although in the public eye death from structural collapse appears to be a leading cause of fatality, the reality of its impact is different. An assessment of (U.S. Fire Administration 2006b) firefighter fatalities for 2005 reveals that being caught or trapped was a contributing cause to only 7.8% of on duty fatalities. Again, stress/overexertion was considered the leading cause of death (53.9%) in 2005. A more in depth assessment by the National Institute of Standards and Technology (NIST) (Brassel and Evans 2003) of collapses resulting from structures weakened by fire, states that between the years of 1994 and 2002 nationwide 63 deaths were caused by structural collapse in 47 fires. Fatality was divided into two categories: 1) Firefighter is caught or trapped in structure, unable to escape or be rescued and 2) struck by an object and severely injured by a piece of collapsing structure, usually while working outside. Previous studies according to NIST found that rates of injury are constant, with 60% of deaths occurring in structures where firefighters have been caught or trapped, and 40% due to being struck or making contact with a an object. In Brassel and Evans (2003) study, being caught or trapped accounted for 85% of total deaths. Overall, Brassel and Evans (2003) conclude that the number of firefighter fatalities due to collapse has declined annually since 1979.

Cardiac arrest appears to be a significant cause of mortality for many firefighters. In Fahy's (2005) analysis of fire fighter fatalities over 1995-2004, 440 firefighters died due to cardiac arrest while engaged in activity related to their profession. Around one third of deaths resulting from cardiac arrest occurred during fire ground operations, with roughly 25% of deaths taking place while responding to or returning from fires. Traveling en route to or from a fire appears to bear significant risk to the lives of fire fighters. Other relevant activities in which cardiac arrests occurred were training (11.4%), emergency incident unrelated to fire (10.7%), administrative duties (10.5%) and other activities such as fire prevention, inspection and maintenance (7%). Of the 440 who died during 1995-2004, 307 were volunteer firefighters while 117 were career fire fighters. Nearly 93% of firefighters 60 years old and older who were victims of cardiac arrest were volunteer fire fighters. Fahy (2005) shows that of those fire fighters who died of cardiac arrest, a large proportion (43.5%) had exhibited some form of heart-related problems prior to death. Firefighter deaths to sudden cardiac arrest are a threat to fire fighters, particularly for volunteer firefighters in the U.S. Fahy & LeBlanc (2006) report overexertion as the leading cause of fatal injuries for fire fighters in 2005. Falls, jumps or slips were the second leading cause of fire fighter injuries in 2003 (27.6%).

Firefighter Injuries

The causes for firefighter injuries are just as diverse as those for fatalities. The leading cause of firefighter injuries in 2003 was overexertion or strain, which contributed to 32.4% of injuries (Karter and Molis 2004). In 2004, overexertion or strain (25.7%) was a significant factor in fire fighter injuries, however falls, jumps and slips (29.7%) became the leading cause of injuries (Karter and Molis 2005). Other causes of injuries in 2004 were being struck by an object (12.2%); contact with an object (9.0%); exposure to fire objects (8.8%); exposure to chemicals or radiation (1.6%); extreme weather (1.3%) and other (11.7%).

Karter Jr. and Molis' (2004) analysis of 2003 NFPA data revealed a decrease (2.5%) in the number of firefighter injuries in the line of duty during the previous year. Karter Jr. and Molis (2005) confirmed a decrease (3.7%) in injuries in the line of duty for firefighters in 2004. These rates of fire fighter injury are the lowest since 1977, according to these reports. Fire ground duty (includes structure fires, vehicle fires, brush fires, etc) was the leading category of activity in which injuries occurred for both studies by Karter Jr. and Molis, accounting for almost half of all injuries. Other notable categories were non-fire emergency, other on-duty, training and responding/returning.

Karter Jr. and Molis (2004) found that the number of fires responded to is directly related to the population protected by fire service, with highly populated regions having higher response rates. Incidentally, the number of fire ground injuries a department has is directly related to the number of fires it responds. It can be hypothesized that larger fire departments have higher rates of injury due to the greater frequency to which they respond to calls for assistance. An assessment of fire ground injuries for both years (2003 and 2004) shows the Northeastern U.S. area of the country as having significantly higher rates of injuries than other regions. The Northeastern U.S. is a highly populated region, with many cities (New York; Philadelphia; Washington, D.C.; Boston) possibly accounting for the increased response to fires and thus the high number of injuries to firemen. Overall, studies reveal firefighter injuries have decreased significantly, from 102,900 in 1988 to 75,840 in 2004.

Conclusion

The National Fire Incident Reporting System (NFIRS) is the most comprehensive data set in the U.S. used to analyze fire safety issues. This data set is collected from fire departments in nearly every state (U.S. Fire Administration 2004). It captures specifics of fire events, such as factors surrounding the cause of a fire, actions taken to mitigate exposure to risk of death and injury for civilians and firefighters, as well as the human and financial costs of fires. This is the only data set available that includes details on fires, making it highly valuable for analyses. There has been extensive analysis completed by the U.S. Fire Administration in recent decades. The NFIRS data set has proved to be an important tool in educating professionals as well as the general public on factors associated with risk to fires in the US.

Although the NFIRS data set is a great resource to analyze fire safety issues, there are many limitations to the reliability of this data set. The participation of relevant entities is uneven throughout the nation, causing concern over the representative nature of this data set. Almost every state volunteers in this program. However, not every fire department in those states supply information (U.S. Fire Administration 2004). Approximately 14,000 fire departments nationally collect data on fire (U.S. Fire

Administration 2006c), accounting only for approximately 33% of all fires responded to annually (U.S. Fire Administration 2004). There are also concerns over reliability and over missing values. Anywhere from 25-40% of values are missing in the variables in the NFIRS data sets (Green et al. accessed 5-12-06), leading many researchers to apply methods of inputting values to variables of interest, but all these approaches make important and very often untested assumptions about the data. In addition, there is a need to standardize methodologies for analyses of NFIRS data so as to strengthen the reliability of the findings of fire safety research (Hall Jr. and Harwood 1989). The ability to replicate previous NFIRS research is a concern, since multiple versions of modules in the data have been prepared. In 1999, version 5.0 of the NFIRS database began to be utilized; reportedly it is better and more detailed than the older 4.1 version in capturing fire events. Nevertheless, there were data conversion problems that took place in local fire departments during the time period in which the switch occurred, which causes uncertainty about replicating previous research findings using data from version 4.1 or earlier. Given the importance of fire for the security of the nation, there is an urgent need to improve the reliability and validity of data systems about this hazard which would allow for more nuanced understandings of the causes of this hazard.

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Urban Search and Rescue (US&R) and Structural Collapse: Annotated Bibliography

Borden, Frank. 1992. "US&R: Rescue and EMS in a Hostile Environment." *American Fire Journal* (September): 14-19.

This article discusses the origination of US&R capability in the US; the conceptualization of US&R; the type of activities carried out; considerations for these emergency response assets as well as how medical care is provided in such a context. The article opens with a discussion of the "golden day" theory of victim entrapment, how most (live) victims are rescued within the first 24 hours. After a structural collapse, the likelihood of saving a live victim decreases with time entrapped; this is the golden day theory. The development of US&R as a tactical component of FEMA in the US is discussed. US&R is then conceptualized as an integrated response system of highly-specialized equipment; well-trained personnel from different disciplines; effective communications; and an established method of command. Preparation before an incident is emphasized for US&R capabilities. The article discusses US&R's organization (including command/coordination, search, rescue, medical, and technical); rescue operations (for the injured, entrapped, those in void spaces or those entombed); prioritizing tasks; and medical considerations. In addition, a brief description of how the need for medical care is assessed for those victims involved in a structural collapse is provided. The article concludes by acknowledging the complexities and challenges involved in creating an effective US&R team. Although not highly detailed, it offers good overview of US&R activities that may be helpful to the uninformed.

Collins, Larry. 2004/2005. "Managing Collapse Rescue Operations: 10 Steps to Commanding Structure Collapse Emergencies, Part 3." ***Advanced Rescue Technology Vol.*** **7, No. 6 (December/January): 44-50.**

Collins offers advice on how to approach specific types of structural collapse from a professional emergency responder viewpoint. This article reviews strategies for rescue in typical collapse patterns, assigning S&R resources, and how to apply the concepts of LCES to rescue operations. Collins reviews several common and all too familiar types of collapse (pancake, midstory, lean-to, v-shaped, a-frame, 90 degree, curtain fall, cantilever, inward/outward, and total) and how to proceed in searching these structures. The rescue options for pancake collapse include entering through a vertical shaft, laterally from the outside (which is dangerous), to work through the collapse area layer by layer (with either cranes or chain saws), or to approach the area from the bottom up. For mid-story collapses, rescuers can come in through the floor and then breach downwards to the collapse zone. In lean-to collapses, victims are most likely in the void spaces under the "V" shape that is formed, they can be accessed by removing the top debris and breaching downward, by breaching the surrounding walls (which is risky), or breaching upward (which places rescuers below the collapse zone). The same approaches are useful for tent (or A-frame) collapses. Collins offers insight into the other variations (90-degree, curtain fall, cantilever, inward/outward, overturned, and total collapse) and how emergency responders should act when carrying out S&R activities.

Collins stresses advantages to incident commanders understanding local, regional and state S&R resources, due to the great variation these resources encompass across the US. Collins also discusses the application of the LCES wild land fire concept to rescue operations. LCES stands for lookout, communication, escape route, and safety zone. This process for search and rescue is intended to establish a system to ensure the safety or emergency responders working in weakened structures. It has successfully been implemented by several US&R taskforces during operations at the Oklahoma City

Bombing, 9/11, and the Pentagon collapse. Collins offers practical advice on S&R and safety that is reflective of actions taken by S&R actors while on an emergency response.

Hashagen, Paul 1995. "Collapsed Operations Through History." *Firehouse*, Vol. 20, No. 9: 122-124

This article traces collapsed rescue operations throughout history beginning with the first rescue company established in 1915 up to the creation of 25 FEMA Urban Search and Rescue teams in 1992. In 1915, after facing several situations that were beyond the means of the average fire company, the New York City Fire Department decided that a special unit was needed to operate, utilizing specialized training and equipment, at some emergencies and fires. Several firefighters were handpicked to work on this new unit (called Rescue Company 1) on March 6, 1915. On September 22 of that year Rescue Company 1 responded to a call regarding a caved in under construction subway station, where numerous people were killed and many more trapped and injured in the wreckage. The tools and equipment carried by the rescue company began to grow as more and better gear were added and as their role in search and rescue expanded. The growth of heavy rescue in New York included the formation of a second company in 1925 and two more in 1931. In other US cities, such as Boston (where the first rescue company was founded in 1917) and San Francisco (1922), other rescue companies began to form during this time period.

Besides manmade disasters, firefighters have worked at an array of natural disasters also, such as floods, tornadoes, hurricanes, and earthquakes. In these situations firefighters are called to rescue those left trapped and injured. Realizing that major disasters could overwhelm even the largest and best equipped fire departments, in 1992 the Federal Emergency Management Agency selected 25 Urban Search and Rescue teams in 17 states to make up the first network for catastrophic disasters. The task forces are designed to include search, rescue, medial and technical elements to provide an integrated, self-contained approach to locating, extracting and treating victims. This article is a good starting point to uncover the development of US collapse rescue operations.

O'Connell, John P. 1994a. "The Structural Collapse Team: Part 1: Recruiting and Training Your Rescuers." *Rescue* (January/February): 53-59.

O'Connell writes on the establishment of a structural collapse team and provides a good overview of how such a process may evolve for those outside the industry of emergency response. Due to recent catastrophic events and new federal regulations, many fire departments have been prompted to organize heavy rescue teams specializing in collapse operations. These teams are deployed on diverse types of emergency operations including: trench, building collapse, and confined rescue. This article is the first in a three part series focusing on protocols and training that can be used when forming a collapsed rescue team. The article presents basic training and personnel needs that will be useful in conducting operations focusing on collapse and rescue. The article also includes information on various types of structural collapses.

O'Connell, John P. 1994b. "The Structural Collapse Team:

Part 2: Training and Tools for Collapse Rescue." ***Rescue*** **(March/April): 67-73.**

O'Connell offers a review of common tools for use in S&R as well as a training guide for actors engaged in searching a structural collapse. This article is the second in a three part series focusing on how to best establish, train, and equip a structural collapse rescue team. The article reiterates the fact that (as earthquakes in Los Angeles have shown) rescuers need to be prepared for collapsed structures with trapped victims. Tools that may be useful to teams are described including hand, measuring, digging, prying, cutting, hammering, mechanical and electric tools. A description of high tech tools is also included in this text by O'Connell. However, as a result of the high costs of these tools, fire services have not kept pace with the most up to date advances in technology. Although informative, because this is an old article the examination of tools used and advice on training search teams requires revisiting.

O'Connell, John P. 1994c. "The Structural Collapse Team: Part 3: Equipment and Apparatus for Teams on a Tight Budget." ***Rescue*** **(September/October): 61, 63, 65-67.**

O'Connell concludes his three part series on how to establish, train and equip a structural collapse team by focusing on apparatus, equipment and tactics used when engaged in S&R. O'Connell offers advice on ways to purchase equipment on a tight budget, a reflection of the fact that many teams may face a lack of funds to support services. Attention is paid to modular equipment and tractor trailers as well as generators, gas-detecting instruments, electricity-detecting equipment, and air systems. Specific rigging equipment, shoring systems, and lumber (for shoring or cribbing operations) are also mentioned. As with O'Connell's' previous work in this series, the information presented requires revisiting due to the age of the article. Changes may have occurred in how such teams approach obtaining equipment as well as the use of shoring systems.

Wieder, Mike. 1999. "IMS Consortium Releases New Document on Structural Collapse and US&R Incidents." ***Speaking of Fire*** **(January): 13.**

Wieder briefly examines the birth of the National Fire Service Incident Management System Consortium and its role in incident management. Wieder also conceptualizes and discusses the duties of US&R. The National Fire Service Incident Management System Consortium is an organization that grew out of an initiative by the International Association of Fire Chiefs to merge the FIRESCOPE Incident Command System and the Phoenix Fire Ground Command into one incident management system that could be used in all jurisdictions. According to Weider, the Consortium's work would be reflected in future course revisions done by the National Fire Academy in Maryland. This Consortium had focused attention on US&R incidents and structural collapse because they have become important issues to fire departments. The Consortium is continuing to apply the incident management system to other types of incidents and release materials on these topics. Wider touches upon the conceptualization of US&R and duties carried out during emergency response. The article concludes with recommending the book *Structural Collapse and US&R Operations* for more information on the basics of IMS, US&R resources and capabilities.

This is an informative piece in order to understand the IMS consortium at the time the article was written. This piece is not beneficial in understanding the current complexities that US&R taskforces (at the national and local level) deal with during a response.

Williams, Geoff. 2000. "Checking US&R Team Vital Signs."
***Fire Chief* (November): 56-58.**

This article examines a method of assessing the effectiveness and safety of US&R teams. An Incident Command System must maintain operational, planning, logistic, and (sometimes) financial control of US&R teams. However, until recently, this system has not included a way to evaluate the effectiveness of a team's performance throughout their task. As a result, a SOCO system (Scene of Operations Command Organization) method was created in 1992 as a standardized layout plan for teams at a scene. The main areas that SOCO evaluates are: appropriateness and effectiveness of tactics, assessment and application of equipment, appropriateness of equipment servicing schedules, appropriateness of hazard awareness communications, assessment of health, safety, and welfare needs, assessment of psychological depreciation effects, and assessment of physical fatigue effects. Benefits of this evaluation include being able to recognize if a team is succeeding or falling behind, tracking psychological effects of S&R (the example of one team finding four fatalities in a day is given), seeing whether equipment is readily available for use at a site, comparing the effectiveness of different types of equipment and tools, facilitating communication and sharing discoveries of common hazards. A sample of the evaluation is provided. The article finds SOCO evaluations to be beneficial if US&R teams are familiar with how they work and understand the advantages of using them. Further research is warranted to uncover if such methods are currently still in use to evaluate US&R teams, how widespread these methods are, as well as how valid these methods are in measuring the effectiveness of these capabilities.

Mitigation Civilian Mortality and Injury in Fires

Mitigation

Fleming, Russell P. 2003 "Determining how well Sprinklers
Can work." *NFPA Journal* (March/April)

http://www.nfpa.org/publicColumn.asp?categoryID=&itemID=19757&src=NFPAJournal&cookie%5Ftest=1
(accessed 8-2-06).

Fleming offers a very brief article examining the need for automatic sprinkler systems in structures in order to mitigate fires, as well as the current debate over their use. In addition the author touches upon advances in the National Fire Incident Reporting System (NFIRS) that permit a better analysis of these systems on mitigation. Historically, two contrasting views on fire suppression surround sprinklers; should buildings rely on automatic sprinklers or should active firefighting be the source of aid. This debate is discussed as ever present, citing the World Trade Center collapse as resulting possibly due to the heavy reliance on sprinkler systems and not passive firefighting. This issue of reliability is tied into talk about the NFIRS version 5.0 that enables a more thorough collection of fire data, permitting a better assessment of the influence of sprinklers on scene. Version 5.0 asks questions such as how many sprinklers operated, whether they failed to operate, and information on the size of the fire, permitting a better understanding of how well sprinklers mitigate fire. Fleming gives a narrow but good review on the debate for using sprinklers to the novice. The discussion on the improvements to collecting data on use of sprinklers and fire is helpful information to those researching this phenomenon.

Klaene, Ben and Russ Sanders. 2001. "Fighting Fires in Protected Buildings: Shutting Down the Suppression System Prematurely is a Common Error at Sprinklered Properties." ***NFPA Journal*** **(September/October)**
http://www.nfpa.org/publicColumn.asp?categoryID=&itemID=19866&src=NFPAJournal (accessed 7-9-06).

This piece examines the actions of firefighters in suppressing fires and how they may hinder the effectiveness of automatic sprinkler systems. Automatic sprinkler systems are often a highly valued component of fire suppression tactics, one that must be incorporated into the actions of firefighters. Automatic sprinkler systems are designed to control or extinguish fires before help arrives. The firefighter's duty is to have procedures in place that support this system, and not hinder its ability to mitigate fires. Actions of firefighters, such as bad judgments like shutting off the automatic system upon arrival or drawing water away from the sprinklers by operating hoses often lessen the effectiveness of a resource such as automatic sprinklers. The authors contend hose lines used by firefighters should be attached to an alternate water source on scene so that capabilities of sprinklers are not weakened. If firefighters have to choose between using hose lines and supplying the sprinkler system with water, it's generally best to supply the sprinkler system. These recommendations by the authors are intended to allow both of the structural components of automatic sprinklers and the actions of firefighters to work at an optimum level to mitigate harm from fires.

McGuire, Kevin. 2005. "Great Escape: Developing an Evacuation plan for people with disabilities." ***NFPA Journal*** **(March/April): 55-59.**

According to McGuire, civilians with disabilities are a vulnerable population to structural fires, and evacuation plans must take their physical limitations into consideration. The author examines the possible risk fire poses to the disabled population, as well as factors for incorporating this population into evacuation plans. Nearly 20% of U.S. inhabitants have some form of a disability. Such a fact is exemplified by the Americans with Disabilities Act (ADA) enacted in 1990. This legislation requires new built structures to be accessible to individuals with a disability. Such codes as the: NFPA 101 (*Life Safety*), NFPA 5000 (*Building Construction and Safety Code*), the International Building Code, and the *American National Standard for Accessible and Usable Buildings and Facilities* have come after the ADA to incorporate new legislation in building construction.

Although legislation has been passed to aid those with disabilities, difficulties often arise in fire events. In evacuations, those in wheelchairs are often instructed to wait in a designated area, and rescuers return for these people. This may result in risky situations for the disabled, causing many in the disability community to advocate for safety provisions to be provided to employees, residents, or visitors with disabilities. An example of a risky situation involving the disabled population in a fire occurred at a Maryland mall. In the event of a fire, the only evacuation option for the disabled was an elevator, which individual got trapped in for almost an hour. This example illustrates the potential danger that a lack of evacuation planning has for the disabled population. Subsequently, an individual involved in this situation sued under Title 3 of the ADA and won the case. Such an event demonstrates the importance of having accessible evacuation routes for individuals with disabilities. A sound disability evacuation plan, according to NFPA 101 (Life safety) code must have a system for reporting fire incidents, include staff responsibilities during evacuations, have fire drills, and explain the fire protection system to those who may use it. Several directives are given by McGuire for the development of a disability evacuation plan: learn the building, know who is disabled within the building at all times, have the equipment (such as lightweight evacuating chairs) and visible indications of how to evacuate, train staff on how to use the new plan, and coordinate the plan with emergency response personnel. If these are incorporated in disability evacuation pans, perhaps more lives will be saved and those with disabilities will be cared for in times of need during a fire. McGuire offers a thorough examination of an at risk population to fires that must be considered when developing plans to mitigate exposure to fire risk.

Moore, Wayne. 2006. "Smoke Alarms More Important than Ever: New Requirements in NFPA 72-2007." ***NFPA Journal*** **(November/December)**
http://www.nfpa.org/publicColumn.asp?categoryID=&itemID=30776&src=NFPAJournal&cookie%5Ftest=1
(accessed 11-12-06).

Wayne like Fleming (2003) and Klaene and Sanders (2001) focus on the effectiveness of systems within structures designed to help mitigate exposure to fires. Wayne focuses on the winter months (December, January and February) in the U.S. and how increase rates of home structure fire deaths could me mitigated by use of fire alarm systems. This study uncovers the reality that a significant proportion of residential structure fires occur during the winter months of the year. Nearly 30% of the reported home structure fires and 29% of the home structure fire deaths occurred in December, January, or February with January containing the highest figure of reported home fires and home fire deaths during the winter months. Home heating units are viewed as a causal variable in winter month fires with 49% of reported home heating fires occurring during December, January, or February. Time of day as well as year correlate to an increase in the number of instances of fire death. Home fires were reported mostly around the dinner hour, with the hour between 6 and 7 pm serving as the time in which the highest volume of home fires occurred. Of reported home fires, 21% occurred between 11pm and 7am; however 51% of home fire deaths occurred during these hours. The winter season coupled with late night and early morning hours prove to be a lethal time for civilians and home fire deaths. This is a common finding in U.S. fire science research; the winter months are often associated with high incidents of fire related deaths.

Rohr, Kimberly D. and John Hall Jr. 2005. "U.S. Experience with Sprinklers and other Fire Extinguishing Equipment." ***National Fire Protection Association***.
http://www.nfpa.org/assets/files//PDF/SprinklerSummary.pdf (accessed 7-8-06).

Rohr and Hall Jr., similar to Fleming (2003), assess the influence of automatic sprinklers and other automatic suppression devices on human survival and property loss in structural fires. This analysis is conducted utilizing version 5.0 and version 4.1 of the National Fire Incident reporting System (NFIRS) data on sprinklers. Similar to claims made by Fleming (2003), the authors contend that with version 5.0, more detailed information is able to be captured in coding for automatic extinguishing equipment, enabling a better prediction of estimates of sprinkler reliability. However, it must be noted that version 4.1 data was used nationally up until 1999 when 5.0 began to be implemented. Version 4.1 could not isolate the impact of sprinklers alone on mitigating harm to life and property. Version 4.1 data collection often captured the impact of sprinklers as well as other automatic systems. More generally, a limitation is that NFIRS data only captures those fires reported to a fire department.

Using NFIRS 5.0 (1999-2002) data, it is found that when sprinklers are present, the chances of dying in a fire and the average property loss per fire are both cut by one-half to two-thirds, compared to fires where sprinklers are not present. The ability to mitigate deaths across several property types is assessed by the authors. Examining the average number of civilian deaths per thousand fires (1989-1998) deaths in manufacturing property deaths dropped 60% (2.0 to 0.8 deaths per thousand fires). Store and office fires dropped 74% (1.0 to 0.3 deaths per thousand fires). Health care properties caring for the elderly or ill dropped 75% (4.9 to 1.2 deaths per thousand fires) and hotel and motel fatalities fell 91% (from 9.1 to 0.8 deaths per thousand fires) during this time period examined. The authors also examine the average number of dollars lost in relation to property damage per fire in 1989-1998. Automatic suppression equipment reduced dollar loss across the following property types according to percentage: dollar loss by stores and office fires dropped 53%, manufacturing properties dropped 64%, health care properties caring for the elderly and the ill dropped 64%, and public assembly properties dropped 70% according to this analysis. Automatic suppression systems failed in nearly 7% of structure fires, and 2/3 of these were due to systems being turned off (1999-2002, version 5.0). When used to mitigate fires, automatic extinguishing equipment such as sprinklers can save lives and mitigate property loss. This research benefits from advances of the NFIRS version 5.0 data. However it does raise issues over the reliability of studies on automatic fire suppression conducted using 4.1 data in the discipline of Fire Science.

