Installing & Maintaining Residential Sprinkler Systems: Exploring The Deterrence Factors Of Massachusetts Homeowners

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Chapter One:

Introduction

Since the birth of the fire service, the field has always taken a reactive approach to deal with issues such as combating fires and responding to incidents on the national level. The result of this reactive approach was an evident growth in civilian injuries and fatalities around the world. “Fire prevention work in many countries today has become more focused on making evidence-based decisions, i.e., developing regulations and guidelines based on state-of-the-art knowledge about different fire safety challenges and possible risk-reducing measures” (Steen-Hansen, Storesund, & Sesseng, 2021). What the fire service has done to combat that issue was develop a more proactive approach to fire. This included creating a fire prevention plan called the 5 E’s of Fire Prevention: Education, Engineering, Enforcement, Economic Incentive/Disincentive, and Emergency Response. The goal of this model was to get ahead of the fire issue the world faced to try and mitigate any problems that provoke the spread of fire; however, despite the newly developed efforts in fire prevention, there came more issues to solve.

Another issue that has since posed a large threat to the State of Massachusetts regarding fire is the changing practices of modern building construction and building materials used today compared to those used in the past. Older buildings used raw materials that ignited at much higher temperatures and transferred heat through slower burn rates; whereas, the materials used in today’s modern construction are much more synthetic and composed of materials that ignite with ease and release larger amounts of heat. “What used to be a two-by-twelve piece of sawn lumber that we knew could hold a certain amount of strength of weight and acted a certain way in fire conditions, we can build cheaper now by using trusses or engineered wood,” said Kevin Gallagher, Acushnet's fire chief (Sperance, 2021). The vulnerability of these new materials

causes fires to spread faster, which makes it difficult for fire departments to adequately respond to and extinguish fires within an appropriate time frame that avoids the least amount of civilian injuries and fatalities. New construction materials shorten the time frame for residents to evacuate the building safely and pose a higher risk of becoming trapped within the home itself. This problem manifests from the luxury of having cheaper construction costs, but at what risk? Not to mention the combination of the reactive nature of the fire service, and the now, far more dangerous newly constructed buildings- the odds are quite literally life or death.

Due to the changes in building construction and the increased smoking habit, there has been an expanding number of civilian deaths in fires. Because these buildings have cheaper materials, they're more prone to fires, and since the growth rate of these fires is much faster the residents have less time to escape. The National Fire Protection Association (NFPA) reported that in 2013 the leading cause of death for civilians was from fire in the home. Of the leading causes of these residential fires, cooking materials and careless disposal of smoking materials are the most common (Flynn, 2010). This means that the problem of modern building construction is affecting the way fires spread and the chance that people survive. Also, society today has become accustomed to smoking, and it's reached the point where people avidly smoke inside their homes, which puts the community at even more risk for fire. "The continuing high prevalence of cigarette smoking among specific subpopulations, many of them vulnerable, is one of the most pressing challenges facing the tobacco control community… Despite the overall substantial decrease in the prevalence of cigarette smoking in the United States in the last 50 years, there remain persistent intergroup disparities in cigarette smoking prevalence (including pipes, cigars, marijuana, & hookah)" (Drope, Liber, Cahn, Stoklosa, Kennedy, Douglas, & Drope J, 2018). The mixture of these fire vulnerable building materials and the careless disposal

of smoking substances leads to a fire problem that can only be mitigated through further engineering and prevention techniques.

While most research on residential fires has identified the alarming prevalence of civilian deaths due to careless disposal of smoking materials, few studies have explored the core relationship between fire death in the home, the lack of residential sprinkler systems and building and fire code enforcement; Especially when considering the changing practices in modern building construction. This lack of research leaves the potential solution for the growing number of residential fire deaths to go unsolved. The consequences are allocating unnecessary time and resources responding to home fires/fatalities that could be easily solved by installing residential fire sprinkler systems, which have been proven to mitigate fire loss and decrease fire death within the home. The Home Fire Sprinkler Coalition stated that fire sprinklers respond when they sense a large amount of heat and operate with or without response of a homeowner, controlling the spread of deadly heat, toxic smoke, and flames, all in time to maintain the fire at a small level so a resident may escape. “In his 2012 report, U.S. Experience with Sprinklers, John R. Hall, Jr. of NFPA noted that fire sprinklers were present in only 6% of reported home fires in 2006-2010. The death rate per 1,000 reported home fires was 83% lower when wet pipe sprinkler systems were present compared to reported home fires without any automatic extinguishing systems” (Ahrens, 2013).

Statement of the Problem

Research Problem

The majority (92%) of civilian deaths occur from fire in the home, almost 25% of which begin from fire in the bedroom, and 24% originate in the living room (Ahrens, 2013). Of these causes, the leading issue to home fire death stems from the careless disposal of smoking

materials. The United States smoking phenomenon has been on a slow decline; however, particular subgroups have continued to stay resilient in participating in other smoking habits such as pipes, cigars, marijuana, and hookah (Drope, Liber, Cahn, Stoklosa, Kennedy, Douglas, & Drope J, 2018). Also, issues such as new building construction methods, leading to the use of far more unsafe materials and building practices that, when under fire conditions, do not withstand the same amount of tolerance as raw materials used in older construction. These negative impacts have led to an increase in the number of fires and fire deaths amongst members of the State of Massachusetts, and there's an immediate need to be addressed through reconsideration and implementation of the 5 E's Fire Prevention Model.

Lack of Knowledge & Education

There is a lack of knowledge and education on the effectiveness of residential sprinkler systems. This lack of knowledge leads members of the Massachusetts community to neglect the need for such fire protection systems in their own residential homes. In 2010 this issue alone left over approximately 94% of residences unprotected from fire (only 6% of reported home fires in Massachusetts had residential sprinkler systems in 2010) (Ahrens, 2013). That meant that 94% of residences that had suffered from fire were at increased risk of death than the remaining 6% who did have residential sprinklers. The NFPA also stated in a 2010 report that the death rate per 1,000 reported home fires was 83% lower when wet pipe sprinkler systems were present compared to those that did not have any form of suppression systems. This is a huge issue when it comes to discussing the survivability of home fires, and there's a notable difference between the benefits of residential sprinklers when it comes down to the life and death of the families that suffer from a fire in the U.S.

Lack of Economic Incentive

The deficiency of economic incentive/disincentive for residential sprinkler installation from insurance companies is another reason why there are far fewer residential sprinkler systems in homes today. Most insurance companies offer a form of discount, with the average being approximately 10% for approved home fire sprinkler protection (NFPA, 2018). However, though this may seem like a great deal, it is also the only form of incentive for homeowners to install sprinkler systems in their homes, and it is not enough because it hasn't caused many to do so. A lot of the fight between residence owners and the fire department is due to the unwillingness to pay for the sprinkler systems in the first place. This goes along with the scarcity of knowledge and common misconception regarding the cost of sprinkler systems. Many homeowners are worried about paying for something that might cause more damage to their home than it saves, when in actuality, a home fire sprinkler system could cost on average the same amount as an upgrade to their carpeting and provide better benefits than the latter.

Lack of Enforcement and Development of Fire & Building Code

The near-absence of development and enforcement of fire & building codes that require installing of residential sprinkler systems in homes is another issue for fire safety (there is code that requires sprinklers to be installed in new non-residential buildings, but not homes in general). NFPA 13R is the National Fire Code for the Standard on the Installation of Sprinkler Systems in One-and-Two-Family Dwellings and Manufactured Homes. This fire code is updated every couple of years, and the current edition that is available to the public (9th) relies on the 2015 edition of the International Building Code, meaning that it is somewhat outdated and does not accurately reflect the current changes in today's economy (Sperance, 2021). Something else to consider is that NFPA 13R reflects a fire code that gives regulation on how residential fire sprinkler systems should be installed, but not why and where they should be installed. In other

words, this document supports those who already decide for themselves they want sprinkler systems but does not require all residences under a certain condition to install them.