Stevenson, Mark R. and Andy H. Lee 2003. "Smoke Alarms and Residential Fire mortality in the United States: an ecologic study." ***Fire Safety Journal*** **Vol. 38, No. 1: 43-52.**

Stevenson and Lee use an ecological approach to assess the influence of smoke alarms on mortality of multiple groups in residential fires in the US. Previous literature has found that smoke alarms mitigate the risk of death and injury to residential fires, however there has been little focus on an ecologic association between smoke alarms and residential fire mortality. Using the prevalence of smoke alarms along with many covariates (% of vacant houses per state; % of rental and mobile homes; % of overcrowded homes; % of volunteer firefighters; % of population living in rural areas; education, race, alcohol use; smoking and household income) each state in the US was examined to determine the ecological relationship between smoke alarms and residential fire mortality. The authors found that the prevalence of at least one smoke alarm in a US household was 93.6%. Their analysis revealed that presence of a smoke alarm was significantly negatively associated with residential fire mortality, although this relationship was minimal. The authors conclude this relationship is marginal due to the fact that although many homes have a fire alarm, it is assumed that 1/3 to 1/2 do not function. As well, the authors also uncovered that residential fire mortality rates are heightened in the southeastern states, possibly due to greater proportion of sub-standard housing that place them at greater risk. This ecological approach is a rarely used theoretical framework in Fire Science. It is a sound start to analysis looking at how social systems interact with their environment and how this relates to mortality in residential fires.

Williams, Corrine; Jeremy Fraser-Mitchell; Stuart Campbell and R. Harrosion. 2004. "Effectiveness of Sprinklers in Residential Premises: Section 3: Pilot Study. http://www.bre.co.uk/filelibrary/sprinklers_section3.pdf (accessed 2-15-07).

This study, similar in topic to Fleming (2003) and Rohr and Hall Jr. (2005) focuses on sprinklers and their ability to mitigate loss in residential fires. A literature review on residential sprinklers in the USA, New Zealand, Vancouver, and Scottsdale Arizona found that the USA is the only country to have residential sprinklers in sufficient numbers for direct statistical estimates to be made. In the United States as a whole, between 1988 and 1997 there were 466,000 fires per year in residential properties with 347,600 fires occurring in one or two family homes and 105,500 occurring in apartments. In the USA from 1988 to 1997, sprinklers extinguished 1,600 out of 466,000 residential fires and 300 out of a total of 347,600 fires in one or two family homes. Sprinklers extinguished 1,000 out of a total of 105,500 fires in apartments. These low numbers are the result of a low proportion of residential properties being fitted with sprinklers, rather than the ineffectiveness of sprinklers themselves.

As of July 5, 1985, all new multi-family and commercial structures in Scottsdale were required to have sprinklers. All new single-family homes were required to do so as of January 1, 1986. The study of the impact of sprinklers in Scottsdale clamed a 95.8% reduction in the number of deaths in structures upgrading from nothing to sprinklers plus alarms, compared to a 50% reduction when upgrading to smoke alarms only. Over 10 years, automatic sprinkler systems have had a role in saving 8 lives and there has not been a fire related death in sprinkler property. Potential fire loss was dramatically reduced due to sprinklers. This piece raises questions as to the social and cultural factors that influenced the fitting of properties with sprinkler systems, and how capital influences the addition of this safety measure to residences.

Wolf, Alisa. 1997a. "Getting Out." ***NFPA Journal*** **(September/October): 68-74.**

Board and care facilities are a concern for the potential lethality they may pose to individuals if they catch fire. Wolf examines this type of structure, the threat it poses, as well as factors that may limit exposure to harm for those who reside in such facilities. Board and care facilities are establishments that provide personal and not medical care to residents. These often may be converted residential homes. Board and care is a wide ranging category, encompassing boarding houses without nursing care. Although it may be difficult to define board-and-care facilities, there are similarities among fires in such structures, such as flames generated due to "smoking materials," the absence of automatic sprinklers, a lack of automatic closing doors, few exits, lack of proper evacuation, and not having "protected and separated" exit routes.

Fires in a board and care facility are an increasing concern for the National Fire Protection Administration (NFPA). Wolf offers an example of the danger such a structure holds. In one board and care fire in Pennsylvania in 1997 an attendant at a care facility had silenced a fire alarm one night, assuming it was a false. However a real fire existed, an evacuation was called for, and nine people died from the fire – six of which failed to evacuate. The building suffered extreme fire damage (including a collapsed roof) from what began as a lit cigarette on the front porch with property loss totaling around $270,000. An issue of contention in this event was the use of the *Life Safety Code* in labeling residents of such establishments. The Pennsylvania Division of Personal Care Homes uses terms of either "mobile" or "immobile" to describe residents. In the above incident residents were classified as being "mobile." If the *Life Safety Code* was implemented, which uses "prompt, slow and impractical" labels, they would have been considered slow. The labeling involved in this process may have impacted the level of assistance provided to them during evacuation. The code is considered by many specialists to be a great way to reduce fatalities if followed. Wolf offers some suggestions on mitigating harm in board and care fires, such as automatic sprinklers which may decrease harm in such fires. However, with many of these suggestions, funding is an obstacle. Low interest loans, grants, or state help are possible options to help these facilities pay costs. Training evacuees on fire mitigation may help, especially in such facilities as board and care where residents are elderly or disabled. Training may combat a common factor of board and care facilities such as a lack of resources that many face. According to Wolf, a hard to mitigate factor of board and care facilities is a lack of compliance with standards of care, forcing many to operate illegally. This factor may impede the level of care, as well as structural and social factors that may mitigate harm to fire.

Civilian Death and Injury

Angus, Derek; Ernesto A. Pretto; Joel I. Abrams; Norma Ceciliano; Yukihoro Watoh; Bulent Kirimli; Agah Vertug; Louise Comfort. 1997. "Epidemiologic Assessment of mortality, building collapse pattern, and medical response after the 1992 earthquake in Turkey." ***Prehospital and Disaster Medicine*** **Vol. 12, No. 3: 49-58.**

The article conducts a case study of the 1992 earthquake in Turkey, and focuses on how the existence of human made structures led to the greatest number of injuries and deaths due to collapse during this event. This study looks at the impact of this earthquake in terms of mortality, building collapse patterns, and medical responses. The survey used in the study gathered information on location, injuries, initial actions and prior training of survivors and responders, and the management of dead and dying victims. With this, a case-control design was made to assess the relationship between injury, mortality, location, and building collapse patterns. Results found extensive structural damage throughout the region. The majority of those who died were inside a structure during the quake. Unreinforced masonry, "soft" designs, and one-story adobe structures suffered the most damage, with the most extensive damage occurring in both rural and urban areas. Most of the individuals who were killed died a slow death while trapped. Due to this discovery, the idea that "rescue efforts in major earthquakes…may improve survival" is supported. However, the 24 hour golden rule, namely the greatest window of opportunity for rescue immediately after an event where structural collapse occurs still applies. This piece reaffirms the importance of time in search and rescue activities, and how cultural influences on structures built can create vulnerabilities to hazards.

Comeau, Ed. 2003. "Campus Fire Safety" Chapter 7, Section 5 in NFPA Fire Protection Handbook. 19th Edition.
http://www.nfpa.org/assets/files/PDF/Research/FPHcampusfiresafety.pdf (accessed 7-8-06).

Comeau addresses the risk of fires associated with both on and off campus residential occupancies at colleges and universities and provides strategies for minimizing this threat. Due to the large volume of students potentially exposed to fires in residential halls, universities have taken control to improve the level of fire safety in these buildings as opposed to off campus residences where these institutions have little authority. On campus safety measures include: regulating the combustibility of contents such as furniture, walls, and floor finish; regulating the use of applications such as microwaves and refrigerators; and regulating the use of candles incense and smoking. Off campus fires, such as in Greek houses tend to pose problems with 23 fraternity fires occurring between 1990 and 2000 nationally in the US. Because of the number of recognized problems in Greek houses, a number of communities have passed ordinances and laws requiring these houses to be equipped with automatic fire sprinklers. Because regulations are not as strongly enforced in off campus housing (resulting in highly combustible furniture, appliance use, smoking, candles and nonfunctioning fire detectors) off campus housing poses many risks to college students.

The NFPA provides the latest data for campus residential fires in the report: *School, College, and University Dormitories and Fraternity and Sorority House Fires in the United States 1994-1998* and finds that from 1994-1998 there was an average of 1570 structural fires in dormitories, sorority and fraternity houses causing an estimated 9.1 million dollars a year in direct damages. Three in every five property fires are the result of a combination of incendiary and suspicious causes, cooking, and smoking.

Preventative techniques used to create a fire free environment include evaluating and inspecting students living spaces, making sure there are sufficient exits that are properly illuminated, reducing fuel load, reducing ignition sources (such as smoking, candles, and electrical fires) and making sure smoke detectors are properly installed and working. The piece also recommends that the universities work closely with municipal fire departments in all areas of fire protection. The chapter suggests that education and training courses be conducted for all students, faculty, and staff at universities. Although this study provides insight into a rarely examined population that is at risk of fire related deaths or injuries, a focus on the influence of fire risk on regional (geographic) and social demographics would also aid in additional fire analysis.

Cook County Commission "Report of the Cook County Commission Investigating the 69 West Washington Building Fire of October 17, 2003."
http://www.co.cook.il.us/Fire_Commission/Master%20Reports/07.07.04%20County%20Report%20Final.pdf
(accessed 10-15-06).

This report analyzes death and injuries that resulted from a Chicago high rise building fire on October 17, 2003. Smoke inhalation in this fire caused six civilian deaths and additional injuries to others. An independent commission studying the incident found that the opening of a stairwell door on the 12th floor compromised the stairwell. Eighty minutes later firefighters found victims in the 14th floor stairwell. The commission concluded that the six deaths and the serious injuries would not have occurred if the building had been equipped with fire sprinklers, and/ or had the stairwell doors automatically locked in the event of a fire. The actions and inactions of the Chicago Fire Department were found by the commission to contribute to the deaths and serious injuries that occurred that day. Because very little research or descriptive analysis has been composed on how search and rescue tactics of emergency responders impact injury and death of potential victims, this is an important piece. Further analysis in this area is warranted.

Duncanson Mavis, Alistair Woodward, and Papaarangi Reid.
2002. "Socioeconomic deprivation and fatal unintentional domestic fire incidents in New Zealand 1993-1998." ***Fire Safety Journal*** **Vol. 37, No. 2: 165-179.**

This article uses a cross sectional study to investigate the relationship between socioeconomic deprivation and risk to an unintentional fatal domestic fire incidents in Aortearoa, New Zealand. The article reviews previous literature on fire related mortality and reiterates previous studies have found mortality rates to be at their highest for adults over the age of 65 and children under the age of five (these findings are similar to those in Hall Jr. 2005a). Previous international literature on the topic also concludes socially and materially deprived households are most likely to experience the highest rates of fatal fire incidents. Fire service data from 1995-1997 in New Zealand finds that fire deaths are most likely to occur in rental homes, and in the cheapest houses in the lowest value parts of town.

This study obtains New Zealand fire mortality data from the New Zealand Fire Service Fire Information Recording System (FIRS) for the period of July 1993 to June 1998. This data set contained only fatal fires and omitted incidents resulting in non-fatal injuries. Findings show that, consistent with other studies, there is an increased risk of fire fatalities in socio-economically deprived populations. There is an increased risk of fire in homes where the percentage of persons in the home over 25 had less than 8 years of schooling, there was more than one person in the room, and the percentage of people in the household were below the poverty level. A decreased fire risk occurred in homes where the proportion of houses were owner-occupied, households had an income above $15,000, children under 18 lived with both parents, and adults over 25 had at least a high school education. This study confirms previous findings that socio-economic status is an important factor impacting one's exposure to fire hazards.

Hall Jr., John and Beatrice Harwood. 1995. "Smoke or Burns – Which is Deadlier?" ***NFPA Journal*** **(January/February): 41-43.**

This article revisits a 1989 study previously conducted to analyze the role burns and smoke inhalation play in causing fire deaths in the United States. The classic study of smoke inhalation vs. burns was conducted by Berl and Halpin in 1978. That study analyzed fire deaths occurring in Maryland from 1972 through 1977, and found that approximately half of the victims studied had carboxyhemoglobin levels of at least 50 percent, enough to cause death. Another one-fourth of victims had carboxyhemoglobin levels of 30 to 50 percent, which, when combined with other conditions, would have caused death. Therefore, this study estimated that smoke inhalation accounted for three-fourths of all fire deaths. This approach assumed that carbon monoxide poisoning was the most likely cause of death and that any other causes would be considered only after the possibility of carbon monoxide poisoning had proven insufficient to explain death.

There are two valid national fire fatality tracking methods that use annually updated data and are coded so as to permit analyses of smoke inhalation and burns. One is derived from the combination of two fire incident reporting systems based on fire department reports, as compiled by the U.S. Fire Administration and the NFPA. The other is the national death certificate database, which is collected by the National Center for Health Statistics from state and local authorities. The fire incident database reflects the assessment of fire officers, which are typically made at the scene of a fire. In this database, nearly three-fourths of fire deaths in a typical year are coded as having been caused by an unknown combination of burns and smoke inhalation. Of those deaths attributed to only one or the other cause of death, analysis collected from 1981 through 1985 showed that smoke inhalation alone was sited four times as often as burns alone. Data collected from 1985 through 1989 shows that the ratio has declined from three and a half to one.

The death certificate database show that from 1979 to 1990, total fire deaths measured by death certificates declined by 30 percent. Fire death caused by burns declined by 50 percent, and fire death caused by smoke inhalation declined by 15 percent. In addition to these numbers, it was found that total fire deaths measured by the NFPA declined by 31 percent, total reported fires declined by 29 percent, and reported structure fires declined by 40 percent. The authors conclude that the chances of actually experiencing a reported structure fire have been declining rapidly, but the chances of dying if you have a reported structure fire have been rising.

The question of why has there been such a difference in the trends in burn and smoke inhalation deaths is posed. Several possibilities are suggested. First, changes in the composition of furnishings, finishes, and other materials in buildings may generate smoke more rapidly or produce smoke that is more toxic than was true in past decades, leading more quickly to incapacitation and fatalities if a large fire occurs, even as the probability of having a large fire has declined. Second, changes in product design and in the public's knowledge of, and behavior toward, fire hazards may have shifted in ways that affect the kinds of fires that lead to burn deaths more than the kinds of fires that lead to smoke inhalation deaths. Third, advances in the treatment of fire victims may have changed what would have been fatality victims into injury victims. Those advances may have benefited burn patients more, producing a larger increase in the percentage of badly burned victims who survive than the percentage of those suffering from serious smoke inhalations who survive fires.

The current study by Hall Jr. and Hardwood finds that the share of U.S. fire deaths due to smoke inhalation continues to climb, even as the total number of fire deaths, and the number of smoke inhalation fire deaths in particular, continues to decline. The article concludes by stating that smoke inhalation is the leading cause of fire deaths, exceeding burn deaths by roughly seven to three as of 1990 and probably three to one by now, given that the smoke inhalation share has been steadily increasing more than one percentage point per year, since 1979. It is becoming clear that any future reduction in the total number of fire deaths will have to come from a reduction in those deaths caused by smoke inhalation. Strategies to prevent smoke inhalation fire deaths could include product design changes that would make ignition even less likely or make fire growth slower should ignition occur. Additional compartmenting, such as more doors between more rooms in homes, would be another approach.

Hall Jr., John R. 2005a. "Characteristics of Home Fire

Victims."- *National Fire Protection Association*.
http://www.nfpa.org/assets/files/PDF/CharacteristicsOfHomeSummary.pdf#search=%22Characteristics%20of%20Home%20Fire%20Victims%22 (accessed 8-12-06)

Social demographic characteristics impact our experiences in the social world and this NFPA report reveals their influence in the context of residence fires. This piece reviews the relationship of social demographic characteristics to fatalities and injuries of civilians in home fires. According to age, children under five are twice as likely to die in home fires compared to the average population. Adults over the age of 65 are more than twice the average population to die in home fires. Although the percentages for children deaths have been declining in recent years, percentages of elderly deaths continue to increase. One suggestion as to why child deaths are decreasing are the CPSC (US Consumer Product Safety Commission) requirements for childproof locks on lighters instituted in 1994. Across gender, males have an increased risk of fire related deaths. American men have a 38% higher risk of home fire deaths and an 18% higher risk of home fire injury than women. Men are usually trying to control the fire when they are injured, while women are more likely to be injured while trying to escape. Smoke inhalation (toxic gasses and/or oxygen deprivation) deaths are twice as likely in home fires as deaths from burns. In terms of proximity, the closer the victim was to the actual fire, the more likely their fatal injury was related to burns. The disabled also have an increased fire risk with 28% of fatal home fire victims having some type of disability or age-related limitation. The study also found that two out of every five fatal fire victims never wake up before being hurt. This research, although informative, may be enhanced by looking at ethnicity and cultural variations on how people use space in the home and how this may relate to injury and mortality.

Hasofar, A.M and I. Thomas 2006 "Analysis of fatalities and injuries in building fire statistics." *Fire Safety Journal* Vol. 41, No. 1: 2-14

This paper assesses those characteristics of fires and personal traits of victims which influence risk of human civilian causalities. Through the use of general linear models coupled with analysis of deviance, the authors examine 1993 National Fire Incident Reporting System (NFIRS) data to attain those factors that produce greater risk for mortality in apartment fires. This paper measures danger to occupants as: the number of causalities (injuries and fatalities) per fire; proportion of fatalities among causalities; proportion of fires with causalities; and number of fatalities per fire. The fire factors impacting the number of casualties and the proportion of casualties are: the extent of fire damage; the area of fire origin; the material ignited as well as the ignition factor. The areas of fire origination considered the most serious to fatalities were found to be: lounge areas; sleeping rooms and kitchens. The materials considered most lethal were fabric and flammable liquids. Children playing with cigarettes and fire were found to be the most dangerous ignition factors in this study. In assessing absolute number of fatalities, the form of material ignited and the form of heat ignition were highly influential characteristics of fires. Such items as sofas, chairs, and bedding were found to be the most dangerous forms of material ignited, while electrical equipment, matches, lighters, and cigarettes were considered the most dangerous forms of heat ignition. Assessing those personal factors contributing to a high proportion of casualties that lead to fatalities were: the condition preventing escape (burning clothes, incapacitation, fire between the causality and exit and no time to escape); the condition before injury (bedridden, too old, drugs and alcohol and asleep); the activity at time of injury (unable to act, sleeping, escaping and irrational behavior); the location at ignition (involved with ignition, in room of fire origin, in building of fire origin and floor of fire origin); and the cause of injury (exposure to fire products such as flame, smoke, gas and heat). There are a great variety of physical and social factors uncovered that relate to fatalities of civilians, providing information on causal factors that possibly could be analyzed in future research. This is one of the few complex assessments of human and structural factors impacting causalities in fires. However replication is warranted in light of the fact that NFIRS version 5.0, begun use in 1999, provides for more detail in fire events. Perhaps new analysis may reveal different outcomes using a more detailed data set.

Holborn, P.G.; P.F. Nolan and J. Golt 2003. "An analysis of fatal unintentional dwelling fires investigated by London Fire Brigade between 1996 and 2000." ***Fire Safety Journal*** **Vol. 38, No. 1: 1-42.**

This study utilizes data from the London Fire Brigade Real Fire Library (a database collected from actual fire incidents) to examine risk factors for civilian mortality in unintentional dwelling fires. The causes of unintentional dwelling fires, in order of prevalence were found to be: careless disposal of cigarette, cigar, tobacco or matches; careless action associated with a cigarette; misuse of cooking appliance; placing an object near a heating source or an individual getting too close to a heating source. Seasonal variation played a role in fire ignition; fires caused by smoking and cooking materials were highest in winter months, similar to US findings (Moore 2006). Times of the day in which fire ignition occurred were spread throughout the day, with the hours between 9am and noon having the lowest rate of occurrence. In examining materials igniting fires, bedding (pillows, blankets, etc) were most often ignited in a dwelling, followed by upholstered furniture. This data reveals a strong correlation between fatal fires started by smoking materials (cigars, cigarettes or tobacco) and areas where they originate (bedding and upholstered furniture). The majority of deaths in this of study (1996-2000) involved single deaths in a dwelling. Of these fatalities, those aged 60 older accounted for 57%, while fewer deaths occurred amongst those under the age of 20 (9%). Those aged 60 or older were 3 times more likely to die in a winter month (November-February) than in a summer month (June –August). Alcohol is a factor in mortality, with most deaths related to this substance occurring between 9pm and 3am. At least one fifth of fire fatalities had some form of physical disability, the majority of which were 60 or older. The leading cause of death is often described as smoke inhalation, representing 42% of deaths, followed by burns (19%), while 25% of all fatalities were due to both smoke inhalation and burns. Having a working smoke alarm was correlated with lowered risk to fatalities. In examining the room of origination, a nearly 33% started in the living room, while 29% started in the bedroom and 20% started in the kitchen. In examining types of building structures, close to 50% of fatalities occurred in apartments, 13% in converted flats, 22% in terraced houses with 13% in semi-attached houses. Similar to Duncanson, Woodward, and Reid's study of fire risk in New Zealand (2002), greater fatalities occurred in London areas that experienced higher levels of social deprivation as assessed by unemployment, low income, health, education, crime and housing,.

Karter Jr., Michael. 2001. "2000 United States Fire Loss Report." ***NFPA Journal*** **(September/October): 81-87.**

By examining factors surrounding civilian death and injuries as well as firefighter death and injuries, Kater Jr. offers a thorough summary of loss attributed to fires in the US for 2000. Although the number of fires is decreasing, civilian mortality rates are increasing in the US. Analyzing NFPA data revealed nearly 30% of all fires occurred in structures and 75% of these fires were residential. The total of civilian deaths has increased about 13% from 1999 to 2000. Most of these deaths were in residential properties (3,445 people). The number of civilians injured by fire in 2000 reached 22,350, which was an increase of 2.2% since 1999. It is noted by Karter Jr. that underreporting in civilian injuries is likely due to the reality of some fires not requiring fire service to extinguish them and injuries may still occur. A large portion of civilian injuries are from residential fires (almost 78%). Of firefighters, 102 died in the line of duty in 2000 (almost a 9% decrease from 1999). Structural fires in 2000 caused an approximate $11.2 billion dollars in property damage (almost 12% more than 1999). Regional comparisons of fire losses are made with the south having the highest death rate at 17.7 deaths per million. Geographically, the northeast has the highest injury rate at 111.7 injuries per million populations. Safety education is suggested on how to prevent fires from starting and how to reduce injury or deaths when they do occur.

Karter, Jr., Michael J. 2006 "Fire Loss in the United States During 2005: Full Report." Fire Analysis and Research Division: ***National Fire Protection Association***
http://www.nfpa.org/assets/files/PDF/OS.fireloss.pdf (accessed 8-14-06).

Karter Jr. offers analysis of the occurrence and impact of fires on civilians and firefighter populations with this piece. According to this report, U.S fire departments responded to an estimated 1,602,000 fires in 2005 resulting in 3,675 civilian fire fatalities, 17,925 civilian fire injuries and an estimated $10,672,000,000 in direct property loss. Home fires caused 3,030 or 82% of civilian fire deaths. Of the residential fires, 56.2% occurred in one and two family dwellings and 18.4% occurred in apartments. Intentionally set fires resulted in 315 civilian deaths.

Fire losses were studied by region and community size. Civilian fire death rates by size of community were examined for the 2001-2005 period with the smallest communities (with a population under 2,500) having the highest rate of death at more than twice the national average rate. Civilian deaths for 2005 were measured nationwide and by region. In 2005, there were 12.4 civilian deaths per million populations nationwide. The Northcentral region of the US had the most civilian deaths with 15.5 deaths per million populations, followed by the South with 13.8 deaths per million populations. The Northeast had 13.0 deaths per million populations, which was slightly over the national average and the West had the least civilian deaths with 6.8 deaths per million populations.

At the community level, civilian fire deaths per million were also assessed by region and community in 2005. The Northeast had the highest rates of civilian fire deaths for communities of 500,000 or more with and for the smallest communities with populations of less than 2,500. The Northcentral had the highest rates of civilian fire deaths for communities of 250,000 to 499,999 and for communities of 10,000 to 24,999. The South had the highest rates for civilian fire deaths for communities of 50,000 to 249,999 and for communities of 2,500 to 9,999. These figures reveal the diverse rates of civilian fatalities that occur within the US when comparing regions. These regional, community and population variations in loss to fire reveal diverse experiences in the US. Further analyses on how such variation relates to fire capabilities in these regions is warranted.

Latane, Bibb and John Darley. 1968. "Group Inhibition of Bystander Intervention In Emergencies." ***Journal of Personality and Social Psychology*** **Vol. 10, No.3: 215-221.**

This article explores situational factors which influence a person's decision to intervene in an emergency situation. The authors elucidate how when other people are (or are perceived to be) in the same situation as an individual, intervention decreases. The lack of accountability when an incident occurs is one of the suspected reasons for this occurrence. Isolation was purposely used in the Latané and Darley study to address this diffusion of responsibility, although other factors are acknowledged for different situations. Isolation was created for subjects, so when hearing a person having an epileptic attack, could not effectively communicate with one another. However, the authors hypothesize that even when participants can meet and interact; they will go against the norm of helping and may be less effective in assisting someone in need of emergency care. This occurs in the following way: there is an "ambiguous event," such as seeing smoke or a perceived medical problem, and a witness to the event must interpret whether or not the situation warrants action. This individual's perception of the seriousness of the problem is strongly affected by others' action, inaction, and body language when witnessing the same event. A key aspect of this is not only that a person is watching for others' reactions; but that the person also feels he/she is being evaluated as well. The attempt to remain calm to avoid embarrassment gives the false impression of calmness and composure, which can then affect others' reactions.

This study by Latane and Darley consisted of male students being told they were being interviewed about campus life. As they waited alone in a room, smoke began to fill the room for up to six minutes (or until the participant reported the smoke). This was conducted with a student (alone), a three-person group (2 of which were part of the experiment and acted as naïve subjects), and a group of three subjects, and the dependant variable measured was time. Alone, the median for participants reported smoke within 2 minutes (75% reported smoke); with the two naive subjects, only one out of ten reported it at all; and only 38% of the groups composed of subjects reported at all (with only one person doing so within 4 minutes).

The point at which participants first realized there was smoke in the room was also analyzed, and it was found that when alone, it took about 5 seconds, and when in a group, about 20 seconds. Goffman's work (1963) is considered when hypothesizing that when alone people feel more comfortable gazing around the room than when others are present. Subjects later told the "interviewers" about the smoke, with strange considerations of what it could be (smog, vapors, a "truth gas" to force honesty, etc) but did not mention fire. Most subjects also claimed other individuals in the room had no affect on their decision to not report the smoke. Three main actions are concluded as necesS&Ry for intervention in an emergency situation: recognizing there is a problem, perceiving it as an emergency, and taking action. While several possibilities are given for the inaction taken in their experiment, it was found that others in the room (and especially the passive naïve subjects) decreased reporting the incident. This is an early assessment on collective meaning making in a simulated emergency context. In relation to current study on fires and structures, this is a rare if not highly unlikely empirical approach to examining behaviors in emergency situations.

McCarthy, Robert. 2000. "1999 Catastrophic Multiple Death Fires." *NFPA Journal* (September/October): 52-64.

Catastrophic fires, defined as those fires causing five or more deaths in a residential property and three or more in a non residential structure are examined by McCarthy in the US in 1999. This article analyzes 44 catastrophic multiple death fires that lead to 214 deaths in 1999. Specific incidents from Iowa, Minnesota, Michigan, Illinois, Maryland, New York, Louisiana, Massachusetts, Kentucky, North Carolina, Alabama, Wisconsin, Tennessee, Texas, Pennsylvania, California, Virginia, South Carolina, Arkansas, Georgia, Nevada, Utah, and Washington are briefly explained. Of these fires 21 were in residential occupancies (17 in single family homes and 4 in apartment buildings), killing a total of 112 people and 3 firefighters. Major causes of the fires examined included heating equipment, especially electrical equipment, heaters, and cooking equipment.

Catastrophic nonresidential deaths (nonresidential fires that caused 3 or more deaths) are also examined with 16 fires killing a total of 63 people. Seven catastrophic fires occurred outside of structures and killed 36 people. In many of the catastrophic home fires smoke detectors were not present. Many of these residential catastrophic fires could have been prevented if certain guidelines had been followed. Fire prevention techniques and the safe use of appliances in the home are keys to reducing catastrophic fires. The best way to prevent fires is to practice good fire prevention; including using extension cords safely, being present when candles are used or something is cooking, and keeping combustibles away from heating sources. The most important things in the home are smoke alarms, sprinklers, and a backup evacuation plan. This analysis offers good insight into causes and context of these types of events in 1999.

National Fire Protection Association. 1996. "Burning Issues." *NFPA Journal* (January/February): 104.

This article focuses on poverty and fire risk using previous studies to show that poor households have the greatest risk of fire deaths in the US. A contributing factor to this claim is the existence of security bars in poor homes. While these bars stop intruders from entering homes, they also prevent an easy evacuation in the case of fire. Between 1986 and 1991, on average of 16 deaths per year from fire were due to the presence of security bars in homes. Not having a smoke detector or having a broken detector decreased the chance of survival (60% of fire deaths occur in the 7% of homes that do not have detectors). Having a detector decreases the risk of death by 40-50%. Other factors revealed in mentioned studies include lack of education, leaving children unattended, not having enough money to pay utilities (so space heaters, candles, or open oven doors are used instead), lack of communication (such as not being able to afford a phone), and living in an area of high crime (arson plays a large role in these areas) as contributing to increased exposure to fire risk for poor families in the US. This examination of US studies on poverty and its relation to increased risk for loss in fires reflects findings found in international studies such as Duncanson, Woodward and Reid's 2002 study conducted in New Zealand. Social stratification appears to play a role in vulnerability of poor and racial and ethnic minority populations to the risk of fires. Further comparative research across the U.S could reveal common themes within these at risk populations that could possibly be ameliorated to reduce risk.

Petraglia, John S. 1991. "Fire and the Aging of America."
***NFPA Journal* (March/April): 37-46.**

This article by Petraglia focuses on the causes for increased risk to fatalities in fires for elderly populations in the US, as well as proposed safety tips to mitigate this threat. Individuals over age 65 are one of the groups (along with pre-school children and the poor) at highest at risk to fire fatalities in the US. The problem is expected to grow as life expectancy increases. One of the major reasons the fatality rate of the elderly is so high is that nearly one-fifth of elderly victims are bedridden or have a type of physical handicap which makes it difficult for them to escape from a fire. Also, the elderly have reduced sensory functions that may delay the ability to recognize a threat and evacuate. The inability to hear fire alarms or smell smoke only further exacerbates the situation, as does not being able to crouch low to avoid smoke and medical problems that are quickly worsened by smoke. Fires caused by smoking are the leading killer of elderly victims followed by fires that begin with heating equipment and those that start during cooking. Portable heaters, which are used increasingly due to rising energy costs, also lead to many deaths of the elderly

The article provides a list of fire safety tips for older adults: the use of safe smoking habits (primarily not smoking in bed), proper cooking behaviors, taking care when heating the home, being careful with electrical equipment, as well as other precautions to keep safe from fire such as installing smoke alarms and placing a whistle and telephone by the bed. Guides for the elderly on what to do and how to prepare for fires are available from FEMA, the National Safety Council, the US Consumer Protection Commission, and other agencies and fire departments.

One program touted by Petraglia that focuses on the growing accessibility needs of disabled Americans is an adaptable firesafe demonstration house. This adaptable firesafe demonstration house has a number of enhanced features that are specially tailored towards elder adults and the disabled including a pull-out ironing board at wheelchair height, hardwired smoke detectors and strobe lights that flash to alert the hearing impaired, an overhead fan or bed-vibrating mechanism that can be plugged into a special outlet to alert the blind to a fire, and automatic sprinklers. The article concludes with the suggestion that our society has already started enhancing safety features for the elderly and is in a good position to further such efforts. The vulnerability of the elderly appears to be a growing concern as our national population ages and continues to live longer. These proposed safety tips and advances in fire safety measures offer suggestions on how to help this at risk population.

U.S. Department of Homeland Security. 2002a. "Fatal Fires."

U.S. Fire Administration National Fire Data Center *Topical Fire Research Series,* Vol. 2, No. 20: 1-4 http://www.usfa.dhs.gov/downloads/pdf/tfrs/v2i20.pdf (accessed 7-28-06).

This report summarizes some of the major characteristics of fatalities in residential structure fires such as incidence, causes and gender and age variation of civilian victims in the US. Findings show each year an estimated 3,600 fatal fires cause 4,300 fatalities among civilians in the US. Single death fatalities accounted for 83% of civilian deaths while multiple fatalities accounted for 17% of those who died. The majority of fatal fires (78%) occurred in structures, with a significant proportion (94%) in residential properties. The leading causes of fires generating a single fatality was smoking (24%) followed closely by arson (20%). It was found that fatal fires more often occurred in winter. Although smoke alarms are purported to be in 90% of residential structures, in 77% of fatal no-residential fires and 55% of fatal residential fires they were absent at the time of fire. The report profiled fatalities and found that males were killed more frequently in fires and children up to 9 years old accounted for 16% of fire fatalities. Older population (65 and older) is the population who suffer the greatest fatalities (nearly 25%). Of the behaviors engaged by victims, 47% were asleep while 27% were awake and unimpaired. This report reflects many of the common factors such as time of year (winter), age (the very young and elderly) and causes (i.e. smoking, arson) that are related to the occurrence of structure fire fatalities.

U.S. Department of Homeland Security. 2004a. "Fire Risk."
U.S. Fire Administration/National Fire Data Center *Topical Fire Research Series*, Vol. 4, No. 7: 1-6
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v4i7.pdf
(accessed 7-6-06)

This piece looks at how geography, age, race and socio-economic status influence exposure to the risk of fire. Fire risk, which is defined as "the potential for injury or death of a person or damage or loss to property," is the basis of this study. Demographic and socio-economic data is examined to determine variations in risk. Across race, those with a greater risk of death or injury from fire are African Americans, American Indians and males. These assessments of deaths/injuries were composed with per capita rates, which (or a "common population size") to account for population differences (varied rates of aging and death).

In terms of age, mental and physical abilities are important factors for risk and fire fatalities. The general population's "relative risk" of dying in a fire is around .3. Children age 4 and under have a 1.2 relative risk, and age 80-84 is a 3.3 risk. The highest category is age 85+, with a 4.6 relative risk. With an expected increase of elderly (from 12.5% to 20% within a few decades – cited from US Census), there is an assumption that both fatalities and injuries will increase in this category. When considering fire injuries, the general population has a relative risk of .8. Ages 5-9 have the highest risk for children (1.0) and the highest rate (1.4) is shared by both age categories 20-24 and 30-34.

Other significant risk factors mentioned are SES (with the poor at a disproportionate risk), and geographic location (with the South having greater risk), both of which are partly due to the method of heating used in a residence. In addition, males are 1.6 times more likely to be killed in a fire than women and at least 1.5 times more

likely to be injured. Male behavior is a fire situation is a speculated reason. African Americans and American Indians have a higher risk of a fire fatality, and are 50% and 30% more likely, respectively. This study reveals how age, race, gender, socio-economic status and region are important social and geographical factors related to fire fatality and injury in the US.

U.S. Department of Homeland Security. 2005a. "Fatal Fires." US Fire Administration National Fire Data Center *Topical Fire Research Series* Vol. 5, No. 1: 1-7 http://www.usfa.dhs.gov/downloads/pdf/tfrs/v5i1.pdf (accessed 8-9-06)

This piece examines the incidence, building type, outcomes, mitigation and behavioral factors associated with fires for civilians that prove fatal for 2002. In 2002, there were nearly 1.7 million fires reported causing 3,380 civilian deaths. Most cases (86%) of fatal fires only involved one death. In general, fatal fires caused more damage and dollar loss than non-fatal fires. The dollar losses associated with these fatal fires in 2002 was eight times higher than dollar losses from all other fires. Similarly fatal fires also tend to cause injuries, 32 times greater than nonfatal fire rates. Fatal fires generally occurred inside residential buildings (69%) accounting for the majority (74%) of fatalities. Outdoor fires accounted for 3.1% of fatal fires. The leading causes of single death fatal fires in 2002 were: arson (27%) and careless smoking (18%). Where there were multiple deaths in the fire, the cause was more likely to be heating (26%). Fatal residential fires usually started in sleeping (29%) or lounge areas (21%). Fatal fires also follow a season trend with there being more fatal fires in winter months. Time of the day is correlated to fire fatalities, with the hours between 1 a.m. and 4 a.m. as being most lethal. Although fire alarms are reportedly installed in more than 90% of residences today, there were no smoke alarms in 42% of residential fatal fires. Therefore smoke alarms were present in 58% of fatal fires. However, alarms did not operate in 37% of those fires. Victims tended to be male (65%) and older than 65 years old (23%). Most people died because they were asleep (35%) during the fire or they died while trying to escape the building (25%). Human factors that contributed to fatalities included physical disability and alcohol/substance abuse impairment. It was revealed that 63% of the victims were actually involved in the starting of the fire. This source provides valuable information on causes, trends, and how mechanisms designed to mitigate fires relate to civilian fatalities.

U. S. Department of Homeland Security. 2005b. "Residential Fires and Child Casualties." U.S. Fire Administration National Fire Data Center *Topical Fire Research Series*, Vol. 5, No. 2: 1-6 http://www.usfa.dhs.gov/downloads/pdf/tfrs/v5i2.pdf#search=%22Residential%20Fires%20and%20Child%20Casualties%22 (accessed 7-18-06)

Many previous studies on civilian fatalities in fires have revealed residential structures as the context in which many perish. This study focuses on children and fire fatalities in this type of structure for 2002. Approximately 2,500 children age 14 or younger were killed or injured in residential fires in 2002. Of these fires, a little more than half (56%) consisted of children age 5 or younger. Arson (30%), open flame (28%), and heating (17%) were the leading causes of the fire fatalities for children. Of children killed in fires, the majority of fatalities occurred while the children were asleep (55%) with an additional 26% occurring while the child was trying to escape the fire. Trying to escape the fire (35%) was the leading cause of injuries. Nearly 27% of children were injured while they were asleep and 16% were injured trying to control the fire themselves. Upholstered furniture, bedding, cooking materials, and mattresses were the items first ignited in the fatal child fires. Also, similar to the peak for all fatalities in fires, the majority of children fatalities occurred during winter months. Children are one of many populations (along with the elderly) who are susceptible to fire fatalities in the US. More analytical research is warranted to see how social class, race/ethnicity and gender may influence these findings in the US.

U. S. Department of Homeland Security. 2005c. "Residential Fires and Older Adult Casualties." U.S. Fire Administration National Fire Data Center *Topical Fire Research Series*, Vol 5. No. 3: 1-5
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v5i3.pdf#search=%22Residential%20Fires%20and%20Older%20Adult%20Casualties%22 (accessed 8-2-06).

Many previous studies on civilian fatalities in fires have revealed residential structures as the context in which many perish. This study focuses on older adult fire fatalities s specifically in this type of structure for 2002. According to this report older adults (age 65 and over) are more likely to experience fatal injuries in fires compared to the population under 65 years of age. In 2002, approximately 2,320 older adults suffered injuries or fatalities in fires; 720 as deaths and 1,600 as injuries occurring in residential fires. The article speculates that as our elderly population continues to grow, these statistics will continue to rise. The leading cause of elderly fire fatalities were started through careless smoking (25%) with most injuries started by cooking (29%). The behavior engaged in by elderly fatalities to fire was being asleep (39%), followed by attempting to escape (32%) the fire. Older adults that were injured were most often trying to escape the fire (32%) or tried to control the fire (28%). Upholstered furniture, bedding, and clothing accounted for 40% of the first items ignited in fatal older adult fires with the peak for these fires occurring in the winter months. This article reveals the great exposure to fire death and injury that the elderly population faces.

U. S. Department of Homeland Security. 2005d. "Residential Smoking Fires and Casualties." U.S. Fire Administration National Fire Data Center *Topical Fire Research Series*, Vol. 5, No. 5: 1-7
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v5i5.pdf#search=%22Residential%20Smoking%20Fires%20and%20Casualties%22 (accessed 7-7-06).

Smoking is often found as a significant cause of fatalities in fires (U.S. Department of Homeland Security 2005a), this piece examines in depth the incidence of this agent as a cause of fatalities in residential fires for 2002. Utilizing 2002 NFIRS data, the death rate from fires started by smoking was four times greater than by and large the residential fire rate. Although smoking was one of the least frequent causes of fires in 2002, accounting for only 4% of cases, when these types of fires did occur they were often deadly. As well, the injury rate attributed to smoking fires was greater than the overall injury rate for all fires. Smoking fires made up 19% of residential fatalities and 9% of injuries in 2002. The high incidence of death and injury related to smoking fires may be linked to that fact that most of these fires start in the bedroom (28%) while the victim is sleeping. Victims tend to be older (middle-aged or older adults) with 77% of fatalities occurring in victims aged 40 years old or older. Examining behaviors at time of fire, victims tended to be asleep at the time of death (40%) or injury (35%). Alcohol and substance abuse were involved in 23% of these fires. In terms of what was ignited, upholstered furniture and trash accounted for 29% of all residential smoking fires in 2002. Although nearly 90% of residences have fire alarms, many deaths still occur in these structures. This is made evident by analyses revealing that in 2002 64% of the homes had fire alarms in which smoking fires occurred, yet such devices only worked in 39% of the incidents. It is reported that a measure taken by legislatures in attempt to control and hopefully prevent these deaths and injuries is to promote fire-safe cigarettes that extinguish when not being actively smoked. This article reaffirms the potential danger smoking has for fire fatalities in residences, as well as the susceptibility of older populations to this threat. Future research on social demographic characteristics may reveal disparities across race, class and gender in regards to this at risk population.

U.S. Department of Homeland Security. 2006a. "Investigation of Fatal Residential Structure Fires With Operational Smoke Alarms." U.S Fire Administration National Fire Data Center: *Topical Fire Research Series,* Vol. 6, No. 2: 1-5
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v6i2.pdf (accessed 9-4-06).

This study focuses on residential structural fires with fatalities where smoke alarms operated and addresses the characteristics of the fatalities themselves from 2001 to 2004. In the US 96 % of U.S. household have smoke alarms, however alarms operated in less than one quarter of all fatal residential fires. Alarms were present in approximately 60 percent of fatal residential structural fires. Of those fires with alarms present, the alarm functioned properly to alert households 39 % of the time. It was also uncovered that twice as many fatal residential structures with operational alarms occur in one and two family homes as in apartments.

The study also focused on gender, age and race distributions of fatalities in residential structural fires with working smoke alarms, and found that males (57 %) suffered greater fatalities than females (43 %) when smoke alarms operated in fires. Across age, middle aged men died more so than women, which differed from older adult fatalities (those above 65 years of age) where women (55 %) died more so than men (45%). Across race, Whites comprised 80 % of fatalities and African Americans for 15% in residences with working smoke alarms. Although African Americans are grossly over represented in fire fatalities overall, when smoke detectors are present and function, race may fail to be a predictor of fire fatality rates.

Of the behaviors engaged in by this population, this study found most victims were sleeping at the time of the fatal injury (37 %), while a significant proportion (29 %) attempted to escape a fire. Sleeping was an influential factor in child fatalities (82 % of deaths attributed to sleeping were children). Of older adult fatalities, 32% were sleeping or 33 % physically disabled. Alcohol impairment was a contributing element in victims age 15 to 64. The article concludes with recommendations on placement, maintenance, and operational recommendations to ensure that smoke alarms work effectively. This piece is informative; covering a wide breadth of issue in regards to the civilian populations interactions with hazardous fires in residential structures.

U.S. Fire Administration. 2006a. "Fire and the Older Adult."
http://www.usfa.dhs.gov/downloads/pdf/publications/fa-300.pdf#search=%22Fire%20and%20the%20Older%20Adult%22 (8-8-06).

Previous studies have focused on the elderly (U.S. Department of Homeland Security 2005c) as an at risk population to fatal fires, this piece offers another analysis of issues related to such threats, utilizing 2002 NFIRS data. Physical, emotional, social, economic, and residential factors have unique affects on seniors and fire, according to this study. Adults 65 years of age or older are 2.5 times more likely to die in a fire (compared to the overall population). As Americans age, their fire risk increases. For 2002, 34% of deaths in residential structure fires and 14% of the people injured were senior citizens. A factor that increases the risk of fires to the elderly is the loss of sensory ability, a natural byproduct of aging. Older adults also suffer from diminished mental faculties such as dementia and Alzheimer's disease. These things reduce a person's reaction time and make it harder for older adults to realize there is a fire and escape in time. Many older adults are also wheelchair bound or use canes which affect how quickly they can evacuate a burning building. Another factor for older adults is that many of them live on fixed incomes which may prevent them from making home improvements that could decrease their fire risk.

Long term care facilities were also examined and deemed as locations with heightened fire risk. Patient care devices, cooking equipment, electrical devices, compressed gasses, and flammable liquids can all be found inside long term care facilities and increase the fire risk. The architectural layout of these facilities has also been cited as a problem. Nearly 63% of people in long term care facilities are also in wheelchairs making it more difficult for these people to evacuate a building safely. Surprisingly there are no federal standards requiring smoke alarms in nursing home rooms. Hospice care situations present many of the same problems noted above related to long term care facilities.

In regards to gender, older men are more likely to die in fires than women; across race, African Americans are at a greater risk for dying in fires than whites. Older adults are more likely to die in fires that occur in the midmorning or early afternoon than are adults aged 18 to 64. An explanation for this is simply that the elderly tend to be home during these hours while younger adults are at school or at a job. Older adults tended to be asleep or had attempted to escape at the time of their death or injury. It was found that a greater number of younger adults died trying to control the fire themselves. Causes of fatal fires for elderly were usually cooking, smoking, and heating.

Education programs aimed at senior citizens are being tested in several regions and states. Many elderly fire deaths and injuries have been deemed preventable and hopefully education programs will help to decrease elderly deaths and injuries. This article conforms what is known about the elderly as a high risk population for fire fatalities. Its contribution is a discussion of programs aimed at the elderly to curb their susceptibility to death in fires.

Wang, Haihui and Weicheng Fan. 1997. "Progress and Problems of Fire Protection in China." ***Fire Safety Journal*** **Vol. 28, No. 3: 191-205.**

This report examines incidence of fires and their impact on civilian populations in China such as fires, fatalities and injuries attributed to these events from 1984-1994. Fire statistics from 1984-1994 were reported using annual data from the Fire Service Bureau, Ministry of Public Security. Findings show that during the time period under study there was an average of 37,582 fires each year leading to 2,266 deaths and 3,931 injuries on average per year. Previous studies found fires took place more often in winter months in comparison to other seasons and most fatalities occur during this season, similar to U.S. findings (Moore 2006). As well, structural fires are most likely to occur in residential settlements, similar to many U.S. findings (U.S. Department of Homeland Security. 2005a).

An analysis of the causes of fire accidents in recent years found the following conclusions: Due to changes in the economy, present regulations and administrative systems for fire protection fell behind social development. Fire service construction and maintenance is failing to keep up with fast economic growth. Because of the expansion of decoration enterprises and the lack of effective rules and supervision on fire protection in decorated enterprises in recent years, many big fires took place in decorated places. Also, fire protection technology and facilities are not meeting the needs of society. The article concludes that improved legal administration systems for fire protection need to be improved; collaboration needs to take place between specialists from other departments and institutions; more effective and high quality equipment needs to be developed for fire detection; also, the number of personnel should be increased in order to supply fire stations with the necesS&Ry advanced facilities. These factors reveal how economic enterprises and the legal administrative systems designed to mitigate structural fires need to be reassessed to see how they both can better reduce fatalities in the U.S. Similar findings of fire analysis in China begs for a cross-national comparative analysis to assess if such findings are consistent, and if not, how they vary internationally.

Wolf, Alisa. 1997b. "Living Dangerously." ***NFPA Journal*** **(January/February): 44-49.**

This article branching off of the "Getting Out" article by Wolf (1997), focuses on elderly populations in the U.S., revealing individuals over 65 have twice the national average fire death rate. For those older than 75, they three times the national average and at age 85 the rate is four times the average fire death rate. It is mentioned that the population is aging quickly, and the elderly are projected to be 20% of the population in

2030. This concern over the increased risk of elderly fatalities is a common theme echoes through out literature examining this at risk population.

Factors generating fires are examined. Smoking materials are a common cause of fire, and the lack of sprinklers in many buildings or homes are key factors that lead to multiple-death fatalities. Although most people feel safest when they are home, residences are where 80% of fire deaths occur. Smoke is the leading cause of fire related deaths with the risk being highest for those 85 or older. A detailed description of the Ste. Genevieve fire is presented. A study on the Ste. Genevieve fire was analyzed to understand how codes and standards affect fire prevention with finding stating that the response was disorganized, the building lacked safety features, there was only one wheelchair ramp, there were not sufficient sprinklers, and more education on fire safety is necesS&Ry. This article reaffirms the prevailing knowledge in fire fatality literature that the elderly are a high risk population to fire related deaths.

Firefighter Death and Injury

Brassel, Lori. D. & David Evans. nd. "Trends in Firefighter Fatalities Due to Structural Collapse, 1979-2002" National Institute of Standards and Technology (NIST); Technology Administration, U.S. Department of Commerce

http://www.fire.nist.gov/bfrlpubs/fire03/PDF/f03024.pdf (accessed 7-1-06)

Structural collapse is a potentially lethal hazard many firefighters face while responding to a fire. Brassel and Evans examine structural collapses due to weakening of structure by fire, leading to firefighter mortality for the years 1994-2002, comparing previous findings from 1979-1988 & 1983-1992. In total, from 1979 to 2002, 180 firefighter deaths resulted from structural collapse, a concern for many in the industry. It is these losses that are examined.

Firefighter fatality is examined across two dimensions: 1) Firefighters caught or trapped in structure, could not escape or be rescued due to collapse or partial collapse of structure and 2) Firefighters struck and severely injured by some part of a collapsing structure, usually while working outside. These two categories are the two main causes for collapse fatalities in response to a fire, according to this study. Previous research found 60% of firefighter deaths resulted from being caught or trapped, while 40% of firefighter deaths were due to being struck by or making contact with an object. From 1994-2002, 63 deaths occurred from structural collapse, 85% of fatalities were caused by being trapped, 51% of fatalities occurred in residential structures, the type of structure fire that proves to be often deadly for civilians generally. In examining the behaviors in which these firefighter deaths occur, the majority were during fire attack while on call. In examining types of structures firefighters interact with, the percentage of firefighter deaths in collapses occurring on residential property has risen in the ladder portion of the time frame under study. Overall, the number of firefighter deaths in collapses has decreased since 1979. This study is informative in its analysis of rates of firefighter deaths in relation to structural collapse, reporting on how this threat has diminished slightly according to this research. Future research on collapse would do well to examine how firefighter behaviors in residences may impact their own mortality rates in regards to collapse.