Summary

The majority of civilian deaths occur from fire in the home. Of these causes, the leading issue to home fire death stems from the careless disposal of smoking materials. The United States smoking phenomenon has been on a slow decline; however, particular subgroups have continued to partake in unconventional smoking activity. Also, with new building construction practices, today's modern buildings are more unsafe than they've ever been. The three areas related to this research problem are the lack of knowledge and education on residential sprinklers, the lack of a strong economic incentive, and the lack of enforcement and development of substantial fire and building codes on residential sprinkler systems. These issues are undoubtedly why Massachusetts has weak support for implementing fire sprinklers in residential buildings.

Background and Need (Solutions)

Lack of Knowledge & Education

Education of the community on the benefits of residential fire sprinkler systems is important in gaining the support and traction needed to normalize sprinklers' installation in homes. A training and informational town hall session put on by cities and towns in Massachusetts can help the public better understand the motives of the fire department as being a genuine concern for the safety of the community, rather than seeming more like an economic burden. Something that could also work is the display of a "Residential Fire Sprinkler System Fact Page" on the city website to debunk the common misconceptions about sprinkler systems

and provide a platform to showcase and commend those who take the extra step to ensure their home fire safety.

Lack of Economic Incentive

Including a larger economic incentive than the regular 5-10% insurance discount for homeowners would provide a better turnout of people who install sprinklers in their homes. Insurance companies should also provide an economic disincentive such as paying larger premiums for those families that do not have sprinkler systems installed in their homes. Another solution could be having higher premiums only for those who had recently suffered from a home fire and did not have sprinkler systems. This might receive large social backlash because not everyone will be happy paying more just because they don't have sprinklers, but it could be a great reason for people to want to install sprinkler systems. If there is more of an economic incentive (insurance discounts) to install sprinkler systems, then homeowners would do it, and if there is a high disincentive for not having residential sprinklers, then more people would want to install sprinklers.

Lack of Enforcement and Development of Fire & Building Code

There is a critical need for an updated building and fire code that requires all one and two-family dwellings to install residential sprinklers. Not necessarily regulations and guidelines on installing sprinklers, but requirements in having them installed. This is one of the only ways that the fire department can ensure that people will have sprinkler systems installed and would provide a large decrease in residential fire deaths. The ideal solution would be a guiding coalition in the form of actual fire and building code that requires new and old residences to install fire sprinklers within the premises; however, knowing the community and the backlash that would face the fire department, the best option would be to require installation of fire sprinklers in new

residential buildings as a part of the normal construction process. The issue with getting that passed is opposition from the Board of Building Regulations and Standards (BBRS), but with a little convincing, it can be done.

Summary

As previously noted, most research on residential fires have identified the alarming prevalence of civilian deaths due to careless disposal of smoking materials; However, few studies have explored the core relationship between fire death in the home, the lack of residential sprinkler systems and the effectiveness of building and fire code enforcement; Especially when considering the changing practices in modern building construction. This lack of research leaves the potential solution for the growing number of residential fire deaths to go unsolved. The consequences are allocating unnecessary time and resources responding to home fires and fatalities that could be easily solved by installing residential fire sprinkler systems, which have been proven to mitigate fire loss and decrease fire death within the home. Other projects on this particular topic have taken approaches that observe the environmental and economic benefits of residential sprinklers. In contrast, this study will seek to understand how strict fire and building codes benefit the preservation of life in order to obtain support for enforcing similar codes in the State of Massachusetts itself.

Purpose of the Study

The purpose of this study is to explore the current perceptions of Residential Fire Sprinklers by homeowners who have suffered from fire, and also building code officials who participate in developing important construction regulations to increase the installation of residential fire sprinkler protection systems with hopes to reduce the number of civilian fire deaths in Massachusetts.

There are changing practices of modern building construction and building materials used today in comparison to those used in the past. These new materials burn much more quickly than the raw materials used in older construction, and as a result, lessen the time for escape, posing a greater risk for fire death. Also, with the growing concern of the United States smoking phenomenon, there increases the risk of fire hazards within homes. In a home fire, you have less than 3 minutes to escape, and that's not taking into account whether whoever is inside the residence is cognizant of the fire (not asleep or an unsupervised child) or cognitive enough to respond in time (not under the impairment of drugs or alcohol, or mentally/physically disabled) (NFPA, 2018). The National Fire Protection Association states that home fire sprinklers can stop a fire in less than one and a half minutes. By ignoring the importance of residential fire sprinklers, you risk fire's consequences, which are death or serious injury.

To explore the current perceptions on Residential Fire Sprinklers by homeowners and building code officials, the researcher conducted a mixed-method research-based study that included observing library research, observational research, analysis of public records, and comparison of other online data that was conducted before their study. The sample group consisted of but was not limited to Massachusetts residents and building code officials/organizations such as the International Code Council, National Fire Protection Association, and Board of Building Regulations and Standards. The data was collected purely online and did not include any interaction or study of human subjects.

The study's goal was to measure the perceptions around Residential Fire Sprinklers from the perspective of Massachusetts homeowners and building code officials. This study seeks to research the purpose of discovering the benefits of a stricter fire code on sprinkler systems in residential buildings. While not directly measured, this study also had implications for

understanding how strict fire and building codes benefit the preservation of life. This study is expected to reveal a direct correlation between strict integration of residential fire sprinkler laws and a lower amount of fire deaths in residences to serve as driving evidence for adopting similar laws in Massachusetts.

Research Questions

What are the current perceptions on residential fire sprinklers that Massachusetts homeowners have? What are the current perceptions on residential fire sprinklers that building code officials have? What are the current fire/building codes on residential sprinkler systems in Massachusetts? What are the current fire/building codes on residential sprinkler systems in Massachusetts? What is the relationship between residential fire death and the lack of sprinkler systems in homes? Most importantly, what can be done to decrease the number of fire deaths in residences and incorporate a stricter code to enforce the installation of sprinkler systems?

Significance of the Study

This study is of significance to the field of fire science because it addresses the large issue of residential fire death by supporting the implementation of stronger fire code on residential sprinkler systems. This study supports the long-term goal of reducing the number of civilian fire deaths in residences, while achieving the short-term goal of gathering data for supporting a change in fire and building codes of Massachusetts, most importantly NFPA 13R. The participants of this study (the general population) will benefit from this study because they will live comfortably in their homes knowing that they have a reliable source of fire protection, a residential sprinkler system. This study will have a positive impact on the participants because it will provide them a sense of relief on their emotional well-being, they won't have to worry about surviving a fire in their homes, and they also will be able to feel that their personal belongings

are safe as well. This study will positively impact the fire service because it will help make firefighters' jobs much easier and safer. One subgroup that might perceive this study as unhelpful is the construction workers and building code officials because it will be another job task they have to complete.

Definitions

The National Fire Protection Association (NFPA) is a non-profit organization that focuses on eliminating death, injury, property, and economic loss from fire. They make fire codes and standards that govern building and operational procedures to ensure fire safety in the workplace and at home. The International Code Council is an organization that writes model codes and standards for building safety solutions, including product evaluation, accreditation, technology, training, and certification. The Board of Building Regulations and Standards is an organization that is responsible for maintaining the state building codes, hearing appeals, and reviewing decisions by local building code appeals boards. A fire code is a law adopted by state or local jurisdictions that govern requirements for fire safety of buildings, and are enforced by fire prevention officers. A building code is a set of standards that specify the rules for constructed buildings.

Limitations

One limitation in this study regarding the research design is the process done to conduct the study. Most of the data used in this study is found by online analysis of already public sources and does not collect any new research from live sources such as human subjects for opinions on residential fire sprinkler systems, meaning some of the data could be dated. Another limitation is the time and resources because this study has to be conducted within the strict time frame of one college semester which doesn't allow for much time to go out and conduct research

over a long period of time. The last limitation is funding because there is a budget constraint of zero dollars; this limits the researcher in the various resources they can access and limits their ability to go out and conduct creative research on their own behalf. A wet fire sprinkler system consists of pipes and sprinkler heads that constantly maintain water within so when a fire and a large amount of heat is introduced in the atmosphere, water is discharged immediately onto the fire.