Fahy, Rita. 2005. "Sudden Cardiac Death: US Firefighter Fatalities Due to Sudden Cardiac Arrest 1995-2004." ***NFPA Journal*** **(July/August): 44-47.**

Fahy examines the lingering threat cardiac ailments have for firefighters. Previous research on firefighter mortality reveal cardiac arrests are a significant factor in many deaths of firefighters, Fahy examines in depth this occurrence over a ten year period (1995-2004) of sudden cardiac arrests in the U.S. Fahy examines factors surrounding 440 firefighter deaths during this ten year period. This study uncovers how such a threat to life is a major concern for the firefighting industry.

There are a multitude of situations in which firefighters succumb to sudden cardiac arrests. The highest number of firefighter deaths resulting from sudden cardiac arrests occurred during fire ground operations in this study (35.2%), followed by responding to or returning from a fire scene (25.2%). Training (11.4%), non-fire incidents (nearly 11%), and station duties (10.5%) are further contexts in which sudden cardiac arrests occur for many firefighters.

The medical history of firefighters are often documented when such deaths occur, as well, autopsies are performed on a large volume of firefighter fatalities. Previous medical conditions are considered an influential factor in firefighter deaths under analysis. Close to half of firefighters who died from cardiac related illness had some form of previous heart condition, such as heart attacks and/or surgery related to the heart. The population of firefighters undergoing sudden cardiac arrest ranged from 17 to 81, with a median age of 52. Volunteer firefighters accounted for 93% of cardiac arrests for those over 60, possibly signifying the desire for volunteer firefighters to be active pass the age of retired professionals. Although annual medical evaluations are conducted to ensure the ability of a firefighter to perform tasks related to their profession, there is some concern that firefighters are still active when they should not. Fahy assesses if the NFPA 1582 provisions (*Comprehensive Occupational Medical Program for Fire Departments*), which prohibit those firefighters with existing medical conditions from participating in firefighter duties are being followed.

Of the total 134 firefighters who had prior heart attacks or heart surgery, 50 died during fire ground duty, 31 died while responding to or returning from an alarm, as well as 13 operating in non-fire emergencies that either had a previous heart attack or bypass surgery. It appears regulations to prevent further harm to firefighters are not being followed, according to this analysis. Fahy offers suggestions to mitigate cardiac arrests: annual medical evaluations, screening for coronary artery disease, stress tests, and treatment to those who need it. In addition, wellness and fitness programs should be made available with grants. Fahy offers a helpful examination of the contexts, as well as factors, related to sudden cardiac arrests for fire fighters, a major concern for many in the industry.

Fahy, Rita. 2006. "United States Firefighting Deaths Related to Training 1996-2005." ***NFPA Journal*** **(July/August): 40-49.**

Fahy assesses the rate of firefighter deaths during training, over a 10 year span (1996-2005), highlighting the activities, context, causes and other factors associated with these 100 deaths. It is estimated that 10% of all on-duty firefighter deaths in the U.S. during this time period occurred during training. These deaths occurred in a variety of contexts, with apparatus and equipment drills accounting for the largest number of deaths (36). Of these deaths, 21 resulted from cardiac deaths, 5 from falling, 4 due to aircraft or road crashes, 3 as a result of being hit by a vehicle, 2 from head injuries and 1 from a seizure. Physical fitness training (30) and live-fire training (14) were the second and third leading contexts in which deaths occurred. Physical fitness incidents where death occurred were caused by: cardiac arrest (23); heat stroke (3); stroke or aneurysm (3), and from a disease (1). Fatal injuries are divided into specific instances (events that caused death), and the nature of fatal injury (the medical reason for dying).

In examining training related deaths by cause of fatal injury or illness, stress or overexertion was a leading variable in mortality (62%). Assessing the medical nature of these causes for fatalities in training, 53 deaths resulted from sudden cardiac arrests. Cardiac related conditions appear to be a significant threat to firefighter mortality within the realm of training, as seen in previous analysis (Fahy 2005). Age is also studied as a variable in training deaths, (an age range of firefighters between 17 and 74, with 43 as a median). Firefighters 60 or over have a fatality rate twice the average of younger firefighters. Increased age is found to correlate with susceptibility to cardiac arrests, within this study. Trainings are intended to reduce fatalities; therefore these continued deaths are a concern for many in the fire industry. NFPA standards on safety, such as processes in conducting live wire training that may mitigate training deaths are proposed. Also, routine tests and service checks are promoted to ensure compliance with these standards. Although deaths attributed to trainings accounts for a small proportion of overall firefighter fatalities, this research highlights the importance of empirical analyses and provides insight into how to mitigate future harm.

Fahy, Rita and Paul Leblanc. 2006. "U.S. Firefighter Fatalities for 2005." *NFPA Journal* (July/August): 50-60

Fahy and LeBlanc examine the context, cause, social demographics and contributing factors associated with on-duty U.S. firefighter fatalities in 2005. On-duty fatalities include any injury sustained in the line of duty that proves fatal, any illness that was incurred as a result of actions while on duty that proves fatal, and fatal mishaps involving non-emergency occupational hazards that occur while on duty. There were 87 firefighter fatalities in 2005, a considerable decrease from 103 in 2004. Within this total number of fatalities for 2005, three multiple-fatality incidents occurred, however the 87 fatalities are the lowest since 1993. By type of duty, responding to and returning from an alarm (30%) and fire ground activity (29%) were the contexts in which the majority of deaths occurred. Other on-duty activities (24%), training (13%), and non-fire emergencies (5%) were the remaining activities in which the 87 deaths occurred in 2005. The 25 fire ground deaths that did occur in 2005 were the lowest since 1977 (when NFPA data collection began). In assessing the causes of fatal injury or deaths, of the 87 in 2005 stress and overexertion accounted for the majority of deaths (54%).

Heart attacks are often a contributing factor in firefighter deaths where stress and overexertion play a role. Being struck by an object (25%) was the second major cause of deaths in 2005, followed by being caught or trapped (9%), other (7%) and falls (5%) were significant causes of fatal injury and illness. Fahy and LeBlanc examine the nature of fatality and injury of firefighter, what is often listed as the cause of death on a death certificate. Cardiac arrests (46%) were the leading causal factor of fatal firefighter death and illness in 2005, followed by internal trauma (24%), asphyxiation (7%), Stroke (7%) and crushing (5%) as the other most significant causes.

Age is social demographic variable tied to firefighter fatality and illness, with those over 40 highly correlated with cardiac arrests. Firefighters in their 20s had a death rate half the overall average for firefighters; those in their 30s had a death rate 2/3 of the overall average, those in their 50s had a death rate twice the average overall rate of death. With the increase in age, firefighters are more susceptible to fatalities, according to this data. Fahy and LeBlanc assess property types, and how these relate to fatalities for 2005. Of the 25 fire ground deaths, 18 occurred in residential properties. Assessing firefighter fatality rates per 100,000 by property type, vacant or non-residential structures appear more dangerous for firefighters than in residential structures. The authors contend this may be to the ability to quickly notify fire departments of a residential property sooner than a non-residential fire. Cardiac arrest, highly associated with age according to this study appears to be a significant threat to the firefighter population. Further analysis on the region, population density in which these firefighters serve, race/ ethnicity information on these firefighters may provide insight into how this threat is differentiated amongst the firefighter population. This piece offers rich analysis of factors associated with firefighter fatalities for 2005.

Karter Jr., Michael & Joseph Molis. 2004. "Firefighter Injuries for 2003." *NFPA Journal* (November/December): 58-65

Karter Jr. and Molis review the rates, context, and factors contributing to firefighter injuries in 2003. This analysis is based upon national Fire Protection Administration (NFPA) data collected nationally for 2004. In comparison to 2002, there was a 2.5% decrease in firefighter injuries in 2003, totaling 78,750. The leading context in which injuries occurred were in fire ground activities (48.%). Subsequent contexts such as other on-duty activities (18.4%), non-fire emergencies (17.5%), training (9%), and responding to or returning from an alarm (6.6%) accounted for all other injuries in 2003. The causes of fire ground injuries are examined by Karter Jr. and Molis in detail. Overexertion/Strain (32.4%) was the leading cause of fire ground injuries in 2003, followed by falls, jumps and slips (27.6%), exposure to fire products (10.6%), contact with an object and other as causes.

Population is a factor in the rate of firefighter injury. Those regions with larger populations were found to have higher rates for injury. Comparing the number of firefighter injuries for every 100 fire ground fires responded to, injury rates are found to be impacted by response rate. Karter Jr. and Molis illustrate that a city with a larger population has an increased number of fire departments, who respond to a greater number of alarms. A higher departmental response rate correlates with a greater number of injuries. Regionally, the Northeastern US comparatively has a larger number of fire ground injuries nationally.

Karter Jr. and Molis acknowledge firefighting injuries will never be totally eliminated, however a risk management system coupled with technology may mitigate harm. The authors' suggestion: making safety a priority for management, establishing a safety committee to recommend policies, obtaining and using proper safety equipment, using self contained breathing apparatus (SCBA), enforcing policies for safe driving for fire service vehicles, having sufficient responders, routine medical exams for firefighters, adopting an incident command system ICS, training and education standards, and programs to discover fires at an earlier stage. Injuries are a major concern for an institution such as firefighting that is charged with delivering a high level of assistance in times of great need. This piece, with its analysis of context and actions in which injuries occur, offers valuable information for those who would work to mitigate such injuries.

Karter Jr., Michael and Joseph Molis. 2005. "Firefighter Injuries for 2004." ***NFPA Journal*** **(November/December): 50-57.**

Karter Jr. and Molis review the rates of, context, causes and factors contributing to firefighter injuries in 2004. This analysis is based upon National Fire Protection Administration (NFPA) data collected nationally for 2004. In comparison to 2003, there was a 3.7% decrease in firefighter injuries in 2004, totaling 75,840. The leading context in which injuries occurred was in fire ground activities (48.6%). Subsequent contexts such as other on-duty activities (18.7%), non-fire emergencies (17.3%), training (8.8%), and responding to or returning from an alarm (6.3%) accounted for all other injuries in 2004. The causes of fire ground injuries are examined by Karter Jr. and Molis in detail. Falls, jumps and slips (29.7%) were the leading cause of fire ground injuries in 2004, followed by overexertion/strain (25.7%), struck by an object (12.2%), other (11.7%), contact with an object (9%), Exposure to fire products (8.8%), exposure to chemicals (1.6%) and extreme weather (1.3%).

Population is a factor in the rate of firefighter injury. Those regions of the US with larger populations were found to have higher rates for injury for firefighters. Comparing the number of firefighter injuries for every 100 fire ground fires responded to, injury rate is found to be impacted by response rate. Karter Jr. and Molis illustrate that a city with a larger population has an increased number of fire departments, who respond to a greater number of alarms. A higher departmental response rate correlates with a greater number of injuries. Regionally, the Northeastern US comparatively has a larger number of fire ground injuries nationally. Karter Jr. and Molis acknowledge firefighting injuries will never be totally eliminated, however a risk management system coupled with technology may mitigate harm.

The authors offer the following suggestions: making safety a priority for management, establishing a safety committee to recommend policies, obtaining and using proper safety equipment, using self contained breathing apparatus (SCBA), enforcing policies for safe driving for fire service vehicles, having sufficient responders, routine medical exams for firefighters, and adopting an incident command system ICS, training and education standards, and programs to discover fires at an earlier stage. Injuries are a major concern for an institution such as firefighting that is charged with delivering a high level of assistance in times of great need. This piece, with its analysis of context and actions in which injuries occur, offers valuable information for those who would work to mitigate such injuries.

U. S. Fire Administration. 2005. "Fire fighter fatalities

In The United States in 2004."   FEMA
http://www.usfa.dhs.gov/downloads/pdf/publications/fa-299-508.pdf (accessed 7-3-06).

This piece by the U.S. Fire Administration (USFA) reviews the causes, context, social demographics and contributing factors associated with the 117 on-duty firefighter deaths in 2004. Of the 117 total firefighter deaths, the cause or circumstance that resulted in a fatality were: stress/overexertion (66); vehicle collision (20); struck by and object (10); caught/trapped (8); collapse (6); fall (5); and other (2). The cause of these fatalities for firefighters in 2004 was: heart attack (61); internal trauma (31); crushed (8); asphyxiation (5); CVA (6); burns (3); drowning (2); and other (3).

It appears that heart attacks are a major cause of firefighter deaths in 2004 (see Fahy and Leblanc 2006). Firefighter fatalities for 2004 are assessed by type of duty in which these deaths occurred, fire ground operations (30) was the leading category followed by responding or returning from a fire (22). The subsequent categories were other on duty (18); training (13); non-fire emergencies (11) and after an incident (23) in which fire deaths occurred. 14 firefighters died while engaged in a training activity. In examining fire ground deaths (30) specifically, fire attack (16) was the leading activity in which death occurred for firefighters, followed by search and rescue (4), water supply (3), scene safety (2), incident command (2), ventilation (2) and suppression support (1). Interestingly, volunteer firefighters outnumbered career firefighter deaths, and males outnumbered female deaths in 2004. Seasonal variations are an important component in possibly predicting firefighter deaths. The months of March (17), April (12), February (11), December (10), and January (9) accounted for as significant number of firefighter deaths in 2004. The winter months along with early Spring correlate with a majority of deaths in 2004. The time of the day in which the majority of firefighter deaths occurred for 2004 were highest in the hours of 5pm-7pm (20), 7pm-9pm (14), 9am-11am (13), 1pm-3pm (12) and 7am-9am (11). A large portion of firefighter deaths in 2004 occurred during late morning and evening hours. The USFA offers a thorough summary of factors impacting firefighter fatalities in 2004.

U.S. Fire Administration 2006b. "Firefighter Fatalities in the United States in 2005."
http://www.usfa.dhs.gov/downloads/pdf/publications/fa-306-508.pdf (accessed 7-9-06).

This piece by the U.S. Fire Administration (USFA) reviews the causes, context, social demographics and contributing factors associated with the 115 on-duty firefighter deaths in 2005. Of the 115 total firefighter deaths, the cause or circumstance that resulted in a fatality were: stress/overexertion (62); vehicle collision (25); caught/trapped (9); fall (5); struck by and object (4); contact/exposure (3); assault (1); and other (6). The nature of these fatalities for firefighters in 2005 according to the USFA was: heart attack (55); internal trauma (32); asphyxiation (8); CVA (6); burns (3); crushed (2); electrocution (2); heat exhaustion (1) and other (6). It appears that heart attacks were a major cause of firefighter deaths in 2005.

Firefighter fatalities for 2005 are assessed by type of duty in which these deaths occurred, with fire ground operations (27) as the leading category followed by responding or returning from a fire (23). The subsequent categories were other on duty

(24); training (14); non-fire emergencies (6) and after an incident (21) in which fire deaths occurred. 14 firefighters died while engaged in a training activity. In examining fire ground deaths (27) specifically, fire attack (11) was the leading activity in which death occurred for firefighters, followed by search and rescue (6), water supply (2), incident command (2), scene safety (1) and other (5). Interestingly, volunteer firefighters (81) outnumbered career firefighter deaths (34), and males (112) outnumbered female deaths in 2005.

Seasonal variations are an important component in possibly predicting firefighter deaths. The months of April (16) November (14), January (14), February (12), June (12) and March (10) accounted for the majority of the 115 firefighter deaths in 2005. The winter months along with the beginning of summer and spring are the times of the year in which a majority of deaths occurred in 2005. The time of the day in which the majority of firefighter deaths occurred for 2005 were highest in the hours of 1pm-3pm (19), 11am-1pm (15), 5pm-7pm (10), followed by late night/early morning hours 7pm-3pm (35). The USFA offers a thorough summary of factors impacting firefighter fatalities in 2005.

Structural and Economic Loss due to fire

Karter Jr., Michael. 2005. "U.S. Fire Loss for 2004." *NFPA Journal* (September/October): 44-49.

This piece on loss totals to fires from the National Fire Prevention Agency reports on the occurrence of residential fires, response to these fires, and the total human, structural, and dollar loss attributed to these events for 2004. The following statistics are highlighted in this article. Public fire departments responded to over 1.5 million fires, with 526,000 fires occurring in structures (this number increased slightly from the year before). Of these fires, 78% of all were in residential property (410,500). Non structure fires encompassed almost 300,000 vehicle fires, over 727,000 fires occurred in outside properties. In 2004 nearly 3,900 civilian deaths occurred. Around 3,190 deaths occurred in residences, 520 civilians were in vehicle fires on highways, and 80 people dieing in nonresidential structures.

In terms of monetary loss: $8,314,000,000 in property damage, $5,948,000,000 in property loss, and $714,000,000 in property loss from intentionally set fires. Of the 1,550,500 fires responded to, an estimated $9,794,000,000 in property damage occurred.

In terms of fire types, the most common are outside fires, structural fires, and vehicle fires, respectively. Types of structures are broken into categories with numbers of occurrences for civilian deaths. One- or two-family homes (2,680) and apartments (510) are the two main categories for civilian deaths to occur. There are several goals which may reduce home fire deaths (which is 82% of all civilian deaths): education in fire prevention, better use of smoke alarms, installing sprinklers, safer everyday products, and better examining those groups that are most vulnerable to fires. Civilian injuries are also mentioned since there were nearly 18,000 injuries from 3,900 fires in 2004, of which 14,175 of these were in residential properties. It is noted that civilian injuries in general are likely to be an underreported statistic. This piece is a fair analysis of fire threats posed nationally in 2004.

Badger, Stephen G. and Thomas Johnson. 2000. "1999 Large

-Loss Fires and Explosions." ***NFPA Journal*** **(November/December): 79-96.**

This piece examines large fire loss events and explosions in the US for 1999. Large fire loss refers to high dollar value losses attributed to fires. The 66 costliest fires in 1999 amounted to over $2 billion from lost property, took 25 lives and injured an additional 127 people (including both civilians and firefighters). These 66 fires only represent .004% of all fires estimated for that year. Of large loss fires causing $10 million or more in 1999, manufacturing (33.3%), storage (18.2%), stores and offices (12.1%) and residential (9.1%) accounted for the top four types of fires resulting in the most damage. It was found that 56 of these fires (85%) occurred in structures, reflecting that 88% of the total losses were structural. Only 17 of the 56 structures that were part of the large-loss fires had automatic suppression equipment. In 1999 the number of large-loss fires rose by 16%, yet the direct property loss rose by 95.4%. The major fires usually are the ones lacking fire suppression systems. In 1999, 16% did not have any type of fire protection. U.S large loss incidents for 1999 are listed by state with brief descriptions for all fires provided. Large fire losses are a concern to industries and businesses, warranting further research on how these events are social disruptions to economic activity of communities. In fire studies the lack of functioning fire suppression devices such as alarms and sprinklers may be cause for analysis in the occurrence of these large loss fires.

Causes of Fire

Ahrens, Marty. and Jennifer Mieth. nd. "A Special Study of Massachusetts Candle Fires during 1999." Public Education Manager, Office of the State Fire Marshal of Massachusetts. NFPA.
http://www.mass.gov/dfs/osfm/pubed/docs/masscandle.pdf#search=%22A%20Special%20Study%20of%20Massachusetts%20Candle%20Fires%20during%201999%22
(accessed 6-20-06).

This study assesses the incidence, causes and impacts of candle fires in Massachusetts from 1993 to 1997. NFPA derives national estimates of the fire problem by combining two sources, the NFPA annual fire department survey and the National Fire Incident Reporting System (NFIRS). However, this detailed information is derived from solely from NFIRS data was analyzed between 1993 through 1997. Its findings reveal that nearly half of home candle fires originated in the bedroom. More than one-third of these fires started because candles were left unattended, abandoned or inadequately controlled. One-fifth of fires occurred because some form of combustible material was left too close to a candle. In regards to time of year, December had twice the number of home candle fires as an average month. This data raised questions to the researchers for the need to examine (based upon this Massachusetts study) the types of candles and types of people (mainly age and sex) involved in these fires.

The study identified 301 candle fires reported in 1999 through the Massachusetts Fire Incident Reporting System (MFIRS), using these reporting departments, sent out a survey to conduct more in depth analysis. There was a high response rate of 220 (73%)

of this survey. Findings revealed that 73% of the 196 candle users of known age were over 20 (similar to 74% of the population over 20 years old). Only 6% of the candle users in this study were over 65 (older adults account for 14% of the population). Two-thirds of the candle users were between 20 and 64, inclusive, and teenagers faced the greatest *risk* of a candle fire. Although they comprised only 9% of the population, they accounted for 21% of the fires, meaning they were more than twice as likely to have a candle fire then the population in general. Because candle fires appear to be such a concern in Massachusetts, future research replicating such a study is warranted in other regions to assess the ability to generalize these findings to the overall nation. In addition, since this analysis is not based upon the newer and, according to some, more descriptive NFIRS version 5.0 data, revisiting such a study may be warranted.

Coutts, D.A. nd. "Gas induced fire and Explosion Frequencies." National Fire Protection Administration http://www.osti.gov/bridge/servlets/purl/503450-P1hGXH/webviewable/503450.pdf (accessed 8-5-06).

Each year over 2,900 non-residential structural fires occur in the U.S. where a gas is the first item ignited. Details from these events are collected by the National Fire Incident Reporting System (NFIRS) through an extensive reporting network. This extensive data set (800,000 fires in non-residential structures over a 5-year period) is an underutilized resource within the Department of Energy (DOE) community. Explosions in nuclear facilities can have very severe consequences. The explosion can both damage the facility containment and provide a mechanism for significant radiological dispersion. In addition, an explosion can have significant worker safety implications. In light of our national security focus, threats to lifelines such as gas and other forms of energy warrants an assessment of how loss and response to such events may impact our nation.

Flynn, Bill. 2001. "Trends in Home Heating and Cooking Fires." ***NFPA Journal*** **(March/April)** **http://www.findarticles.com/p/articles/mi_qa3737/is_200103/ai_n8934219** (accessed 7-10-06).

In many reports, cooking and home heating are often leading causes of fires within residences. Trends in cooking and heating fires are analyzed in this article using data from the U.S. Home Heating Patterns and Trends study (NFPA) to highlight their prevalence within recent years. Fires involving both types of agents have decreased in the 1990s according to this author, although heating fires (in the home) are 1) more harmful than cooking fires, 2) the third leading cause of fire deaths, and 3) the third main factor in property damage. While both cooking and heating fires have seen a decline in fatalities, injuries from cooking fires have increased. Space heaters alone caused 33% of all home heating fires in 1997, up from twenty five percent in 1980. Some argue that improper use of space heaters is the cause. For cooking fires, the main cause of fires is leaving cooking unattended. The conclusion is that overall, more education is needed for consumers and the safety standards for products must be strengthened.

Hall, Jr., John R. 2005b. "Intentional Fires and Arson." –

National Fire Protection Association (**March)**
http://www.nfpa.org/assets/files/PDF/ArsonSummary.pdf#search=%22Intentional%20Fires%20and%20Arson%22 (accessed 5-16-06).

This piece examines rates for intentionally set fires in the U.S. in 2003. It is estimated that nearly 37,500 intentional structure fires were reported in the U.S. This figure does not include suspicious fires or those of unknown causes. This is the lowest number of intentional fires ever recorded, according to this study at the time. Property damage and deaths related to intentional fires have decreased, according to this report. The 2003 arson offense rate per 100,000 people dropped to a historic low of 30.4. Juveniles account for half of those arrested under arson charges (as of 1994). In terms where such fires originate, lavatories and exterior walls are usually the site of origin for intentional fires. It is revealed that large cities have more arson fires than small towns. This piece is good start for those interested in rates of occurrence and causes for intentionally set fires in the U.S.

Hall, Jr., John R. 2006. "Fireworks: Related injuries, deaths and fires." National Fire Protection Association (June)
http://www.nfpa.org/assets/files/pdf/os.fireworks.pdf#search=%22Fireworks%20-%20Related%20injuries%2C%20deaths%2C%20and%20fires%20AND%20John%20R.%20Hall%2C%20Jr..%22 (accessed 6-22-06).

This piece analyzes the prevalence of firework related injuries, deaths and fires over several longitudinal time periods form 1980 to 2004. In 2004, 9,600 fireworks-related injuries were treated in U.S. hospital emergency rooms. The trend in fireworks-related injuries has been mostly up since 1996, with a sharp spike in 2000-2001, primarily due to celebrations of the new millennium. Firework related injuries were higher in 1984-1995 than in recent years but lower in the mid-1970s and earlier. In 2004, five out of six (85%) emergency room fireworks injuries involved fireworks that Federal regulations permit consumers to use. Sprinklers, fountains, and novelties accounted for 40% of all fireworks related injuries in 2004. More than two-fifths of fireworks injuries in 2004 were to the head and over half (53%) were to extremities. The majority of fireworks injuries in 2004 were to children, with the largest number of child related fireworks injuries between ages 5-9. The risk of fire death relative to exposure shows fireworks as the riskiest consumer product. In 2003, an estimated 2,300 reported structure or vehicle fires started by fireworks. These fires resulted in 5 reported civilian deaths, 60 civilian injuries, and $58 million in direct property damage. Because, firework injuries disproportionately impact the young, more research on how this group gains access to fireworks is necessary in order to potentially mitigate harm resulting from this activity.

Miller, Alison. 1991. "Where There's Smoking there's Fire." NFPA Journal (January/February): 86-93.