Ethical Considerations

This study follows a procedural model conducted ethically because it adheres to the Institutional Review Boards' requirements. It does not use human subjects or conduct surveys in any way, so it is exempt from any unethical conduct. This research procedure was done carefully and is meant to cause no harm to the researcher, unintended participants, and organizations or institutions because it merely studies library and observational research online. The study simply analyzes public records and compares various fire-scene scenarios to determine the root cause of Massachusetts' issue with high fire death and understand if they would benefit from a stricter fire code.

Chapter Two: Review of The Literature

Introduction

The fire service has always taken a reactive approach to fire safety and responding to incidents on the national level. The consequences of taking a more reactive approach was an evident growth in civilian injuries and fatalities. The fire service had since created a fire prevention plan focused on enforcing a more proactive approach to fire safety. This plan included educating the public, engineering new fire protection systems, enforcing fire and building codes, creating economic incentives for following fire safety protocols, and developing

a strong emergency response protocol to reduce the loss of life in both fire and medical emergency situations. At the beginning of its time, this prevention model was effective in reducing the amount of fire-related deaths; however, the issue the fire service now faces today is that the majority of civilian deaths occur from fire in the home, and that's partly due to the lack of utilization and strict adherence of the 5 E's of Fire Prevention.

The literature review addresses three areas of research related to the overwhelming amount of civilian deaths in homes from fire partly due to the lack of utilization and strict adherence to the 5 E's of Fire Prevention. The first section addresses research related to the lack of knowledge and education the public has on the effectiveness of residential sprinkler systems and promising interventions to counteract those effects are addressed. The second section discusses the current lack of economic incentives for installing residential fire sprinkler systems and how an increased incentive/disincentive from insurance companies could encourage homeowners to cooperate. Finally, the third section discusses research related to the lack of enforcement and development of fire and building codes requiring residential sprinklers in one and two-family homes and discusses how states with stricter regulations might be the model for understanding and solving the life-threatening issue of non-fire-suppressed homes.

Current Perception and Common Misconceptions of Residential Sprinklers

The research area covered in this section is the lack of knowledge and education the public has on residential sprinkler systems and the resulting misconceptions they hold against residential sprinklers as a result of that. The first article written by Frattaroli, Pollack, Cook, Salomon, Omaki, & Gielen talks about the public's opinion concerning the residential sprinkler systems for 1-and 2 family homes. More specifically, it looks at homeowners' decisions to purchase homes with residential sprinkler systems (RSS) and their experiences with the

technology; Also comparing how RSS homeowners and owners of homes without RSS value sprinkler systems and their levels of support for policies to mandate RSS in new homes (Frattaroli, Pollack, Cook, Salomon, Omaki, & Gielen, 2015). The study was conducted by Shannon Frattaroli, Keisha Pollack, Phillip Cook, Michele Salomon, Elise Omaki, and Andrea Gielen in 2015 to offer insight into strategies to promote residential sprinkler systems in the future. This type of study uses a weighted scale to consider the demographics of all participants in relation to the general U.S population. It also uses a propensity score by means of estimating the effects of an online survey treatment to predict what biases might arise from participants before they take part in the study.

The study took place via a national targeted web panel of members who were U.S. owners of 1 and 2 family homes at least 18 years of age (Frattaroli et al., 2015). The study collected samples from all demographics, including an oversampling of those of color (African American and Hispanic Participants). Approximately 385,000 members received an invitation to respond to the survey, and those who did not respond received one follow-up invitation; however, the overall goal was to collect responses from 1,000 homeowners with sprinkler systems and an additional 1,000 homeowners without sprinkler systems (Frattaroli et al., 2015). The final sample was based on the most accurate representation of 1,357 homeowners of 1 and 2 family homes without RSS and 976 without RSS. The participants were given a survey based on questions surrounding the topics of RSS in the home, the decision to purchase an RSS equipped home, experience with current RSS, other injury prevention devices in the home, attitudes and beliefs about fire prevention, RSS in future homes and the value of RSS, and home fire experience in the community (Frattaroli et al., 2015). Frattaroli states that the approach was

based on a willingness to pay, meaning that those who took the survey were to reflect their likelihood of installing an RSS in a new home the same size as their current one.

The study experts first created a draft survey and tested it amongst several members of the research team, and then once the final product was developed, the survey was posted online, and participants were given a login to the website to take the survey once; On average it took about 14 minutes to complete (Frattaroli et al., 2015). According to Frattaroli, there were two versions of the survey, one for those who had homes with sprinklers and another shorter survey for those who did not. Therefore the independent variable would be the fact that the survey assessed homeowners' perceptions of residential sprinkler systems; on the other hand, the dependent variable was whether or not the homeowner already owned a sprinkler system for their home. The data was analyzed using a weighted scale to represent the U.S. population of homeowners 18 yrs or older and to reflect each category and subgroup of the sample, using the 2011 current population census survey (Frattaroli et al., 2015). Frattaroli also stated that procedures such as including a propensity score were done to account for potential biases related to attitudes and behaviors that can arise from using an online survey.

The results indicated that, on average, out of the survey sample, most RSS homeowners lived in newer and larger homes, reported higher incomes, higher educational achievement, and more disabilities than those living in homes without sprinkler systems (Frattaroli et al., 2015). Frattaroli also stated that most homeowners reported that they learned about RSS from a variety of sources, and when rating them on a scale from 1-5, with five being the best, there was a mean score of 3.7; however, what was also noted was that between 12-15% of homeowners reported that someone from each of their groups recommended against buying a sprinkler equipped home,

with 16 percent of homeowners confirming that they did not even know about the RSS when they purchased their homes in the first place (Frattaroli et al., 2015).

Several conclusions can be made from this survey and study about U.S. homeowners' views towards residential sprinkler systems. First, both homeowners who have residential sprinkler systems and homeowners who don't have residential sprinkler systems do show a level of care for their personal home and life safety; however, what differentiates the level of concern between the two groups is that homeowners with RSS tend to be better off financially and look more into compliance with safety standards than homeowners without RSS. Therefore it is more likely for wealthier homeowners to look into implementing RSS than those who are less wealthy, meaning that they are more cognizant and knowledgeable of the benefits RSS provides than the less wealthy homeowners. This research is important to the current researchers' study because it proves one of two issues: 1.) there isn't enough information provided to the general public about residential sprinklers and their benefits, or 2.) The public (those who are non-wealthy more likely than not) does not understand the information that is provided or has no interest in learning about the benefits of residential sprinklers due to a number of reasons.

There were several limitations in the Frattaroli et al. (2015) study, as the reliance on self-reported data and non-random samples. This meant that there was an inability to validate responses, and since the sample group was focused on owners of 1 and 2 family homes, there left a small number of respondents for the survey. This can be addressed by utilizing in-person surveys and randomizing the samples of people, so the data is not restricted to just 1 and 2 family homeowners. This would allow for the opportunity of a more diverse range of responses that cover more than just the homeowner's perspective.

The second article (Clothing flammability and burn injuries: public opinion concerning an overlooked, preventable public health problem), looks at the risks of clothing flammability and burn injuries related to the overlooked and preventable fire problem of lack of sprinkler systems in U.S. homes. Fire and burn-related injuries are a leading cause of morbidity and mortality worldwide, and in the United States, house fires are the leading cause of fire-related death (Frattaroli, Spivak, Pollack, Gielen, Salomon, & Damant, 2016). According to the study, improvements have been made in the building code and prevalence of smoke alarms within homes; however, the clothing-related fire risks have received relatively little investment in prevention. Therefore, the purpose of the study was to describe knowledge of clothing flammability risk, public support for clothing flammability warning labels, and stronger regulation to reduce the fire risk (Frattaroli et al., 2016). This study was published by the authors Shannon Frattaroli, Steven Spivak, Keshia Pollack, Andrea Gielen, Michele Salomon, and Gordon Damant in May 2016.