This article examines how fires, civilian death and injury are often caused by smoking materials and how behaviors and age of civilians relate to this phenomenon. The article opens with a story about a specific fire in which some residents evacuated while others failed to, causing death in a fire attribute to smoking materials. The cause of this fire was a form of "smoking material," most likely a cigarette. Smoking materials, the leading cause of civilian deaths from fire, refer to lit tobacco products, not matches or lighters. In terms of injuries, smoking materials are the second most common factor in generating such harm. The number of structural fires caused by smoking materials has decreased (by 47%) since 1989, however the low decrease in civilian fatalities (17%) illustrates how fires that do occur are becoming more severe. Cigarettes are the primary fire material which starts fires, and inattentive behavior (i.e. forgetting, careless placement, falling asleep, etc) is the most common reason behind these fires occurring. Property damage is often due to fires started by mattresses, bedding, furniture, and trash. People under the age of 18 have a lower risk of fire death (since this age group is less likely to be smokers). Smoke detectors are considered to have a large role in providing more time for escape. People may be slow to evacuate for several reasons: age, disabilities, drugs or alcohol, or due to a handicap. Fires that were not caused by smoking usually occur more on weekends. Direct property loss and civilian deaths occurred more often on weekends. Fires and associated losses due smoking material fires are more likely to occur between midnight and 6am than are fires of other causes.

This article has several conclusions for mitigating harm from smoking materials. To save more lives, reducing smoking-material fires in mattresses, bedding and upholstered furniture alone may not be sufficient. Attempting to change behavior with smokers (such as not smoking in bed right before going to sleep) is found to be very difficult, and this topic is not even a goal for change. Instead, new technology (such as the "safe cigarette," which does not ignite surrounding objects as regular cigarettes do) is suggested. The issue of smoking material fires is summarized as complex and problematic, with new strategies needed for the future.

National Fire Protection Association. 2006. "Major Causes of Fire: Leading Causes Of Structure Fires in Homes 1999-2002 annual Averages." http://www.nfpa.org/itemDetail.asp?categoryID=952&itemID=23186&URL=Research%20&%20Reports/Fire%20statistics/Major%20causes%20of%20fire (accessed 7-23-06).

As previous research has shown, residential fires are proved most deadly for civilian populations. This article utilizing NFPA, provides an in depth analysis on the leading causes of structural fires in homes based on annual averages from between 1999-2002. Cooking equipment fires made up the leading cause of fire with 28%. Heating equipment fires made up 14% of fires, intentional fires 9%, electrical distribution or lighting equipment 9%, smoking materials 7%, candles 5%, exposure to other fires 4%, playing with heat source 4% and clothing washers or dryers 4%. The most civilian deaths were caused by fires due to smoking materials (29%) followed by intentional fires set (19%). Heating equipment fires caused 11% of civilian deaths between 1999 and 2002 and cooking equipment fires lead to death in 9% of the cases. As seen in previous literature (Flynn 2001), heating and cooking are significant threats for residence fires. These two, along with smoking appear to be a threat to the generation of residence fires.

Rohr, Kimberly. 2003. "Examining Structure Fires Where

Christmas Trees Were the Form of Material First Ignited, 1999." National Fire Protection Association.
http://www.nfpa.org/assets/files/PDF/Christmas99.PDF#search=%22Examining%20Structure%20Fires%20Where%20Christmas%20Trees%20Were%20the%20Form%20of%20Material%20First%20Ignited%2C%201999%22 (accessed 6-15-06).

This is a study on the ignition of fires, occurrence of deaths and monetary loss attributed to Christmas tress igniting in 1999. The NFPA Annual Fire Department Survey was the main source for the study, providing an overview of the fire experience in the previous year; NFIRS was used to detail the information.

Christmas trees (real and artificial) were items first ignited in an estimated 370 home fires during 1999. These fires caused an estimated five civilian deaths, 60 civilian injuries, and $15.7 million in direct property damage in 1999. The term homes referred to one- and two-family dwellings, manufactured housing and apartments. The leading area of origin for Christmas tree fires and associated losses was the living room, den or family room. Roughly one-third of the Christmas tree fires were started by bulbs, lamps or lighting, and one-quarter were started by cords or plugs. Sixteen percent of the fires occurred because a heat source was too close to the Christmas tree and 9% were started by children (or others) playing with fire or other heat source. Although Christmas tree fires reflect a small proportion of fires in the U.S. annually, this is still a significant proportion of loss that warrants further research. However it must be taken into account that social, cultural practices upon a diversified population as the U.S. may reveal that this threat varies according to these factors.

Rohr, Kimberly D. 2005. "Product First Ignited in US Home Fires." – National Fire Protection Association (April)
http://www.nfpa.org/assets/files/PDF/ProductsExecSum.pdf#search=%22Product%20First%20Ignited%20in%20US%20Home%20Fires%22 (accessed 5-10-06).

This report is a summary of a study released by the National Fire Protection Association on combustible products which cause home fires. Generally, according to this report people have control over the size, characteristics, and arrangement of the fuel load in their homes and how potential heat sources interact with the fuel. It was found that in relation to this autonomy, mattress and bedding-related fires account for most fires, property damage, and injuries in the home. Interior wall coverings are subsequent materials that help ignite home fires. Comparatively, it was found that fires started by upholstered furniture cause the most deaths. Future research on home items that ignite fires should examine how social demographic characteristics relate to behaviors that may influence the preponderance of these home fires. Putting this understanding of causes of fires in a social context may improve attempts to mitigate harm from fires.

U.S. Department of Homeland Security. 2001. "Arson in the United States." US Fire Administration National Fire data Center *Topical Fire Research Series*, Vol. 1, No. 8: 1-5
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v1i8.pdf (accessed 5-4-06).

This paper is about arson, claimed here to be the leading cause of fire in the United States. Analysis of NFIRS data from 1996 to 1998 compared dollar loss, injuries, and deaths for both non-arson and arson fire. While arson fires resulted in higher than average dollar loss in relation to all fires, deaths and injuries were slightly lower. In terms of location, NFIRS data was also used to determine where arson occurs – structures, vehicles, or outside, with outside fires being the most common (50% of cases). Arson fires were most likely to peak around specific dates, most notably July 4th, Halloween, and New Years. Arson is a significant issue in regards to fire loss, as well as an economic concern that may impact the functioning of commerce in many areas. Further research on how such losses impact communities is warranted. Also, replication of this study is warranted since the initial analysis was completed without using the updated and more in depth NFIRS version 5.0 data which may reveal new insight into this phenomenon.

U.S. Department of Homeland Security. 2002b. "Mattress and Bedding Fire in Residential Structures." US Fire Administration National Fire Data Center *Topical Fire Research Series*, Vol. 2, No. 17: 1-4 http://www.usfa.dhs.gov/downloads/pdf/tfrs/v2i17.pdf (accessed 5-11-06).

Mattresses, pillows, and bedding fires make up a large component of structure fires every year in the U.S. Approximately 20,800 fires are related to mattress/bedding according to data from the NFIRS analyzed from 1996 to 1998. Most of these fires are started by children playing with matches and lighters (25%) and by careless smoking (25%). Nearly 2,200 injuries are caused by mattress/bedding fires. Most of these injuries (68%) happened when an individual was trying to control the fire by him or herself. 380 deaths are attributed to mattress/bedding fires. Most of these victims (42%) were asleep at the time of the fire. Escaping a fire (30%) accounted for a large proportion of deaths. In terms of location, 83% of mattress/bedding fire started, not surprisingly, in the bedroom. The rest of the mattress/bedding fires started in crawlspaces, garages, and attics where the mattress was being stored.

The most significant finding of this report is that many injuries and deaths could have been prevented. There were no smoke alarms in 42% of the buildings that had mattress/bedding fires. If more smoke alarms were put in place, residents would be more likely to wake up and have enough time to evacuate the building. Mattress/bedding fires could also be prevented by making sure lighters and matches are kept away from children and educating adults about the dangers of smoking in bed. More injuries and deaths could also be avoided if people were educated about the danger of trying to put out a fire alone. If people just evacuated their residence and called the fire department immediately, they would be less likely to get hurt or die. This piece reflects common threats to fire death and injury found in other literature (lack of or faulty fire alarms, smoking in bed, and attempting to extinguish a fire themselves) that may be able to be remedied through education.

U.S. Department of Homeland Security. 2004b. "Kitchen

Fires." US Fire Administration National Fire Data Center *Topical Fire Research Series*, Vol. 4, No. 4: 1-6
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v4i4.pdf (accessed 5-20-06).

This piece examines the preponderance of and causes for kitchen fires in the U.S. in 2002. Kitchen fires made up about 30% of all reported structure fires in 2002. Kitchen fires accounted for 12% of deaths, 32% of injuries, and 10 % of property losses in structure fires in 2002. In 2002, there were an estimated 156,500 kitchen fires responsible for 331 fatalities, 4,914 injuries, and $876 million in property loss. Kitchen fires caused less property damage and fewer deaths, but resulted in more injuries when compared to all structure fires. A large proportion (90%) of kitchen fires are cooking fires which started by unattended equipment. Oils, fats, and grease are the leading products that ignite. There is no seasonal pattern for kitchen fires, but there is a daytime peak between 6 and 7 p.m. when people are most likely to be cooking dinner. Smoke alarms were present and worked in 45% of kitchen fires whereas this is true for only 29% in structure fires generally. Kitchen fires were on residential property 89% of time. Although generating less loss than structure fires overall, kitchen fires are still a significant threat to social disruption in lives of many.

U.S. Department of Homeland Security. 2005e. "Structure Cooking Fires" US Fire Administration National Fire Data Center *Topical Fire Research Series*, Vol. 5, No. 6: 1-5
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v5i6.pdf#search=%22Structure%20Cooking%20Fires%22
(accessed 5-21-06).

This piece examines structure fires ignited by cooking fires in the US for 2002. According to NFIRS data, cooking was the leading cause of fires and fire injuries in structures. In 2002 alone, cooking-related fires caused approximately 185,600 fires in structures, 3,875 injuries, 80 deaths, and $481 million in property damage. Deaths and property losses due to cooking fires are rather low in comparison to fires ignited by other causes. Most of the property damage in cooking fires was generally due to a cooking pot or stove. Cooking fires make up 36% of reported structure fires; however they are largely considered small fires (94%) and result in little loss of life or injury. Cooking fires are more common around dinner and lunch time. There is a slight decrease in cooking fires during summer months when more people are barbecuing outside or away on vacation. Generally it is the actual food or fats, oils, and grease that start the fire (41%). These fires are most likely to start when the cooking is left unattended (30%). Most cooking fires occur in residential buildings (80%). In 45% of all cooking structure fires, a smoke alarm was present and operated. The fact that these alarms alerted people about the fire may explain the low number of deaths associated with cooking-related fires. Cooking fires are preventable so more people should be educated about the danger of leaving cooking unattended, wearing loose clothing while cooking, and of cooking with flammable liquids like alcohol. This article offers good analysis on factors contributing to cooking fires in the US.

Fire Studies

Civilian Behavior

Bryan, John L. 2002 "Behavioral Response to Fire and Smoke" *The Society of Fire Protection Engineers (SFPE) handbook of Fire Protection Engineering* edited by Philip J. DiNenno, Dougal Drysdale, Craig L. Beyler, W. Douglas Walton, Richard L.P. Custer, John R. Hall Jr. and John M. Watts. National Fire Protection Association, Quincy, Massachusetts: 315-341.

Bryan's contribution to the *The Society of Fire Protection Engineers (SFPE) handbook of Fire Protection Engineering* supports this volume's focus on the theoretical and applied knowledge aimed at fire safety engineers. Bryan's "Behavioral Response to Fire and Smoke" is a literature review of relevant research in fire science. Topics such as how people make sense of a threat, as well as broad categorizations of fire behaviors (i.e. fighting, notifying, evacuating) are presented. Bryan's analysis is aided by a cross-national comparison (Britain & US) examining human behaviors exhibited in fires. The volume also notes the difference in fire related behavior across gender. In structural fire events, males often are more likely to fight fires, while females are more likely to call for help. Bryan's literature is one of the few exhaustive summaries in the fire science literature focusing on the actions of human responses to fires. This is one of the more exhaustive resources focused on research summaries of human behavior in fire events. This chapter is a valuable source for those interested in this area of study.

Canter, David ed. *Fire and Human Behavior*. 1980. John Wiley & Sons, New York.

Fire and Human Behavior is an edited book examining how civilians behave when threatened by fire. This piece discusses the occurrence of panic and explores the behavior of those who set fires as well as the context in which fires occur. Of importance is "A Survey of Behavior" by Wood, which discusses general actions of civilians, and breaks these actions down into three categories: 1) concern with evacuation of the building by oneself or with others, 2) concern with firefighting or at least containing the fire, and 3) concern with warning or alerting others, either individuals or the fire brigade. This chapter incorporates gender into the analysis revealing differences of behaviors according to sex, illustrating that women tend to evacuate more so than males in a fire, and men re-enter buildings more so than females. Canter, Breaux and Sime's "Domestic, Multiple Occupancy and Hospital Fires" confirms differential behaviors in fires according to gender. Females are more likely to warn others when encountering smoke, then wait for instruction if a male is present whereas males were more likely to attempt to fight the fire. Male neighbors were more likely to search for people in smoke and attempt to rescue than female neighbors. The authors stipulate the increase in the number of people in a building shortens the time in which a fire becomes recognized. This chapter stresses the rational actions of people in fires as opposed to irrational or panicked reactions. Lerup, Cronrath and Liu's "Fires in Nursing Facilities" uses in depth case studies to describe behavior in a nursing facility exposed to fire, using a model composed of variables such as the building type, deaths, activity, source for fire and agent. This chapter also explores behavior mapping, attempting to break down actions of people in a fire into different time periods. Through modeling, this chapter promotes the idea that any change to improve structures must also accompany any new understanding of behavioral changes impacting the knowledge of occupants and management of such facilities. Designing plans to deal with fires involves both social and structural understanding of the environment in question. Finally, of important significance is Marchant's "Modeling Fire Safety and Risk" which focuses on various types of models (i.e. fault trees) as well as death scenario modeling, such as reverse fire sequence, which starts out with the knowledge of a death in a fire. Such chapters reveal the multitude of methods in which analysis of fire events can take place. *Fire and Human Behavior* is an important work in uncovering significant variables to focus on in analyzing civilian behaviors in fire events. The field requires an updated version of such a piece discussing issues of human behavior and predicting actions that occur within a fire.

Fires and Structure

Badger, Stephen. 2005. "U.S. Multiple-Death Fires in the United States –2004." Fire Analysis and Research Division, *NFPA*. (September/October): 50-61.

This piece by Badger examines multiple death fire in the U.S. for 2004, looking at the variation in rates from 2002 to 2004, examining how context varies incidence, as well as how mitigation efforts relate to impact of such events. A catastrophic multiple-death fire is defined as killing five or more people in a residential area or three or more in a nonresidential area. A short methodology is included: NFPA collects data from national and local news media (including fire service publications) and information on catastrophic fires are requested from a news clipping service. Then information is requested from the departments or agencies in charge of a fire incident. The following numbers are given for occurrences of catastrophic multiple-death fires: 32 fires killed 160 people in 2002, 35 fires killed 307 people in 2003, and 32 fires killed 152 people in 2004. Catastrophic multiple-death fires accounted for .002% of 2004 fires in the United States (out of an estimated 1,550,500 fires in 2004) and almost 4% of fire related deaths (n = 3,900).

It was found that about half of the catastrophic multiple-death fires in 2004 were in a residential area, homes often the sight of civilian fatalities. The death rate slightly increased from 2003 to 2004 (by five deaths). Most fatalities from a fire in 2004 resulted from the lack of automatic suppression equipment in an apartment building. It is noted that a simple behavior can change a successful house evacuation into a deadly situation. Residential incidents are reported in detail are described, highlighting factors that turned situations fatal: broken smoke detectors or ones without batteries, lack of an automatic suppression system, local alarms being disconnected, faulty elevators, and security systems that prevent escape for victims or entry for rescuers. Similar problems were found in nonresidential fires, although the causes of the fire were often explosions instead of cooking or electric equipment issues. Nonstructural fires are also mentioned, and the death figures are included. Detection equipment was reported in 10 of the 17 residential fires. Sixty percent were missing automatic detection systems. Smoke alarms are expressed as important and effective in saving lives. Suggestions of multiple-station smoke alarms, practicing safe evacuation, and quick-release security bars are given. This piece offers practical advice on cutting down the number of multiple death fires in the U.S.

Brannigan, Francis. L. 1997. *Building Construction for the Fire Science*. National Fire Protection Association. Quincy, Massachusetts

This book gives a very detailed overview of physical structures of buildings that firefighters need to be aware of when engaging in methods for fire suppression. Brannigan discusses wood, brick and metal components of buildings, how they react to fire and characteristics of these structures that may lead to possible collapse. The main focus of is on construction types with chapters devoted specifically to the principles of construction, wood construction, ordinary construction, steel construction, concrete construction, and high rise construction amongst others. In addition, the book includes advice on signs to look for in building construction that may lead to collapse and some anecdotal advice of the author's own experience with structural failure. Information on voids, trusses, and automatic sprinklers is also provided. For those interested in a thorough assessment of the various types of structures a firefighter must encounter as well as how it may react to a fire, this is a valuable resource.

Hall Jr., John R. 2005c. "High Rise Building Fires."– National Fire Protection Association. http://www.nfpa.org/assets/files//PDF/HighRiseTOC.pdf#search=%22High%20Rise%20Building%20Fires%20AND%20John%20R.%20Hall%22 (accessed 5-11-06).

This piece is a synopsis of a lengthier report summarizes losses resulting from high rise fires in 2002. In 2002, high rise buildings had 7,300 reported structure fires. There were 15 civilian deaths, 300 civilian injuries, and $26 million in property damage resultant from high rise fires. Four types of building structures are considered high rises: office buildings, hotels, apartment buildings, and hospitals. The risk of death in high rise apartments and hotels are lower than that of non-high rise apartments or hotels. This piece offers a starting point for further analysis of an important subject, emergencies in high rise buildings. In the wake of 9/11, further research on emergencies within high rise buildings may better prepare responders, thus more empirical analysis is warranted.

Norman, John. 2005a. "Private Dwellings" *Fire Officer's Handbook of Tactics*, 3rd edition. Penn well Publishing, Tulsa, Oklahoma: 271-280.

Because fires in private dwellings make up the majority of structural fires in the United States (more than 70% of fires annually), this chapter focuses on fires in one and two family homes. The chapter goes into detail regarding the deficits in design and construction that make private dwellings susceptible to the spread of fires. Some major problems consist of open stairways that channel the fire upwards toward exposed areas and occupants, the lack of code requirements for the interior of homes (for example, flimsy sheets of wood being nailed over wood studs to create a partition), and common habit of leaving home doors ajar, exposing greater floor space. This chapter goes into detail on how ventilation should be conducted in private dwellings and points out that if fires have not extended into an area directly under a roof, horizontal window ventilation would be sufficient rather than having to cut away at the roof. This chapter also provides detail on how to best cut away at roofs for ventilation purposes, as well as to provide safety for all members performing ventilation tasks. It also explores common problems encountered during this task (such as the presence of solar heating panels and satellite dishes). This chapter offers insight on mitigating the risk to residential structures (physically and behaviorally) in an age where such fires are still a great concern in the US. This chapter appears to be targeted to practitioners, yet may be of interest to safety cautioned home owners as well.

Tremblay, Kenneth. 1994. "Catastrophic Fire Deaths: The Numbers are Back Up." ***NFPA Journal*** **(September/October): 88-109.**

Because catastrophic fire deaths are a concern in fire science literature (Badger 2005), Tremblay examines this topic through analysis of incidence as well as by case study. Catastrophic multiple-death fires (those that kill five people or more in a nonresidential structure or three or more outside of a structure) increased from 1992 to 1993. However, the 51 deaths are still a lower figure than deaths from 1968 to 1991. From these 51 deaths in 1993, 31 were in residential properties, 8 were in nonresidential, and 12 were outside of structures. This number of deaths from residential properties in that year was the second highest in the past seven years. The 1993 Waco fire is mentioned, because the 77 deaths (47 of which were directly due to fire) caused a media frenzy. Many bodies were discovered in groups, with adults having the appearance of trying to protect the young. Main causes of death included smoke inhalation, asphyxiation, and burns. Another significant fire in 1993 was in the Paxton Hotel in Chicago, which led to 20 deaths. Problems with the building included violating their license, a delayed alarm, collapses that delayed rescuers, security bars trapping victims in the building, and lack of interconnecting smoke detectors or sprinklers.

The types of properties in which catastrophic fire deaths occur are mentioned (single-family, duplexes, apartments, hotels, and dorms) and several reasons for catastrophic fires igniting are given (children playing with lighters, candles left unattended, matches or open flames being misused by kids or adults, space heaters, stoves, and other – less common – incidences). The major social issue that is mentioned as a causal factor is poverty. Especially for those in urban areas, the need for protection (bolts, door locks, bars on windows, etc) is also what traps people in burning structures. In one incident, candles were burning because the electricity was shut off.

A lack of smoke detectors is a major factor in multiple-death residential fires. Missing or dead batteries are always an issue, as is the location of the smoke detectors (such as the kitchen, which is an inappropriate place). In 1993, approximately half of the homes reported to have fires did not have detectors (16 of 31). Children are mentioned as having a higher risk of death from fires because of their inability to respond and evacuate. An article was inserted within this article about child-resistant lighters (and how a safety standard was implemented in 1994). A downward trend in general is noted for catastrophic multiple-death fires. The year 1993 was no exception to this trend, with 39 deaths from 8 fires. The 1993 World Trade Center bombing is mentioned, recalling that only 1,000 of the 150,000 people within the towers were found injured. Nonstructural fires are also briefly included, and a few incidents in vehicles or aircraft are explained.

Although comprising a small proportion of fire deaths annually, multiple fire deaths are a significant concern in the fire industry, especially in light of recent events such as the Station Nightclub Fire in Rhode Island in 2003.

U.S. Department of Homeland Security. 2002c "Medical Facility Fires". U.S. Fire Administration National Fire Data Center *Topical Fire Research Series*, Vol. 2, No. 8: 1-6
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v2i8.pdf (accessed 4-25-06).

Through use of NFPA and NFIRS data, this article offers analysis on the incidence of and factors related to medical facility fires. An estimated 2,500 fires occur each year in medical facilities, resulting in $8.7 million in property loss. Eighty-nine percent of medical facility fires occur in hospitals with an additional 10% occurring in clinics. Injuries per medical facility fire are four times greater than that of all U.S. fires with two-thirds of injuries resulting from smoke inhalation. The leading cause of medical facility fires is cooking, with the kitchen as the leading area of fire origin. Most medical facilities are equipped with smoke alarms or sprinklers or a combination of both. Fires in medical facilities are most likely to peak during the months of January and February (similar to many residential fires in the U.S.) and occur more often during the work week. Because little literature has been uncovered on fires in this type of facility, future analysis on socio-economic status of areas in which medical facilities are located, as well as the age of structures may enhance an understanding as to causes for and response to these events.

U.S. Department of Homeland Security. 2004c. "Restaurant Fires." U.S. Fire Administration National Fire Data Center *Topical Fire Research Series* Vol. 4, No. 3: 1-5
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v4i3.pdf#search=%22Restaurant%20Fires%22 (accessed 5-7-06).

This article focuses on U.S. restaurant fires in 2002. An estimated 7,100 restaurant structure fires caused 108 civilian fire injuries and $116 million in property loss in 2002. Less than one-third of these fires occurred in an area known to have a fire alarm and less than half occurred in an area with sprinklers or automatic extinguishment systems. Most restaurant fires were caused by cooking (64%). Cooking materials such as grease and oil were usually the items first ignited. However, restaurant fires are usually confined to the object first ignited (70%). Restaurant fires present a unique risk because such structures generally have large crowds of people present in one area, however, restaurants are also equipped with fire extinguishers and most fires are put out before there is much damage. Restaurant fires generally cause more property damage than regular structure fires, but less property damage than average non-residential structure fires. The peaks for incidence of these fires follow the hours that restaurants are opened. This report also details some of the regulations specific to restaurants.

U.S. Department of Homeland Security. 2004d. "School Fires."

US Fire Administration National Fire Data Center *Topical Fire Research Series*. Vol. 4, No. 6: 1-5
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v4i6.pdf#search=%22School%20Fires%22 (accessed 4-28-06).

This piece examines the prevalence of school structure fires in 2002. Approximately 37% of all school structure fires and 52% of middle and high school structure fires were considered suspicious, with the second leading cause of such fires related to cooking. There were an estimated 14,300 school fires in 2002. Fatalities during these school fires are very rare, with none being reported in 2002. Injuries, however, were higher for school fires than regular non-residential structure fires. The leading area of fire origin was the lavatory. Nearly half of the fires remained confined to the object where they started, such as a trash can. The most commonly ignited items were paper, plastic, wood, and fabric. Fires peaked in July, perhaps because fewer faculty members were present resulting in less of a chance of being caught. It was uncovered that 78% of these school fires occurred during the week, with 55% of total fires occurring between the hours of 8 am and 5 pm. It is proclaimed these fires may be preventable with increased supervision, outreach, and education about fire safety.

U.S. Department of Homeland Security.2006b. "Confined Structure Fires". U.S. Fire Administration National Fire Data Center *Topical Fire Research Series*, Vol. 5, No. 8: 1-5
http://www.usfa.dhs.gov/downloads/pdf/publications/confined-structure-fires.pdf (accessed 6-11-06).