The study took place mainly in the region of the United States, among several owners of one and two-family homes. The participants were composed of two separate samples, one that was representative of homeowners living in sprinkler-equipped homes and the other of homeowners without sprinklered homes. Among the participants included three racial and ethnic groups (White, Black, and Hispanic). The study assures that all participants were homeowners of 1 and 2 family homes, of the age 18 years or older, then had their results weighed separately and then post-weighted into a representative total. Participants were given a cross-sectional survey with the primary aim of assessing the homeowners' experiences with and attitudes toward residential sprinkler systems, as well as other strategies for preventing fire and burn-related injuries (Frattaroli et al., 2016). The study intervention included six clothing flammability

questions developed through reviewing the literature and primarily formed by the expertise of co-authors S.S. and G.D. (Frattaroli et al., 2016).

The survey was pilot tested with fire safety experts and members of the research team, and once finished, to access the survey, invited panel members logged onto the Harris site under their provided information; On average, the survey was completed in less than 14 minutes (Frattaroli et al., 2016). “There was a pre-survey to identify people living in the United States who were 18 years or older in a one or two-family home they owned; Additionally, there was a question to identify whether the respondent owned a sprinkler-equipped home” (Frattaroli et al., 2016). This was what determined who would proceed in taking the full survey. The study’s dependent variables were the following: public awareness of federal standards, opinions about new interventions to reduce risk, satisfaction with current standards, and support for stricter standards. “The data was weighted to be representative of the U.S. population of homeowners 18 years and older; Each category was weighted by the following key demographic variables: household income, education, age, gender, and region of residence” (Frattaroli et al., 2016). Data was also analyzed using a comparison of responses between homeowners with and without RSS by following an approach of market research analysis and improvement of services.

The results indicated that the homeowners in the two groups were significantly different from one another. Those in the sprinkler sample were younger (45 vs. 54 median years), reported higher incomes (35% vs. 26% with household incomes of $100,000 and higher), and were more educated (80% vs. 67% earned a college or graduate degree) (Frattaroli et al., 2016). According to Frattaroli and his colleagues, homeowners with sprinkler systems were more likely to respond correctly to the questions about fabric flammability and to report high levels of familiarity with the federal flammability standards. The study also proved that homeowners with sprinkler

systems reported a significantly higher agreement that federal standards provide enough protection compared to homeowners without sprinklers. “While homeowners overall were evenly split in their views about the effectiveness of current standards, when provided information about the number of people who die and are treated in emergency rooms every year when clothing catches fire, a majority of homeowners (53%) supported stricter federal standards” (Frattaroli et al., 2016).

Several conclusions can be drawn from this study based on the results. First, due to the low level of knowledge about the flammability risk of different materials within the household, it is worth raising awareness and mitigating risk in the future. Also, since owners of sprinkler equipped homes were more likely to report being knowledgeable about flammability standards, the associated risks and provide their support for a labeling policy to improve and reduce those risks, it suggests that support for preventative measures may be most effective in those populations already predisposes to health prevention behaviors (Frattaroli et al., 2016). It also shows light to a potential trend of high socioeconomic status and willingness to comply with and follow or implement fire prevention standards within their homes. As measured in the study, income and education have directly connected to groups that invest in time and or resources to protect themselves and their families. This data is important to the current researcher’s study because it proves that preventative measures such as educating the public is beneficial for all communities and may be important especially to those that are more susceptible to fire due to their reluctance in complying with and supporting fire prevention standards similar to that of residential sprinkler systems.

The study’s limitations were the following: online survey structure leaves a segment of the population uncaptured. A small number of questions devoted to clothing flammability were

assessed for validity based on the participants' discretion, and resources were also limited. There is also a need to develop stronger questions that gain the public's opinion on public safety and specific changes they would support to understand better what needs to be changed and how to support the community better.

The third article, (US experience with sprinklers), talks about the experience people of the United States have had with fire sprinklers in terms of a more general research study. The purpose of this article is to report information about the performance of sprinklers in general terms of how they assisted homeowners and people of other buildings when under the conditions of fire. The author of this article is Marty Ahrens, and it was published by the National Fire Protection Association in July of 2017. The setting of this study was mainly in the United States, with the sample being people who experienced fires in sprinklered buildings from 2010 to 2014. This includes a range of people based on demographics such as ethnicity, socioeconomic status, region, sex, and race. The issue that was explored was the sprinkler operation and effectiveness within several types of occupancies. This involved discovering and analyzing the positive and negative effects of sprinklers, such as the increased life and property safety, along with the low percentage of fire-related injuries and deaths associated with sprinkler presence, and also the reasons for sprinkler failure and ineffectiveness in buildings.