This report marks the first time confined fires were analyzed according to the report. Confined structure fires are defined as small incidents of fire confined to noncombustible containers and there is no flame damage beyond the container. There are six specific types of contained fires: cooking, chimney/flue, incinerator, fuel burner, commercial compactor, and trash/rubbish. Such fires have low rates of serious injuries or large content loss. Studies of unreported fires show that confined small fires are usually studied in order to present a clearer picture about fires that are not reported. Such small fires are not reported to fire departments and as a result are not reported by fire departments to NFIRS. However, even small fires are worth analyzing because all fires start out small.

According to analysis of 2002 NFIRS data confined fires account for 38% of all reported residential fires. Most of these fires are related to cooking (57%). Approximately 52,000 confined fires were reported in 2002 resulting in only 3 deaths and about 500 injuries. Property loss related to confined fires is generally small, although sometimes the "container" of the fire is an oven or furnace which is expensive to replace. Only 3.3% of these fires spread beyond the container, however, these fires had the highest total property loss. Most contained space fires occurred in residential buildings as opposed to educational buildings, storage facilities, businesses, and industries.

Human factors also come into play with confined structure fires. Unattended heat or unsupervised activities cause confined structure fires most frequently. Other human factors include sleeping, drug/alcohol use, and mental or physical disability. There is a peak in confined structure fires during the winter months when buildings require heating. These fires also tend to peak during the lunch and dinner hours when people are more likely to be cooking. Information about alarms was present in about 53% of fires, and of this 53% the alarms went off 63% of the time. The little research conducted warrants future analysis to see how these findings may be consistent in future time periods, as well as cross nationally.

Wutz, Thomas. J. 2000. "Building Construction." ***The Firefighter's Handbook: Essentials of firefighting and Emergency Response,*** **Sandy Clark ed. Delmar Thomson Learning, United States: 322-344.**

This chapter gives a brief overview of the types of building construction in the United States in which firefighters engage in suppression tactics. However, the author also provides a warning that these broad classifications are dangerously incomplete for firefighters and may lead to deadly assumptions about a particular building. The five types of constructions are: 1) Fire-Resistive Construction, 2) Noncombustible Construction, 3) Ordinary Construction, 4) Heavy Timber Construction, 5) Frame Construction 6) Factory Built Construction. This chapter discusses the materials in construction, fire effects on combustible materials (such as steel, concrete, and masonry), as well as void spaces in construction. The chapter ends with a lessons learned section stating that firefighters must know and understand the buildings that fires take place and the fire resistance of each building. For firefighters, knowledge of building construction is highly valuable information for fire suppression. This piece (as well as Brannigan 1997) exemplifies this reality.

EMS:

Walter, Andrea A. 1999 "Emergency Medical Services" ***The Firefighter's Handbook: Essentials of Firefighting and Emergency Response,*** **Sandy Clark ed. Delmar Thompson Learning, United States: 651-678.**

Walter reviews the role, responsibilities and activities of EMS personnel when they respond on site to an emergency. The safety for those injured, either civilians and/or professional emergency responders is proclaimed to be the primary responsibility of EMS personnel. Other topics such as legal considerations, analyzing emergency scene for safety, infection control, assessing a patient, and emergency care are presented in clear detail. Walter gives a thorough yet accessible understanding of the duties and actions of those in the EMS profession.

Case Studies

Accardi, Russell. 1997. "Search Operations at Building Explosion and Collapse." ***Firehouse*** **(October): 88-92.**

This article provides a personal account of the roles that FEMA's US&R FL-TF1 and FL-TF2 taskforces had at the Huberto Vidal explosion on November 21, 1996 in San Juan, Puerto Rico. The initial blast left 18 people dead, 80 injured and at least 30 missing. Before any US&R personnel had arrived at the scene, all surface and lightly trapped victims had been removed by local authorities. The article goes into detail on debris removal tactics that were taken along with search techniques utilized, such as equipment used and the role of canine units on scene. US&R taskforces along with local authorities in Puerto Rico extricated a total of 10 people and located an 11th victim. The most challenging aspects of the scene were reported as integrating the US&R search efforts with the existing efforts already taking place by the local agencies at the scene. This article offers a detailed account of search and rescue activities at a high profile event for those unfamiliar with these teams.

Comeau, Ed. 2002. "Searching for Survivors." *NFPA Journal* (January/February): 62-63.

This article focuses on FEMA US&R taskforces and provides the following basic information on the teams: There are 28 taskforces consisting of 62 members with at least two canine handlers. The equipment cache of each team weighs 60,000 pounds, costs approximately 1.4 million dollars, and contains 16,400 pieces of equipment. The article focuses on the response of US&R taskforces at the World Trade Center (WTC) and the Pentagon on September 11th. Twenty six of the 28 task forces were deployed in response to these attacks. Taskforces set up a base of operations upon reaching the scene and began coordinating their efforts with the New York City Fire Department at the WTC incident. Taskforces at the WTC worked in two shifts, a day shift and a night shift. The initial assignment of the taskforce was to triage the area, to determine the scope of the disaster, the types of buildings involved, and the best places to deploy task forces. After this initial assessment, their activities centered on identifying void spaces, shore these void spaces, and searching them. The article mentions unique challenges teams faced at the World Trade Center such as dealing with the amount of debris needed to be moved and the enormous quantity of dust that presented health hazards to teams on scene. Lessons on how to strengthen US&R teams' capabilities as well as better prepare for and respond to future disasters in the aftermath of the attacks developed, including the need for additional funding, equipment and training are offered. This is a brief yet informative assessment of the US&R presence on site at WTC in the aftermath of 9/11.

Conboy, Mickey. 1997. "Statewide Response to Worker Trapped in Building Collapse." *Firehouse* Vol. 22(June): 50-56.

This case study on a specific structural collapse opens with a story about a building collapse trapping a demolition company's employee, forming a void in which he waited for rescue. The demolition company initially declined assistance, but later realized they did not have the supplies and equipment to free the man. The Sheridan Park Volunteer Fire Company responded and set up the IC post. The NY Office of Fire Prevention and Control, the Erie County Dept. of Emergency Services, the Buffalo Rescue Company 1, and Battalion Chief Ray Downey were among those asked to assist in rescuing the individual. Cold temperatures developed, complicating rescue of the one employee. As a result, a torpedo heater was extended down (with a tube) to heat the victim. The medical status of the victim was carefully watched. The victim was fed through an IV tube and was even able to communicate with his girlfriend and co-workers through the use of a portable radio. The victim was rescued after 14.5 hours from the void space and suffered only bruises and cramped muscles. This article provides a summary of extrication from a building collapse, and explains how different agencies worked together and compiled different experiences and expertise to remove the trapped victim. After this event occurred, the authorization was given for the formation of a

US&R team in New York State. This is an important article, due to the fact that it highlights how actual rescue experience serves as an impetus to the development of search and rescue capabilities in a region.

Murphy, Stephen. 2001. "ARFF Crews Respond to the Front Line at Pentagon." *NFPA Journal* (November/December) http://www.nfpa.org/publicJournalDetail.asp?categoryID=&itemID=20904&src=NFPAJournal&cookie%5Ftest=1 (accessed 6-8-06).

This article examines the Aircraft Rescue Firefighters (ARFF) teams who responded to the Pentagon 9/11 attack. The ARFF were responding to a vehicle accident at the time of the terrorist attack coincidently, permitting them to be among the first responding units to the Pentagon on 9/11. As a result, they were able to set up directly in front of the site of impact at Pentagon. Their foam units stopped most of the flames within minutes of arrival, which helped establish safe evacuation and save lives. These units are described as being right responders in the right place with the right equipment. The article describes the response, and how the Foam Unit 331 was used to control the fire. The structure of the Pentagon is also explained in measurements. This piece highlights the practical experiences of a unique set of firefighters in a historic emergency response situation.

Peterson, Clinton. 1998. "1998 Ames Fire Department Response Time Study." NFIRS Executive Fire Officer Program.

The purpose of this research report is to analyze the current response times of the Ames Fire Department, to make recommendations for insufficiencies found, and update the analysis of the Ames Fire department, which has not been done since 1984. The report compares historical trends and population predictions for 1975, 1995, and 2015 by growth, acres, population, and housing units. The population increase (9%), the increase in response calls (59%) and the total call decrease (9%) are all included. Fire station locations in the community of Ames are also updated.

The literature review looks primarily at the effect standards response times have on fatalities and property loss. The ideal response time for arriving at a scene is five minutes from the time the alarm sounds. This time frame is "the determining factor" as to whether the incident will be considered large or controllable. Training and community concern/pressure can help lower response times. The research report also looks at flashovers and the time required for flashover in structural fires with a standard fuel type and the role of synthetic furniture in fires, which increases the heat, making the situation more dangerous by weakening the truss components of a structure and leading to sudden collapses.

A chart included displays population and emergency calls received by the Aims Fire Department between 1983 and 1997. There is a 10% population increase, and over a 250% increase in total calls. Another chart then projects the population and calls or fire calls received up until 2015. This shows an 11% population increase with an approximate 76% increase in total calls (a 31% increase in just fire calls).

The article explains that the city of Ames is planning on shifting from a "local commercial center" to a "more regional scope," thus changing the zoning department plans. Interestingly, the train traffic increased in Ames from 1998 to 1999, making the time daily crossings are closed around 19%. Delays such as this are considered in response times also. Sight sharing partners are mentioned as a way to spread the fire department throughout the city. GIS was used in this study to determine the locations for the existing and proposed stations. Test runs were conducted to calculate responses within five minutes in terms of the neighborhoods and acres covered. In terms of the neighborhoods covered, with the current stations: 81% of neighborhoods (in current city limits) are within the 5-minute response area, and within the Ames district, 70% are within the 5-minute response goal. With the current stations and railroad crossings closed, 78% of neighborhoods within the current city limits will be within the five minute response area as will 68% within the Ames District. The report also provide statistics for other scenarios, such as one station staying open with the other one closing, two new stations being built, of the creation of four new stations.

The author asserts that since Ames has grown in terms of residential and commercial use of truss construction, risk is increased and quick response time is especially important. Site sharing partners can reduce costs, and train crossings pose a delay in response times. The report concludes by advising that future research consists of recommendations for new station construction (design, costs, preparation, etc). The recommendation is also suggested to close Station 2 and build the three new stations. This is a good example of how a local region assesses its own issue with response, leading to recommendations for improvements.

Process of Fire Fighting

Dodson, David. W. 1999. "Firefighter Survival" *The Firefighter's Handbook: Essentials of Firefighting and Emergency Response* Sandy Clark ed. Delmar Thompson Learning, United States: 680-696.

Dodson discusses several facets of incident preparedness, safety, and treatment of injured firefighters reveals the many dangers they face while answering an alarm. Dodson covers such basics as mental and physical readiness, such as "does the firefighter feel ready to respond". In regards to safety, personal accountability or an understanding of where firefighters are during an event can help keep track of personnel who may be in danger. A facet of accountability is an understanding of each respondent's duties in relation to the fire on scene, which also enables people to be aware of those in danger. Such basic components of safety as rest, hydration and nourishment are discussed. When danger does occur, Dodson discusses processes for escape that may save lives; firefighters must be cognizant of their surroundings and preplan an evacuation route if necessary. Variations on the escape plan such as room, roof/balcony and self rescue are highlighted. Also, how to treat injured or trapped fire fighters is major concern for those dealing with onsite hazards, according to Dodson. A contribution here is the inclusion of Critical Incident Stress (CIS); Dodson discusses the need for firefighters to address thoughts and stress resulting from incidents where tragedy or great stress has occurred. Dodson gives a general overview of the concerns of firefighters on scene, and how these are relevant to the process of firefighting.

Dunn, Vincent. 1992. *Safety and Survival on the Fire ground*.

Fire Engineering Books and Videos, Saddle Brook, NJ.

Dunn covers a variety of dangers and hazards the average firefighter faces while engaging in fire related activities on scene, as well as in transit. Such hazards as structural collapse, aerial ladder climbing, propane gas, cellars, responding to or leaving a fire, and outside venting are addressed. As well, the diverse ways in which fire and smoke can harm firefighters (back drafts, flashover, rollovers, weakening structures leading to collapse, and disorientation) are discussed. In regards to collapse, Dunn discusses the importance of establishing collapse danger zones to attack fires. These are areas where fire engines establish lines of attack with hoses outside the region where collapsed structures may fall on them. This awareness of collapse is a recurring danger for firefighters, one that is evidenced through such actions as these to mitigate exposure to harm. As well, the types of collapse (V-shaped, pancake, lean to, and tent-floor) are addressed, with Dunn offering insight into void spaces that develop in these where survivors may be rescued. Information on search and rescue discusses the standard practice of primary and secondary searches; primary involves a quick search for survivors while the fire still is occurring, a secondary search occurs after the fire has been fully suppressed. Dunn crafts a fine text that reveals the dangers inherent in many duties engaged in by firefighters. This is a valuable resource for practitioners.

Norman, John. 2005b. "Firefighter Safety and Survival" *Fire Officer's Handbook of Tactics* 3rd Edition. Penn Well Corporation, Tulsa, Oklahoma: 247-270.

In this chapter of *Fire Officer's Handbook of Tactics* Norman discusses factors of fire suppression mitigation that may assist in the survival of firefighters engaged in such activities. Norman discusses hazard awareness, or rather the ability for firefighters to recognize dangers and methods in which to protect themselves. An understanding of the type of structure, the number and location of occupants prior to entering a structure, as well as location of a fire may aid in preventing harm to firefighters. Tips on escape training for firefighters, such as how to become untangled in SCBA gear are discussed in hopes of preventing fire deaths of professionals. Firefighter accountability, the understanding of where firefighters are as well as a method in mitigating fire deaths is discussed. Roll calls as promoted by Norman as a tool to ensure accountability. Rapid Intervention Teams (RIT) is promoted as a resource to rescue firefighters in danger. Along with this, methods of removing unconscious fire fighters are reviewed, to inform the reader of proper methods to conduct such behavior on scene when the need arises. This chapter offers practical information on mitigating dangers associated with firefighting for practitioners.

Sardqvist, Stefan and Goran Holmstedt. 2000. "Correlation between firefighting operation and fire area: analysis of statistics." *Fire Technology* Vol. 36, No. 2: 109-130.

Sardqvist and Holmstedt present quantitative analysis on fire detection, the arrival of fire brigades and their relation to mitigating the spread of fires, using 307 non-residential fires in London as a data sample. The six types of structures this study focuses on are: public and commercial premises, schools and hospitals, industrial premises, and hotels and boarding houses. Detection of fires, notification of fires and the arrival of fire

brigades, and how these factors relate to the spread of fires are assessed. The physical aspects under examination are "the area of fire-spread"; fatalities are not included in this analysis. Findings reveal that fires rarely spread once fire brigades arrived on scene. The time at which a fire is initially attempted to be put out, correlates highly with the final level of damage. There was a positive correlation with the fire area when discovered and the final fire area, as well as the fire area upon arrival and the final fire area. These findings support the arrival of fire brigades and their actions in mitigating the spread of fires. Conclusions drawn in the summary are listed as the following: 1) 2/3 of fires were apparently accidental, 2) half of fires were detected by seeing or smelling smoke, 3) fire alarms failed 20% of the time, 4) half of the fires had fire area equivalent to the area at detection (75% of cases had the final fire equal to the area of the fire upon arrival), 5) the hypothesis that time between ignition and intervention is correlated with fire area was not supported (except in cases where the fire is still spreading), 6) total water demand was proportional to the fire area, 7) sprinklers controlled or eliminated 17 of 21 fires, and 8) there is additional research still to be done in this area. This report reveals the importance of statistical analysis on the validity of fire mitigation efforts, uncovering key factors that may assist in controlling the spread of fires in structures.

U.S. Department of Homeland Security. 2006c. "Structure Fire Response Times" U.S. Fire Administration National Fire Data Center *Topical Fire Research Series,* Vol. 5, No. 7: 1-5
http://www.usfa.dhs.gov/downloads/pdf/tfrs/v5i7.pdf#search=%22Structure%20Fire%20Response%20Times%22 (accessed 5-3-06).

Response time of fire departments is often a factor impacting quality of service on scene. The concept of response time is examined, such as the actual conceptualization of this construct. In the fire service, response time is viewed as the time difference between when the call came in to notify a station of a fire emergency and when the first fire truck arrived on scene. To the general public, response time means the time difference between when people become aware of the fire and when the firefighters arrive on scene. This article, however, perceives response time as the time span between when the fire is ignited and extinguished. To examine response times nationally, NFIRS 5.0 data from 2001 and 2002 were analyzed. Across the country, regardless of the season or time of day, response time is generally under 5 minutes for about 50% of incidents in the U.S. Nationwide, the 90th percentile response time is less than 11 minutes. In examining geographic regions of the U.S., the northeast has the quickest response time, while the west has the slowest. Response time appears to relate to population density according to this research. As population density increases, fire stations cover less geographic area, generally causing fire response times to decrease. This piece is informative, in its examination of factors that impact fire station response times.

Fire-related Emergencies:

Norman, John. 2005c. "Fire-related Emergencies" *Fire Officer's Handbook of Tactics,* 3rd edition. Penn Well Corporation, Tulsa, Oklahoma: 363-385.

Norman discusses emergency incidents that involve firefighter response, yet where no fire is present. Such potential dangers as gas leaks, oil burners and incinerators are discussed, as well as the fire service response to such hazards. Norman provides a descriptive analysis of the process in which natural gas is shipped and distributed. As well, tactics on how to manage outside gas leaks (i.e. notify gas company, search and ventilate) are discussed. Various types of oil burners are reviewed as well as methods in which to control such hazards if they become lethal. Norman states that controlling the power source for such dangers are important, as well as using an extinguisher and ventilating impacted areas. Response to carbon monoxide alarms are addressed as well. Norman offers insightful advice and lesson learned knowledge for firefighters dealing with these non-fire events.

Building Collapse

Collapse

Collins, Larry. 2005a. "Ready to Crumble: A Guide to the Basic Kinds of Structural Collapse." *Frontline First Responder* Vol. 3, No. 3: 27-28.

This article acknowledges the various patterns of collapse that may occur in structures, those which firefighters must recognize when engaged in fire ground activities. Causes of pancake collapses include: explosions, a heavy imposed load, and earthquakes amongst others. If there are voids created (under strong structural items – beds, desks, etc) they usually are large enough for a person to survive. Due to their appearance, pancake collapses are sometimes misidentified as total collapses. This leads to the assumption that there are not survivors, when in reality many survive for days. The article suggests that US&R efforts should be continuous until all possible voids are searched. Mid-story collapses are structures that have different durability and strength levels where only the middle of the building resembles a pancake collapse. In lean-to collapses, events similar to the causes of pancake collapses occur and collapse a wall (into a sideways V shape). Voids are usually between the lines of the "V" and beneath a sloped roof or floor. The difference in a V-shaped collapse is that the middle of a floor will cave in to the next level, with people and objects stuck in the center of the V. Renovation accidents, fires, or earthquakes often cause these collapses. A tent or A-frame collapse is when an interior wall in the center is the only thing left to hold up a building, and a tent shape is formed. Survivors are often inside the tent shape. A 90-degree collapse is when walls fall flat (which is usually the exterior walls falling outward). Due to a poof of air when falling, a wall sometimes falls far from the building. In a curtain fall collapse, the materials holding a wall together is destroyed and a pile of debris is formed. Cantilever collapses are when the roof and/or floors are unsupported due to a wall being destroyed. These are highly dangerous, as the collapses may occur suddenly. Attempting to stabilize the building is risky and difficult. During an inward/outward collapse, there are wall fractures horizontally, which lead to chunks of the wall falling (inward and/or outward). Progressive collapses are similar to a domino effect, where one collapse leads to another. The article wraps up by reiterating one must have as much knowledge as possible on types of collapses and the likelihood of where to find victims before responding to a collapse situation can help save lives. This is a valuable resource to those dealing with collapse and search and rescue.

Downey, Raymond. 2001. "Types of Collapse." *WNYF*: 10-11.

This piece, similar to Norman (2005a) examines major forms of structural collapse. Downey, (a high profile NYC firefighter lost on 9/11) lists five types of building collapse: V-shape, A-frame or tent, lean-to, unsupported lean-to, and pancake and gives a short description of each. In order to be able to identify voids created and ways to access those trapped, it is important to know what type of collapse occurred. In v-shaped, the center support is compromised and the structure collapses in a "V" shape, which is where victims usually are. In an A-frame or tent collapse, there is center wall support, but connected buildings and all three walls may be dangerous. Lean-to collapses happen when one side of the structure falls inward. This may have to be shored for protection. The unsupported lean-to (or cantilever collapse) is very dangerous as it is not attached or supported. Falling debris and additional collapses are potential risks. The pancake has the fewest void spaces, since it amounts to a pile of debris. This is brief yet helpful synopsis of types of collapse that would be helpful to one unfamiliar with these types of events.

Dunn, Vincent. 1988. *Collapse of Burning Buildings: A Guide to Fire ground Safety*.: Penn Well Publishing Company, Saddle Brook, NJ.

In recognition of the lack of relevant literature on structural collapse, this book seeks to set forth a guide on dangers associated with these structures firefighters should be aware of. The introduction offers various reasons on the lack of information on building collapse (small benefit to people outside fire industry, inability of fire service to analyze reasons for collapse, no standard definition for collapse, and lack of departmental documentation and records of collapse). The book provides information on building structure, the varied fire resistant types of building construction, and information on possible ways in which structure collapses. Building types are broken down according to materials used (wood, metal, brick) in order to help understand how these structures may react to fire and collapse. The book includes real life fire suppression scenarios that highlight factors influencing collapse of building. This work offers more information on collapse than Brannigan (1997) and also appears to be easier to digest due to its less detailed synopsis of building structures. This book provides lessons learned at the end of each chapter for behaviors that can save lives and limit exposure to risk of collapse. There is discussion on search and rescue in collapse, focused on rescuing firefighters as well as basic schematics on the steps of S&R in collapse; Diagrams are used in order to provide illustrations of voids where trapped victims could be hidden. This book would be useful in simulation modeling due to its valuable information on formations of buildings collapse.

Norman, John. 2005d. "Structural Collapse" in *Fire Officer's Handbook of Tactics*, 3rd edition. Penn Well Publishing, Tulsa, Oklahoma: 387-412.

Because structural collapses are often swift, deadly, and can occur with little warning, they are among the most feared occurrences during fires. Structural collapses account for a large percentage of multiple casualty incidents, although they are not a common occurrence. In this article, the author goes into detail on the causes of structural collapse such as: structural weakness due to faults in design, workmanship, and improper renovations; fire damage to wooden structures; the heating of unprotected steel; the cooling of highly heated cast-iron columns or facades; explosions of fuels, explosions from back draft; overloading of the floors and the expansion of absorbent materials; overloading of the floors and roof; cutting or removing structural members during overhaul; and vibration and impact load. The article also goes into detail regarding a number of collapse indicators to look for in order to make sure that the building is not in danger of collapsing as well as the steps to take when establishing collapse zones, on the chance that a collapse has been recognized.

In the event of a collapsed structure a rescue plan must be put into place. There are five stages to a collapse rescue plan: reconnaissance, accounting and removal of surface victims, searching voids, selected debris removal and tunneling, and general debris removal. The article concludes with a checklist of safety precautions to take during collapse operations. This chapter offers valuable insight to practitioners on how to recognize signs for collapse as well as safety precaution that may help save their lives in such a situation.

Smith, James P. 1997. "Building Collapse Indicators" *Firehouse* (April): 28-35.

Smith, similar to Norman (2005d) examines indicators for collapse, the knowledge of which may save firefighter lives. In many incidents, it was realized, only after a collapse occurred, that seemingly unrelated indicators contributed to the collapse. The article outlines many indicators that could lead to a potential building collapse. Collapse indicators involving fire conditions include: two or more floors fully involved, continued or heavy fire, and high heat and heavy smoke conditions coupled with inadequate ventilation. There are also a number of construction features that should be considered as collapsed indicators including unprotected stool columns and beams exposed to heavy fire, expansion of structural steel being attacked by the heat of the fire, unprotected lightweight steel and steel bar joist roofs subjected to heavy fire conditions, and fire burning in an area containing lightweight wooden building components. The article identifies a number of exterior wall components that can contain a multitude of collapse indicators. Typical wall collapse indicators are: smoke showing through walls, fire showing through walls, old wall cracks enlarging, new wall cracks, building walls, leaning walls, failure on the part of a wall, visible spalling of a brick wall, spalling of concrete and exposing of steel, a wall breaking down under a hose stream and wall spreaders. This information would be valuable to practitioners.

Safety aspects of responding to a building collapse

Brennan, Tom. 1995. "More Reasons That Collapse on the Fire ground Should Not be a Surprise." *Fire Engineering* (March): 222.

Brennan discusses factors that may inform firefighters of potential collapse while engaged in fire suppression. Brennan makes reference to more serious (referred to as "Mayday") situations where responders inside the structure may need to leave than more orderly evacuations from a building collapse. The following are signifiers of potentially hazardous "mayday situations: a partial collapse, the finding of severe cracks in the structure, bulges or leaning walls, distortions (when the shapes of openings in the buildings change from their normal positions), and when individuals are within the collapse area of a building that may collapse. Firefighters are to be cognizant of such signs in their profession in order to better prepare them to save the lives of others as well as themselves. This is a very brief piece that may be valuable to those unfamiliar with structural collapse.

Brennan, Tom. 2000. "Collapse: Movement of the Structure." *Fire Engineering* (June): 136.

Brennan discusses the variety of indicators (physical components assessed after collapse during a size-up) that foretell possible impending collapses. Prior to engaging in search and rescue, it is important to understand signs concerning a secondary collapse. Structural factors such as unusual building movement, moving cracks in the structure, and wall bulges, often due to moving steel supports are significant factors to be aware of while conducting search and rescue. Often firefighters may not recognize these signs immediately because many buildings creak, have cracks, or may even have slight bulges. Brennan argues that these should be easily distinguished from the dangerous building characteristics, and to identify these as red flags for professional emergency responders.

Naum, Christopher 1994. "Collapse Incident Marking Systems for Structural Triage and Search Operations" *Firehouse*, Vol. 19, No.2: 32-39.

Naum presents various methods of marking systems, which may be used for structural triage as well for search and rescue marking. Search and rescue of collapsed structures often proves problematic for many emergency professionals such as fire service, professional search and rescue, as well as others charged with searching and extricating victims of collapse. Marking systems utilized on scene often pass along relevant information of the search process, making it easier to manage the process. Structural triage assists professionals in identifying those factors that need to be addressed in search, such as where search has occurred, where to continue to search, as well as possible concerns for search. According to Naum such systems of marking searched areas create a level of efficiency which is needed to ensure safety of emergency professionals, and prohibit access of unwanted individuals. Naum's conception of structural triage encompasses: the naming of and awareness of collapsed structures within a designated incident perimeter, a quick evaluation of impacted areas, as well as the identification of structures that may collapse, warranting the attention of rescue professionals. The preliminary assessment of each structure is intended to uncover structural conditions, probable occupancy type, and knowledge of entry points into interior regions of the impacted structure. Naum offers several factors that professionals must be cognizant of when developing strategic planning and logistics for tactical deployment: occupancy of collapsed structure, cause of building collapse, time of day, scene intelligence, search and rescue resource availability, and structural condition of the building. In practice, the marking system used consists of a two by two inch square box spray painted near an entrance of a collapsed structure, intended to notify emergency professionals of this much needed information.

Naum, Christopher. 1997a. "Collapse Incident Marking Systems for Structural Triage and Search Operations: Part 1." ***The Voice*** **Vol. 26 No.3: 10-11, 17-20.**

Naum discusses the importance of a formalized structural triage marking system in passing along important information on parameters of the search and rescue process of collapsed structures. Communication between incident command and those engaged in search and rescue is needed to pass along information about the status of searched buildings. A triage allows the incident management team to prioritize incident parameters, assess the situation in its entirety, determine resource commitment requirements, and create operational deployment and task assignments. The three basic steps of structural triage involve the location of buildings in collapse, rapid assessment of these structures, and determination of which buildings need further assessment. Such factors as structural conditions, building type, and entry points should be gathered in an initial assessment. Other factors are incorporated into the S&R deployment in evaluating the situation: reason for occupancy, how the building failed, the time of day, data or other evidence gathering, resources available, and conditions of the building. Naum offers seven examples of marking systems often used to confer information in the field. Structural triage is an important component of search and rescue, one needed to create an efficient process of searching for victims making optimal use of resources in the field. Naum provides basic, yet helpful advice on safety issues for practitioners who engage in search and rescue activities.

Naum, Christopher. 1997b. "Collapse Incident Marking Systems for Structural Triage and Search Operations: Part 2". ***The Voice*** **26 Vol. 26, No. 5: 9, 20.**

Structural triage and incident marking systems are a relevant component of searching for victims of collapsed structures. In this piece, Naum describes in detail steps on how to compose these markings. When entering a structure one makes a single diagonal slash upon leaving a structure one should mark an "X", to notify others that they searched this structure. If a secondary collapse occurs professionals will know possible locations of fellow searchers. Other symbols may be utilized in a search to connote the status of the response, such as the date, as well as if people were found dead or alive. These are important methods for search and rescue that are considered standards for US&R task forces.

Smith, Michael. 2001. "Collapse! Incident Command at a Building Collapse." ***Firehouse*** **(March): 62.**

Smith discusses the important function of incident command on scene, specifically its ability to mitigate harm to firefighters and civilians. Collapsing structures pose a great threat to many due to the presence of heavy materials, which may impede the survival of civilians, aided only by the formation of voids. Smith stresses building evaluation along with restraining the impulse to enter a burning structure as a solution to ensuring safety of civilians and firefighters. Prior to entering a burning structure, interviewing witnesses may produce information on areas of structures that were inhabited prior to collapse. Also, control points are stressed by Smith to be erected around the area to allow rescuers access to the site, and prohibit outsiders. The timeliness of establishing incident command is discussed; Smith states that ICS should be established soon upon arrival to ensure full use of resources on site. In terms of recovery for firefighters, having an area where responders can recuperate and rest is important to the success of the response. These few points on incident command system and search in a structural collapse highlights the importance of command on scene to ensure the safety of all actors on site.

Fire Rescue:

Collins, Larry. 2005b. "Structure Collapse S&R Operations" *Technical Rescue Operations Volume II: Common Emergencies*. Penn Well Corporation, Tulsa, Oklahoma : 53-124.

Collins discusses the various causes of structural collapse, the forms in which they take shape, the process of searching within a structural collapse and safety measures during rescue activities. Such natural hazards as earthquakes, heavy winds, floods and mud slides as well as natural/man made events such as explosions (i.e. natural gas, terrorist) have the ability to cause damage to a structure and may cause that structure to subsequently collapse. These are concerns for professional search and rescue workers, as are structures weakened by fire which call for search and rescue. The standard types of structural collapse reported by Collins are the V-shaped, pancake, lean-to collapse, tent or A-frame collapse, the 90 degree collapse, curtain fall collapse, and the cantilever collapse, inward/outward collapse, and the total collapse. Collins offers suggestions on how to conduct search and rescue operations in the face of such events by looking for void spaces that result from each type of collapse. V-shaped collapses occur when the center of a floor weakens and falls, yet the sides remain in tact forming a V shape. Voids will develop on either side of this V formation, creating spaces for survival. Pancake collapses can create voids if an object such as furniture blocks the falling floor from above, permitting survival. Rescuers can enter the void area by searching each floor as they descend, or by cribbing or shoring one's way into the voids. A lean-to collapse occurs when one side of a floor collapses, yet the other remains intact. This creates a diagonal frame, permitting a void for survival. An A-frame occurs when beams collapsed near outer walls, while an interior beam supports the center of a floor. Void spaces are created on either side of the interior beam, spaces that can be searched for human life. In a cantilever collapse, an outer wall collapses, while a roof and upper floors remain intact. These types of collapses are difficult to manage because trapped individuals are in danger of having the remaining structure collapse on them. Stabilizing a cantilever structure is a priority in order to engage in search and rescue. In addition, look outs are often utilized to warn professionals of impending danger. Collins also discusses the five stages of search and rescue. 1) response, size up, and reconnaissance 2) surface rescue 3) void-space search 4) selected debris removal 5) general debris removal. Collins offers practical advice for firefighters on how to engage in rescue activities in a collapsed structure. This is valuable information for search and rescue professionals and firefighters.

Hall, Richard and Barbara Adams. 1998. "Rescue and Extrication" *Essentials of Firefighting*, 4th edition, Richard Hall and Barbara Adams, eds. Oklahoma State University, Oklahoma: 175-229.

Hall and Adams discuss the central components of search, rescue and extrication of victims in fires. Search and rescue is broken down into two primary phases, primary and secondary searches. Primary search involves a quick search for victims before a structural fire has been controlled. Often this process will be completed prior to full establishment of hoses by a company. Primary searches are usually not thorough because the objective is to check quickly on the presence of live victims. Secondary searches are conducted after the fire is under control, when a more exhaustive search for live and dead victims is permitted. Certain search and rescue tactics are discussed in detail. In hallways, firefighters search both sides to ensure no one overlooks a victim. Upon entering a room a firefighter turns towards a wall and walks along the room until they return to their starting point. This prevents missing an individual and guides a firefighter safely back to their starting point. In certain instances, one firefighter stays by the door while the other conducts a thorough search of the room. Marking systems often assist rescuers in notifying members of fire service about what areas have been searched, making the process more efficient. Crawling on the floor and looking behind furniture is considered a good method in searching for live victims. Methods such as crawling near the floor and checking under furniture are discussed by Hall and Adams as useful in determining the presence of victims. When victims are found, various methods exist that firefighters often employ to extricate victims from a burning structure. The cradle in arms lift, seat lift, two or three person lift, extremities lift, chair lift and the incline lift are a few variations of extricating live victims from a burning structure. Hall and Adams discusses specific forms of structural collapse, such as pancake collapse, v-shaped collapse, lean-to collapse, cantilever collapse and the void spaces they generate which may hide live victims. A pancake collapse may have several small void spaces below the collapsed floor where furniture or other debris upholds the collapsed floor, creating a livable space for victims. A v-type collapse occurs when the center of the floor weakens; falling below in the form of a v. Voids are created on either side of this v-shaped structure. A lean-to collapse, occurring when only one side of a floor collapses, often creates sufficient voids near the wall where the above side of the floor is still intact. A cantilever collapse occurs when one wall of a multi-story building collapses and exposes all floors of the building. Voids are generated by the supported floors. This knowledge on void formation is valuable for many emergency responders involved in the processes of search and rescue.

Hancock, Robert. F. 1999. "Rescue Procedures" *The*

***Firefighters Handbook: Essentials of Firefighting and Emergency Response,* Sandy Clark ed. DelMar Thompson Learning, United States: 429-470.**

Search and rescue of occupants of burning structures is a complex and risky process for many firefighters. Hancock covers some basics of search and rescue for fire fighters entering a burning structure. Search and rescue is broken down into two primary phases, primary and secondary searches (see Hall & Adams 1998). Primary search involves a quick search for victims before the fire has been controlled, often it will be completed prior to full establishment of hoses by a company. Primary searches are usually not thorough; the objective is to check quickly on the presence of live victims. Secondary searches are conducted after the fire is under control and permit a more exhaustive search for live of dead victims. In detail, certain tactics are discussed in search and rescue. The use of a lifeline (i.e. hose, ropes or a hand against a wall) can aid in guiding firefighters as they search through a smoke filled structure. Crawling on the floor and looking behind furniture is considered a good method in searching for live victims. When victims are found, various methods exist that firefighters often employ to extricate victims from a burning structure. Such forms as the firefighter carry, extremity carry, seat carry, blanket drag, clothing drag, firefighter's drag are a few of the option firefighter shave in removing live victims. Hancock also discusses specific forms of structural collapse, such as pancake collapse, lean-to collapse, v-type collapse and the void spaces they generate which may hide live victims. A pancake collapse may have several small void spaces below the collapsed floor where furniture or other debris upholds the collapsed floor, creating a livable space for victims. A lean-to collapse, occurring when only one side of a floor collapses often create sufficient voids near the wall where the above side of the floor is still intact. A V-type collapse occurs when the center of the floor weakens; falling below in the form of a V. Voids are generated on either side of this V-shaped structure. This knowledge on void formation is valuable for many emergency responders charged with search and rescue.

Norman, John. 2005e. "Search and Rescue" *Fire Officers Handbook of Tactics*. 3rd Edition. Penn Well Corporation, Tulsa Oklahoma: 229-244.

The search and rescue of occupants in burning structures is a complex and risky process for many firefighters. In this chapter Norman discusses basic procedures and tactics in search and rescue for fire fighters in a burning structure. Search and rescue is broken down into two primary phases, primary and secondary searches (see Hall & Adams 1998; Hancock 1999). A primary search involves a quick search for victims before the fire has been controlled. Often this will be completed prior to full establishment of hoses by a company. Primary searches are usually not thorough; the objective is to check quickly on the presence of live victims. Secondary searches are conducted after the fire is under control and permit a more exhaustive search for live or dead victims. In the course of search and rescue, safety is a factor to be aware of. Norman discusses several tools to aid search such as: a pike pole for closing doors, a radio, a flashlight, SCBA, guide ropes and thermal imagining are generally used by ire fighters in search and rescue. To aid search, firefighters should gather information on possible location of victims by fellow occupants of burning structures or neighbors. The social bonds between neighbors may be a great source of information in locating trapped or injured victims. In addition, firefighters must be aware of the multitude of places (i.e. cabinets, dresser drawers) in which small children may hide. This piece offers general yet helpful advice on search and rescue tactics that may aid in fire service.

O'Connell, John P. 1993a. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 1: Collapse Voids and Initial Search" *Fire Engineering* (May): 76-85.

This is the premier article in a series that focuses on search and rescue in collapse structures. In this initial effort, O'Connell discusses the various types of voids that develop in a structural collapse as well as strategies for search and rescue in response to each type. The main forms O'Connell presents are the pancake, supported lean to, unsupported lean to, v-shaped, and a-frame collapse and their respective voids that may provide safety to individuals (see Hancock 1999). A pancake collapse involves the total collapse of a floor onto the floors or space below it. Voids may develop if such items as furniture obstruct the falling floor. In the supported lean-to, a collapse occurs when only one side of a floor collapses often creating sufficient voids near the wall where the other side of the floor is still intact. The unsupported lean-to is similar to the lean-to, however instead the failing side of the floor hangs suspended and is supported by electrical cables. Void spaces below may exist. O'Connell states this is a dangerous type of collapse. The v-shaped collapse occurs when the center of the floor weakens; falling below in the form of a v. Voids are generated on either side of this v-shaped structure. An A-frame collapse occurs when beams collapse near outer walls, while an interior beam supports the center of a floor. Void spaces are created on either side of the interior beam. O'Connell offers methods in which to conduct search and rescue. A void entry team comprised of firefighters conducting search and rescue are an important facet of rescuing possible survivors. Void entry involves the initial firefighter locating existing voids, entering and searching while monitored by a team officer. The void entry firefighter decides which debris is to be removed, providing recommendations on what type of fallen material to be cut. A shoring firefighter assists the initial void firefighter by removing debris, shoring structures, or searching as well. Debris removal enables search teams to get closer to possibly trapped victims. Shoring and bracing supports fallen structures permitting search to continue. Support fire personnel clear debris, deliver tools, or assist in void expansion. In collaboration, firefighters can successfully penetrate a structure and examine areas for survivors, hopefully being successful in this endeavor. This is an informative piece for those unfamiliar with the tactics of search and rescue in a collapsed structure.

O'Connell, John P. 1993b. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 2: Size-up and Safety" *Fire Engineering* (June): 113-124.

In structural collapse, survival is often dependent upon the formulation of voids. However in search and rescue efforts, these may pose dangers to rescuers. O'Connell discusses the process of sizing up voids in order to determine what hazards they pose to emergency responders. O'Connell utilizes the acronym F.A.S.T.V.O.I.D.S. which stands for Fire, Additional collapse potential, Structure type and condition, Trapped Occupants, Void Type, Occupancy Type, Immediate utility shutdown, Day or night and finally, Situation that caused collapse. Fire poses a threat for explosions and firefighters must be aware of potential items that may ignite on scene. Because a secondary collapse is possible in collapse situations, firefighters must be aware of shaking, hanging debris or any unstable elements. The type of structure (i.e old or new) and its condition can inform rescuers of where victims may be, or of the dangers it poses to search and rescue. Trapped victims are always the primary concern and firefighters must search extensively for these victims. Occupancy type (i.e. church, school, residential) can inform rescuers on how many victims may need rescuing as well as the possible location of people. O'Connell states that one of the first actions on scene should be to turn off power in order to prevent gas explosions or electrical fires. The time of day can influence the areas of a structure for search. The agent that caused the fire can impact the manner in which a search is carried out. These many factors are to be considered when engaging in search and rescue. This is sound and practical advice on methods to ensure safety in search and rescue. However more recent analysis is warranted to see if such an approach is currently employed by professionals

O'Connell, John P. 1993c. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 3: Box Cribbing" *Fire Engineering* (June): 67-71.

Cribbing techniques are a pivotal component to securing the safety of voids in search and rescue. Cribbing is the process of shoring voids that are three feet high or less. As debris is removed by firefighters from a void, a swivel type locking collar can be secured to ensure the stability of such a small opening for search. For larger voids, standard shoring can be utilized to secure fallen structures. Cribbing is an example of the need to stabilize collapsed structures. In this series O'Connell highlights many issues relevant to search and rescue.

O'Connell, John P. 1993d. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 4: Interior Shoring-Size-up and Team Concept." *Fire Engineering* (August): 127-131.

O'Connell discusses the various forms of shoring voids in a structural collapse, an important function in search and rescue activities. Shoring is conceptualized as wood put in place to support walls or floors to prevent additional collapse, broken down into two main categories of interior and exterior shoring. In interior shoring, door/window, vertical, rake, and diagonal brace are the most used. In a collapse situation, sizing up or assessing a collapsed structure aids in determining steps to proceed for rescue activities. To conduct a size-up, damage and victim locations must be surveyed. After size-up, the placement shoring occurs to make the collapsed environment more stable, or to direct collapsing loads to stable ground. The placement of shoring can go in a variety of areas, based upon a variety of factors on scene. Shoring should be placed one level below any damage. It should support damaged building supports. It must occur under the central area of debris, as well as below the location of victims. Shoring should be erected on solid bearings, and composed from the outside in. During the course of the erection of shoring, rescuers must be aware of signs for movement in the structure that signal another collapse. O'Connell's examination of shoring techniques is a valuable resource to those unfamiliar with this process.

O'Connell, John P. 1993e. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 5: The Diagonal Brace and Vertical Shore" *Fire Engineering* (October):71-76.

O'Connell discusses the implementation of diagonal braces and vertical shoring during the course of search and rescue. A diagonal brace secures wood and metal structures such as a wall that hangs laterally, or unstable. The angle of a diagonal brace must be between 30 to 45 degrees when implemented to secure an unstable wall. Braces are usually placed in the direction of the hanging wall taking into account the height and stability of the wall. In regards to shoring, its main purpose is to stabilize failed walls or ceilings. Vertical shoring composed of the sole plate, the header, the posts, cleats, wedges, center brace and diagonal brace ensures stability of fallen structures. Wedges are used with vertical shores to transfer collapse loads, and steel squares are useful for rescue shoring. O'Connell offers a detailed synopsis of tactics in which to implement braces and vertical shoring to support search and rescue efforts.

O'Connell, John P. 1993f. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 6: Window and Interior Rake Shoring" *Fire Engineering* (October): 78-81.

In search and rescue of collapsed structures, shoring stabilizes void spaces permitting the search for survivors and ensuring the safety of emergency responders. O'Connell discusses the less often used forms of shoring, window and rake shoring. Window shoring stabilizes a window, allowing safe entry of rescue workers into a collapsed structure. An interior rake shore supports unstable walls, columns, or other structural members of a building from the interior. The rake shore suppresses further movement of a damaged structure, transferring stress of the fallen wall to the floor, allowing the load to be disseminated to other structural bearing members. The rake shore highlights another valued use of shoring, distributing loads from structures. O'Connell offers a basic understanding of how to implement these two forms of shoring, allowing the novice to comprehend the importance of these tools for search and rescue.

O'Connell, John P. 1993g. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 7: The Steel square" *Fire Engineering* (November): 64-70.

O'Connell discusses the importance of the steel square, a tool for measuring angles in shoring. The steel square is composed of two steel pieces coming together to form a right angle. On its surface, it holds a variety of measurement scales such as the rafter table, the essex table, the brace table, the octagon table, the hundredth table, the inch scale and the diagonal scale that assist in measuring angles for the implementation of shoring. The most significant benefit of the steel square is its ability in finding the length of any rake shore easily. This eliminates the need to carry and measure wood materials on site. This piece offers detailed analysis of an important tool in shoring. Further analysis is warranted to see the relevancy of this tool today.

O'Connell, John P. 1994d. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 8: Door Shore and Interior Rake Variations" *Fire Engineering* (February): 45-47.

O'Connell continues his series of discussions on tactics and procedures in search and rescue by focusing on door shores and interior rakes. A door shore is similar to a window shore in that it stabilizes an entry for rescue workers, permitting access to conduct search. Interior rakes stabilize of walls that may have been damaged in collapse. Both supports are greatly valued in conducting search and rescue.

O'Connell, John P. 1994e. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 9: Shoring Support Systems" *Fire Engineering* (March): 88-94.

O'Connell discusses the importance in stabilizing damaged or collapsed structures; in particular he examines specific support systems in regards to this matter. O'Connell focuses on various systems of interlocking struts that can be used to immobilize moving structures. Struts are interlocking units that can be incorporated into shoring, making the erection of such structures easier in a time of danger by making them more stable. These struts are suggested by O'Connell to be used in window shoring, door shoring, and vertical shoring or void shoring.

O'Connell, John P. 1994f. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 10: A Case Study of Vertical Shoring" *Fire Engineering* (May): 70-73.

O'Connell sets forth a case study (a gas leak causing an explosion in a three story building in Brooklyn, NY) to highlight the relevance of proper shoring in an event where structural collapse has occurred. In his discussion of shoring, the author states the main two reasons for shoring are to stabilize structures and to redistribute heavy loads away from damaged structures. O'Connell offers some general guidelines on shoring: to begin shoring below the area of damage; to support stable structures; shore under areas where possible victims may be located; shore from the outside in and in areas that can bear on each other. Although very basic, these are important notes on the process of shoring to ensure the safety of victims and emergency response professionals in a structural collapse.

O'Connell, John P. 1994g. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 11: Exterior Rake Shoring" *Fire Engineering* (July): 61-64.

O'Connell discusses rake shoring specifically in this segment of his ongoing series on search and rescue tactics and procedures. There are two main variations of the rake shore often used to support fallen or damaged structures, the friction shore or the fixed rake shore. The friction shore is supported by the compression force of the damaged wall, often this form is not recommended due to its ability to weaken if movement or a secondary collapse occurs. The fixed rake shore is one solid unit where all features of shoring are tied together. This form of rake shoring is more stable, and better to use in a collapsed structure. O'Connell states a major benefit of sound rake shore use is its ability to transfer loads away from damaged walls. Technical advice is provided for locating support centers, such as finding the center of the floor in which one wishes to stabilize, sharing information on the proper placement of this form of shoring. O'Connell offers sage advice on the implementation of rake shoring.

O'Connell, John P. 1994h. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 12: The Solid Sole Rake Shore" *Fire Engineering* (November): 60-64.

O'Connell discusses the general process of erecting shores in search and rescue of collapsed structures. The first step is to erect a wall plate, the sole plate follows ensuring that the area is clear of debris. The raker is next installed; this beam connects the wall plate to the sole plate which lies on the floor. The installation of a top cleat prevents the raker from moving when pressure is applied to it. Installing a bottom cleat prohibits movement of the raker as it connects to the sole plate. O'Connell stresses that lumber size is determined on an incident basis; structural engineers are advised for the decision. Angle iron and pins are presented as common methods of anchoring the rake shore to the structure. As well, O'Connell states the most common angles at which shores are erected are at around 45 degrees. This is practical knowledge those within the search and rescue community as well as those unfamiliar with these concepts can utilize.

O'Connell, John P. 1995a. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 13: The Split Sole Rake Shore" *Fire Engineering* (January): 95-102.

The implementation of a split sole raker occurs when the ground where the intended shore to be placed is comprised of soil (i.e. in more suburban areas). This can be fabricated on scene or prior to arrival of emergency response personnel. The significant difference between this form of shoring and the solid shore raker is in the positioning of the base. Rather than using a sole plate, the base is imbedded in the ground. As well, instead of a one piece bottom brace the bottom brace are two pieces that are anchored alongside the rake at the lowest point. This form of shoring may be useful in residential area homes to aid in search and rescue.

O'Connell, John P. 1995b. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 14: Horizontal Shoring" *Fire Engineering* (March): 92-96.

O'Connell discusses the contexts of use, as well as the purpose for the construction of interior or exterior horizontal shoring. The general purpose is to stabilize normal access ways that have been compromised. Horizontal shoring involves the placement of large wooden beams laterally, joined by wedges to support structures that are either damaged or may collapse. The physical components include: wall plates; struts; hanger cleats; wedges; gusset plates; diagonal braces. These are an important component of search and rescue. This information is useful to those unfamiliar with horizontal shoring.

O'Connell, John P. 1995c. "Collapse Search and Rescue Operations: Tactics and Procedures; Part 15: Air Bag Operations" *Fire Engineering* (July): 50-51.

O'Connell discusses the use of air bags in the process of search and rescue. Air bags are often used in void search due to their ability to lift debris to permit the rescue of trapped individuals. Air bags are often used because removal of debris by hand may take too long, impacting the survival of victims of collapse. Analysis on how prevalent and useful such an approach is in S&R is needed.

Rescue Behavior during and in the aftermath of collapse (as reported)

Murnane, Lynne, Jeff Fortney and Tom Connell. 2003. *Technical Rescue for Structural Collapse*, 1st Edition. Fire Protection Publications, Oklahoma.

Murnane et al discuss the technical aspects of search and rescue (S&R) in structural collapse. This is a textbook for those training for certification as rescue technicians or any emergency personnel who respond to complex rescue incidents requiring special equipment or expertise. "Planning and Scene Assessment" discusses: resources, equipment, layout of a typical deployment, building triage, S&R (large scale searches, surface victim removal, areas to be searched esp. voids), debris removal, structure of incident command, recognizing and mitigating over a dozen types of hazards. "Conducting the search" offers: safety tips on evacuation and escape, details on five types of building collapses (pancake, v-shape, lean-to, a-frame, and cantilever) and where to find victims accordingly, mapping an area to better find victims, types of searches (physical, canine, technical, electronic devices, void). "Shoring and stabilization" discusses: how to evaluate structures, different types of buildings, shoring personnel, equipment and techniques, rakers or braces to support, step-by-step to build different shores. "Lifting systems" offers a science overview on basic principles. "Rope Rescue" examines: how to utilize rope rescue, including anchor points for stability, mechanical information and a step-by-step to set up a rope pulley system. "Breaching and cutting" gives information on equipment to cut through walls or other structures. "Heavy equipment" examines rigging, slings and chains, and maintaining equipment. "Victim and Medical Rescuer Considerations" discusses safety, medical assistance to victims and critical incident stress management. "Incident Termination" focuses on accounting for equipment and people, post incident analysis, debriefing, and other facets of leaving the scene. Murnane et al present key components of operations in which emergency response personnel engage in while conducting search and rescue. This is a great resource for those both unfamiliar and knowledgeable with the above examined concepts

Tracy, Gerald. 2002. "World Trade Center Disaster. Volume 1: Initial Response."*Fire Engineering* 155 Vol. 9: 6-26.

Tracey examines the emergency response to the World Trade Center (WTC) collapse as a case study, focusing on the structural and political impediments to effective search and rescue. Structurally, Tracy illustrates that the WTC failed to withstand the terrorist attacks. The fires ignited, the lack of radio contact on scene, inoperable elevators, as well as complicated stairwells provided obstacles to effective search and rescue. The lack of coordination between and within agencies, occurring due to loss of key personnel and politics across agencies, impeded effective search and rescue. These factors were evident in the lack of incident command after the collapse. The event itself was viewed as overwhelming for the city of New York. Tracey states that firefighter departments need to plan for terrorist attacks and incorporate this threat into their operations. This detailed analysis offers a good synopsis of those characteristics that impeded response on 9/11.

Lessons Learned

Building Collapse Lessons Learned

Downey, Raymond. 2000. "Rescue Operations." ***WNYF:*** **3, 7-8.**

The article focuses on rescue operations in the aftermath of the State Street in New York City, which was a gas explosion that led to a building collapse. Downey emphasizes many of the positive factors that occurred during the response to the State Street Incident and overrode the negative factors. He distinguishes between rescue and response; he also labels the five types of collapse (v-shape, a-frame, lean-to, unsupported lean-to, and pancake collapse). Secondary collapse was a risk in this incident, as was debris was removed by hand. The "six sided approach" evaluated access from one of the six sides (top, bottom, four sides). 23 lessons reinforced were listed, from establishing a collapse zone to "expect the unexpected". This is a good, yet brief example of basic components of fire response integrated into a case study.

Dunn, Vincent. 1982. "Search and Rescue at a Building Collapse." ***Firehouse*** **(April):16, 18, 82-83.**

The author gives a detailed hypothetical situation about a fire that leads to a building collapse and poses questions on: immediate action priorities at a rescue scene, duties in a collapse incident, coordination, and locating the fire. The discussion reveals that control of the rescue operation is a priority on scene and is necesS&Ry before rescuing can occur. The act of digging out buried victims should not be undertaken until control has been established. The best way to gain control of a collapse rescue effort is to rely on a Chief to issue assignments to all responders. When a collapse occurs during a fire, officers should account for all their firefighters at the scene. Also, support personnel are needed for a S&R team engaged in victim removal activities. Likewise, all available rescue tools must be brought to the vicinity of the rescuer and additional help should be called in to relieve initial responders at the scene as well as to continue with the fire extinguishment efforts. The author concludes that although a building collapse trapping firefighters is a terrible occurrence, fire departments must be prepared for everything. This piece is important in highlighting the secondary threats, such as firefighter entrapment, that can occur on scene in a rescue operation.

NIOSH. nd. "Assistance in Preventing Injuries and Deaths of

Fire Fighters due to Structural Collapse" ***ALERT: Request for Assistance In*****. US Department of Health and Human Services, Centers For Disease Control and Prevention.**

http://www.cdc.gov/niosh/pdfs/99-146.pdf.

(accessed 8-12-06).

This article examines firefighter fatalities due to structural collapse. Between 1989 and 1998, 968 firefighters died, with nearly half of these deaths occurring on the fire ground. Three hundred and sixteen firefighter deaths were caused by structural collapse incidents. Predicting a structural collapse is one of the most difficult tasks for firefighters during the initial size up of the incident, due to the fact that structural collapse could occur without warning. Case reports describing incidents involving fire fighter injuries are included and ten steps are recommended by the National Institute of Occupational Safety and Health in order to minimize the risk of firefighter deaths and injuries. The following steps are listed: 1) to ensure that the incident commander conducts an initial size-up and risk assessment of the incident scene before beginning interior firefighting; 2) to ensure that the incident commander always maintains accountability for all personnel at a fire scene – both by location and function: 3) to establish rapid intervention crews and make sure they are positioned to respond immediately to emergencies; 4) to ensure that at least for fire fighters are on scene before beginning interior fir fighting at a structural fire; to 5) equip fire fighters who enter hazardous areas to maintain two-way communications with the incident commander; 6) to ensure that standard operating procedures and equipment are adequate and sufficient to support radio traffic at multiple-responder fire scenes; 7) to provide all fire fighters with personal alert system devices and make sure they wear and activate them when they are involved in fire fighting, rescue, or other hazardous duties; 8) to conduct prefire planning and inspections that cover all building materials and components of a structure; 9) to transmit an audible town or alert immediately when conditions become unsafe for firefighters; 10) to establish a collapse zone around buildings with parapet walls. These tactics are purported to mitigate injuries and deaths attributed to structural collapse for firefighters.

Nicholson, John. 2001a. "Collapse: World Trade Center Aftermath." ***NFPAJournal*** **(November/December): 37-39.**

This article describes how the World Trade Center (WTC) suffered a pancake collapse due to heat and melting of the steel columns within the structures in the aftermath of the September 11th, 2001 terrorist attacks. The issue of sprinklers is addressed with the author stating that because the fire was unconventional, the temperature was too hot, and there was never enough water to stop the fires. Therefore the sprinkler system was overwhelmed. When the World Trade Center was built, it was designed to withstand the stress of an airplane collapse "even a direct hit from a Boeing 707, which was the state of the art jetliner at the time it was designed," (39). Designers took many types of extremes into account when building the World Trade Center. However, they did not imagine that such a collapse was capable of happening. Experts say that in the aftermath of the terrorist attack, there is a greater sense of awareness within the building community that such an event could happen. Practicality and security are found to be difficult to balance in building structures, and engineering innovations include reinforcements, bullet-proof glass, and even limited parking lots. This case study on the WTC is informative as to why such a collapse occurred and how mitigation efforts (i.e. sprinklers) were overwhelmed, leading to such great devastation.

Nicholson, John. 2001b. "Evacuation." ***NFPA Journal*** **(November/December): 40-41.**

The article discusses a new NFPA study soon to be undertaken to analyze how and why people behaved in certain ways during 9/11. This is a follow-up on a 1993 study after the WTC explosion. In terms of lessons learned, NFPA will give several workshops in major cities to either create or enhance existing emergency evacuation planning. Traditionally there has been a "Defend in Place" plan, which recommends evacuating only those floors immediately at risk from a fire and urging all other occupants not immediately at risk to stay where they are. This plan allows rescuers to enter the building, decreases the risk of falling debris because less people would be gathered outside, and lessons risk during the overall exiting of the building. The article states that during a "normal' emergency, such a concept makes a great deal of sense. However, in regards to the events that occurred on September 11th 2001 and in 1993, these were extremely severe conditions. In these situations, evacuating increased survival rates. Reports on 9/11 indicate that people did not panic, but left in an orderly manner. Recommendations from the 1993 incident (mainly the phosphorescent paint on the staircases) increased survival rates. The author concludes with the hope that reports from a study on September 11th will increase the survival rate in future incidents as well as serve as a memorial to those who were injured or died as a result of the World Trade Center collapse. Such an analysis would benefit studies on panic behavior in regards to such an extreme threat as 9/11 and on evacuation behavior in general.

Firefighting Lessons Learned

Blackistone, Steve. 1998. "Report Writing: It Really is Important" ***Firehouse*****, Vol. 23, No. 6: 40.**

Incident reporting is a valuable yet often unpopular duty of emergency response, according to Blackistone. Incident reporting is necesS&Ry in order to communicate information about an event. For example, EMS response entails active documentation on those administering the next level of care information on what assistance has been provided prior. As well, legal issues are born from emergency response, and such reports are used for legal protection to emergency responders. Incident reports do not have to be extensive, yet should capture all pertinent information related to an event. This article raises sound points about the need for incident report writing.

Nicholson, John. 2001c. "Search & Rescue." ***NFPA Journal*** **(November/December): 41-42.**

The events of 9/11 have ushered in new concerns for emergency management in regards to search and rescue in the context of a terrorist attack. Nicholson discusses two new NFPA standards, developed in the wake of 9/11. These new standards: NFPA 1670 (*Operations and Training for Technical Rescue Incidents*) and NFPA 1006 (*Rescue*

Technician Professional Qualifications) are intended to assist local communities in dealing with the aftermath of such hazards. NFPA 1670 helps establish training and safety criteria for communities in the face of potential terrorist attacks, as well as helps formulate parameters of preparation and operational capabilities for local authorities with jurisdiction of an event so that they can mange a response. These initiatives go from the basic operational to light or medium to complex/heavy search and rescue. As well, changes are discussed in dealing with future terrorist attacks, the evolution of equipment, and more sophisticated rescue techniques. Future certification requirements are expected to occur in relation to dealing with search and rescue in such events. It would be beneficial to understand how communities are designated at risk to terrorist threats and how this impacts use of the above mentioned standards. This may reveal popular conceptualizations of who or what is at risk, and how resources are delegated based upon these conceptualizations.

Nicholson, John. 2001d. "Terrorism: Impetus for Change." *NFPA Journal* (November/December):43-45.

Emergency responders often formulate new standards in which to conduct response activities in the wake of catastrophic events, such as 9/11. Nicholson contends that "postmortem changes" are common and recommendations of fire departments and chiefs in the aftermath often lead to the NFPA codes and standards currently used. Many local agencies have new concerns in regards to the threat of terrorist attacks. In post 9/11 emergency response, updating manuals on high-rise building incidents has become a priority for some agencies. Many small cities are discussing disaster response plans in reaction to their lack of preparation for events involving airplane strikes. For example, the LA City Fire Department is currently conducting studies to better understand a plane's impact on building structure. Equally important are attempts to revise guidelines to include a terrorist response plan in many communities nationally, such as threat assessments to learn the locations and occupancy levels of targeted buildings. In reaction to the developing need to adjust to potential terrorist attacks, the NFPA views itself as a "leader in public safety protection," and will keep with their tradition of continually updating standards when needed. This is an interesting piece examining how the growth of the threat of terrorism in the U.S. has altered standards on emergency response.

Prosser, Tony. 2003. "Accidents Will Happen." *Fire* Vol. 96: 23-24.

Prosser examines the prevalence of underreported near miss incidents in the British Fire Service, which may impact the safety of many firefighters. The underreporting of near miss accidents or mistakes may cover up potential lethality to the fire service. Research in Britain estimates near miss incidents to be about 200-600 times the amount of actually recorded accidents, illustrating an inability to examine such incidents that may reveal potential harm to fire service personnel. Prosser states such reasons as: 1) "relative frequency" (when problems, such as loss of communication, occur so regularly that their importance is seen as less); 2) the viewing of potential danger as minimal when the fire is initially small; 3) the time consuming nature of completing a comprehensive evaluation; 4) individuals covering up mistakes when they are responsible; and 5) the geographically diffuse nature of fire service creating an assumption that such an event only happens to them in their company, often limit the reporting of near miss accidents. Prosser offers two theoretical constructs that may support the inclination to not report near misses and accidents. High reliability theory, assumes the structure of an organizational and it management will prevent dangerous situations from occurring. The implementation of safety measures creates this perception that potential lethality will be mitigated by these structures. There are organizations in Britain that share information to improve safety systems, but the lack of near miss data is still problematic. Normal accident theory (Perrow 1984) takes the pessimistic route, arguing that technology leads to major accidents. These same safety system that high reliability theory touted to mitigate harm, are assumed to be the causes of harm. Accidents are not avoided because the equipment and systems that a department has leads to false assurance. Not accounting for all near miss events plays a big role in the incorrect assumptions. Whichever theory is used, near miss events impact safety risks because they are not all properly recorded. This piece examines an often under studied phenomenon in the U.S. An analysis is warranted to see how such underreporting occurs in the U.S.

Smith, James P. 2006. "Improving Fire ground Operations through Post-Fire Analysis." ***Firehouse*****, Vol. 31, No. 4: 26-30.**

Post Incident Analysis (PIA) is often utilized by fire service, permitting them to be reflective of actions committed and how lessons learned may prevent mistakes or fatalities. This assessment is intended to understand actions occurring at events by asking such questions as: what actions were carried out successfully, what areas need improvement, as well as if operational guidelines need restructuring in light of these events. The fire service industry strives to excel, and part of this drive is to prevent the reoccurrence of mistakes. PIA provides methods to curb such errors. There are multiple types of critiques that may occur; generally they are either formal or informal. Informal critiques are for a single or multiple companies to assess actions occurring on scene and their influence on a fire event. These may occur on scene or in a casual manner such as over dinner. A formal critique involves as assessment of action on scene after significant events. In these situations commanding officers of the event often are present during a review of events. When such critiques are conducted, Smith states the following are relevant areas to be assessed: communications – did any problems arise?; size up – dispatch information received and conditions observed during the course of; the fire, as well as problems encountered; incident management system – what staff positions, divisions or groups were created; strategy and tactics – review the strategies developed and the tactics initiated; medical assignments – what medical problems had to be handled?; safety – what were the safety issues?; apparatus and equipment – were apparatus properly placed and utilized?; resources – were requests for additional resources timely?; outside agencies - what agencies were requested and responded? These components of a PIA will provide the needed analysis of events on scene, revealing possible areas for improvement. Such reports are to be shared with the personnel present on scene of the incident, other fire department members, and the mutual aid departments that responded. This process of disclosure may better ensure the production of solutions to problems that arise in analysis. PIA often incorporate lessons learned. This component permits the sharing of information so as to possibly prevent further mistakes. This article is a valuable resource for those interested in the uses and components of a post incident action report.

Stroup, David and Nelson P. Bryner; Jack Lee; Jay McElroy; Gary Roadarmel and William H. Twilley. 2003. "Structural Collapse Fire Tests: Single Story, Ordinary Construction Warehouse." NISTIR 6959 Report (May)

http://www.fire.nist.gov/bfrlpubs/fire04/PDF/f04018.pdf (accessed 7-8-06).

Structural collapse poses a threat for many firefighters in emergency response. This current study sets out to formulate a system to better predict such events so as to save lives of rescuers. Predicting such an event as collapse is problematic due to the abundance of variables one must account for: building type and current condition, size and location of fire, and structural issues are multiple factors that may lead to collapse. A fire department in Phoenix established a study of collapsed structure in order to obtain temperature data, evaluate current techniques, observe the building before and after (to see collapse indicators), and measure carbon monoxide levels to evaluate the health risks. Fire was set to structures (either created for this purpose or were going to be demolished) until part of the building had collapsed. These tests were conducted in a warehouse. Using an electric match and newspaper wooden pallets were ignited in two different tests. The first test to assess flashover conditions revealed that "load on the element, protection of the element, fire intensity, and fire duration" (2) are factors impacting collapse of a structure. A second test of burning structures uncovered the presence of lowered temperatures around the ceiling as an indicator of roof failure (cold air blows in through holes). This research uncovers empirical assessment of fires and structural collapse, and how further use of this method may uncover those factors leading to collapse that may save the lives of firefighters on call.

Touger, Hallie E. 2001. "First Responders." ***NFPA Journal*** **(November/December): 46-47.**

First responders are notably important in a disaster because they are the first to rush in while others are evacuating. In the wake of 9/11 Touger poses several questions about the ready capability of first responders to be prepared for future attacks. Three questions posed in this article are: did first responders have the protective clothing and respiratory protection needed, can the equipment be identified and deployed, and are the first responders adequately prepared and trained? In respect to 9/11, emergency workers' use of special equipment such as breathing apparatus for firefighters or command-and-control shelters were needed but no one knew to ask for them. A system of knowing who to contact locally for these equipment needs is suggested. As well, there is a need for logistics support to transport needed protective gear in the face of such events as terrorist attacks, a concern for many emergency responders. In response to whether first responders are prepared, there is a need for more training by the federal government. Building bonds with other emergency response agencies is encouraged for local responders; these relationships may permit a more effective level of response. A wealth of new concerns among local responders emerged in the wake of 9/11, Touger reveals that the response community is continually adapting to such potential hazards.

Ward, Bryan. 2003. "Post-Incident Analysis: Executive Analysis of Fire Service Operations in Emergency Management." National Fire Academy.

This is an assessment of Post Incident Analysis (PIA) in the fire community to aide the Evesham Fire-Rescue Department, which currently has no method of conducting a PIA. PIAs are programs within fire departments where evaluation of performance in response to a call is able to be conducted. Evesham responds to over 4,500 calls each year, yet does not have evaluation procedures to improve current progress besides customer satisfaction surveys (which lack the technical opinions necesS&Ry for serious departmental changes). This one department serves as a starting point in this analysis to answer the following questions concerning PIAs: 1) On what type of incidents should a post-incident analysis be performed? 2) Who should be involved in the post-incident analysis? 3) What should be examined when performing a post-incident analysis? 4) How will information learned be incorporated into the department's operations and training lesson plans? This piece reveals that conducting a PIA immediately after an incident may benefit a fire department in many ways. A PIA can inform individuals about their performance, provide feedback on how to improve actions on scene, produce teamwork, and prevent similar harmful incidents from occurring again. Two themes emerge in relation to discussion over PIA: to conduct PIA without blaming or criticizing individuals and to ensure any lessons learned from PIA are communicated "department wide and were implemented into the department's procedures and training program". A survey was sent out to 100 departments to collect response to the above mentioned research questions, although a limitation is a lack of knowledge if the responding department utilizes PIAs, only 10 were returned. Multiple responses were permitted for questions asked. For research question 1, which type of incident should have a PIA received responses included : when there are multiple alarm calls (4), with vehicle accidents with entrapment (2), Hazmat (5), Technical Rescue (4), when the IC determines (10), and when the company officer determines (8). Question 2, asks who should be involved in a PIA. All respondents said that all involved at the scene should. Question 3asks what should be examined when performing a PIA. All possible responses were chosen by each respondent: building structure/site layout, review fire code history, dispatch and response times, site operations, rescue operations, staging, communications, support functions, safety sector, accountability, investigations, appropriate policies and procedures, goals and objectives of the analysis, reports from personnel on the incident, recommendations for improvement, and a review of the conditions present, actions taken and effect of the conditions and actions on the safety and health of all members. Question 4 asks how lessons learned will be incorporated. Only 4 departments keep the reports on file and post it in the station (or online). Ward uncovers a paradox in the fire community; although PIA's are touted as being a valuable resource for fire departments, few conduct them. This study warrants further analysis on the possible lack of compliance with PIAs, an assessment that may improve the performance of those charged with saving lives in the time of need.

Wolf, Alisa. 2000. "Resources and responses: fire service

organization and deployment." ***NFPA Journal*** **(November/December): 51-54.**

Staffing in the fire service industry is often a concern in communities, due to the fact that the closing of one fire house may impact response rates and subsequently survival for civilians. Wolf examines the initiative of one community where the threat of fire house closings spawned concern over response rates to fires. Residents in Colorado Springs, through research on fire department's statistics and response rates, managed to keep open a fire house and establish a new one by advocating for funding. The actions of this community helped spawn two new NFPA standards: 1710 (*Organization and Deployment of Fire Suppression, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*) and 1720 (*Organization and Deployment of Fire Suppression, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments*). These standards are intended to assist other communities in their desire to maintain sufficient response rates to fire. With these standards, citizens will be better informed of what the fire departments can and cannot handle, and funding may be easier to obtain in the future. Prior to these, no national fire service standards existed for ensuring sufficient response rates for fire service. These initiatives aim at saving lives by maintaining an adequate level of response for communities.

NFIRS Data

Greene, Michael A., Linda E. Smith, Mark S. Levenson, Signe Hiser and Jean C. Mah "Raking Fire Data" U. S. Consumer Product Safety Commission
http://www.fcsm.gov/01papers/Greene.pdf#search=%22RAKING%20FIRE%20DATA%22 (accessed 5-12-06).

Missing values are a concern for statistical analysis, perhaps even more so when such computation is intended to examine factors that impact the survival of individuals in fires. This study discusses the process of inputting missing values in data sets, using the National Fire Incident Reporting System's (NFIRS) data on fatalities, injuries and property loss in fires. This process of raking is utilized by the U. S. Consumer Product Safety Commission in their analysis of the NFIRS data set. In general, 25 to 40% of values are missing in the NFIRS data sets, causing many organizations and agencies to apply methods of inputting missing values to complete analysis. Raking applies to individual cell counts; the use of iterative proportional fitting adjusts cells and margins to estimate missing values. Raking becomes a sound methodology in inputting missing values so as to permit statistical analysis.

Hall Jr., John R. and Beatrice Harwood. 1989. "The National

Estimates Approach to U.S. Fire Statistics" *Fire Technology*, Vol. 25, No. 2: 99-113.

This article examines the issue of a standardized methodology for calculating national estimates on fire statistics, utilizing the National Fire Incident Reporting System (NFIRS) data set collected by the United States Fire Administration (USFA). A consensus on standardized methodology is assumed to advance the fire community towards a unified set of assumptions that can be examined in analyses of fire issues. Without such a consensus, disparate approaches would lead to a cacophony of efforts to analyze fire data, harming any sense of credibility that the field desires. The authors utilize a scaling ratio, based upon data collected by the NFPA survey and NFIRS data set upon a specific variable of interest, to attain national estimates with NFIRS data. This article highlights the need to strengthen NFIRS data sets so that they are better representative of national estimates, as well as to unify estimates so that a greater credibility exists in analyses.

U.S. Fire Administration. 2004. "Fire in the United States 1992-2001" 13th Edition

http://www.usfa.dhs.gov/statistics/reports/fius.shtm
(accessed 5-31-06).

This report by the U.S. Fire administration is the thirteenth edition of a series that assesses the national landscape on fires in the US with a large focus on the latest year in which data is available. This analyses covers the rate of fires in the US, comparing to other nations; assess financial costs; regional variation in fire casualties; fire rates according to property types; the nature of firefighter and civilian deaths for this 10 year period. This longitudinal study utilizes the NFIRS data set amongst others (National Fire Protection Association, NFPA; National Center for Health Statistics, NCHS; data from state fire Marshall's offices or the equivalent and the U.S. Census Bureau and the Consumer Price Index) to compose this analyses. This piece is important in illuminating the compliance rate nationally of local fire departments in compiling NFIRS data. This study claims that as of 2001, 49 states were reporting information from emergency response. However, there are variations within a state that complies; if a state is counted as complying with NFIRS this does not mean that all departments report data. It is estimated that 38% of departments within reporting states collect data on fire response. Nearly 33% of all U.S. fires to which fire departments responded were captured by NFIRS data in 2001. This highlights the low proportion of total US fire departments that collect such data. However, this percentage of US fire departments is considered to be a large enough sample to extrapolate various elements of the fire problem in the US, according to this study. Another issue discussed is the various forms of the incident report used to collect local fire data used in the national NFIRS. In 1999, version 5.0 of the database began to be utilized; reportedly better and more detailed in capturing fire events than the older 4.1 version. In the transition phase (1999-2000), where fire departments began to use version 5.0, 4.1 data has been converted to be uniform with this latest database. This is a valuable piece for those interested in knowing more about the uses of NFIRS data to examine fire related problem in the U.S.

U.S. Fire Administration. 2006c. National Fire Incident Reporting System: Version 5.0 Design documentation
http://nfirs.fema.gov/_download/nfirspec_2006.pdf
(accessed 6-3-06).

This publication describes the process of the National Fire Incident Reporting System (NFIRS) data set on a national basis. This work also describes in detail the multiple modules in which data is collected, the conversion tables for versions 4.1 to 5.0, and system implementation guidelines for software for data documentation. NFIRS is jointly managed by the U.S. Fire Administration (USFA) and the National Fire Information Council (NFIC), with NFIC acting as a user's group of volunteers that maintains the existing system and who develop new changes to improve the NFIRS system. Approximately 14,000 fire departments participate in the data collection process. After responding to an incident, a fire department participating in the NFIRS system would fill out the specific modules relating to the incident. Local departments send completed modules to a state body that aggregates this information; this statewide data base is sent to the National Fire Data Center (NFDC) at the USFA. The USFA conducts analyses and the results are found in various publications that are produced, based upon national estimates with this uniform data set. There are various modules that may be utilized to capture data relevant to response on scene, only if certain events or actions occur, warranting documentation. These modules are: the Basic Module, Fire Module, Structure Fire Module, Civilian Fire Casualty Module, Fire Service Casualty Module, EMS Module, Hazardous Materials Module, Wildland Module, apparatus Module, Personnel Module and the Arson Module. With version 5.0 beginning to be implemented in 2000, there was a need for conversion of 4.1 data. The information offered here is to better assist local fire departments in this transformation process. As well, there is an analyses of software used in data documentation that can help the local fire department in being NFIRS compliant. This is a sound piece for understanding the basics of how NFIRS is used at the local level as well as the process of how the data is amalgamated for national estimates.