Estimates and statistical data were derived from the details collected by the U.S. Fire Administration’s (USFA’s) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's annual fire department experience survey (FES) (Ahrens, 2017). The study also utilized the FES fire and loss estimates to divide and create comparable totals for those fires reported to local fire departments but not captured by NFIRS. Marty Ahrens' research collected various means of data on the fire sprinklers in all occupancies such as: sprinkler

presence and type, fires in properties with sprinklers vs. no automatic extinguishing systems (AES), sprinkler operation, effectiveness and problems, civilian deaths in sprinklered properties, and unwanted activations (Ahrens, 2017). For the researcher's study, there will be more of a focus on Marty Ahren's reports of sprinklers in home fires and the positive and negative effects associated to better understand the connection between residences with sprinkler systems and those without.

The variables that were measured in this study for sprinklers in home fires were the following: sprinkler presence and type in home fires, fires in home fires with sprinklers vs. no AES, sprinkler operation, effectiveness and problems in home fires, the impact of smoke alarms and sprinklers on deaths per 1,000 home fires, and unwanted activations (Ahrens, 2017). The data in this study was analyzed and coded through the National Fire Incident Reporting System. The results of this study indicated that the death rate per 1,000 reported fires was 81% lower in homes with sprinklers than in homes with no AES; And the civilian injury rate per 1,000 reported fires was 31% lower in homes with sprinklers than in homes with no AES (Ahrens, 2017). The study also found that sprinklers operated in 94% of home fires in which sprinklers were present and fires were considered large enough to activate them. There were only 6,800 unintentional sprinkler activations in 2014. When sprinkler systems were considered ineffective (46%), and the water did not reach the fire, the leading cause was to be determined as the system was shut off 62% of the time (Ahrens, 2017).

Conclusions made from this study are that residential sprinkler systems are an effective and important part of fire prevention. The impact they have on reducing the number of civilian deaths and injuries in fire is more than present compared with unprotected homes. This study is valuable to the researcher's current study because it validates enough public information released

about the performance of residential sprinklers. It also proves that there are enough benefits for installing them in a home. But the issue now is why it hasn't convinced a majority of the public to protect their homes. A limitation or weakness of this study is that it provides valuable and strong information on the benefits of sprinklers in home fires. Still, it is targeted more towards an audience of people with fire-background knowledge. This should be utilized in fire education and as a means of obtaining more public awareness to reduce the number of unprotected homes in the United States.

Section 1 Summary

The research literature indicates that despite all of the information provided on residential sprinkler effectiveness, some of the general public still has a negative perception. The three research articles evaluated in this section provide insight into the public's current perceptions and misconceptions on the residential fire sprinkler system. The participants of these studies were divided into two halves based on their ideal standpoint. On the one hand, there were the people who supported the installation of residential sprinklers, and on the other, there were those who wanted nothing to do with them. The percentage of the public who supported residential sprinklers was typically made up of a demographic associated with higher levels of education, income, and more disabilities than those who opposed or had a neutral standpoint on residential sprinklers. These research articles also prove that despite all of the evidence provided on the effectiveness of residential sprinklers, there still seems to be a lack of implementation on the public's part. These findings reinforce the argument that the majority of the public who have unprotected homes have no interest in learning about or implementing these public safety features due to something other than educational reasons. The researcher suggests further investigation into the cause of this deterrence. The evident reason may be the lack of financial

incentives or disincentives from outside sources such as government and insurance agencies. Despite the wealth of information, prior research has provided, several weaknesses limited their ability to gather genuine responses. These limitations included relying on self-reported data and non-random samples. This meant that there was an inability to validate responses, and since all studies were conducted with owners of 1 and 2 family homes, there left a small number of respondents for the survey. In the current study, this can be addressed by utilizing in-person surveys and randomizing the samples of people, so the data is not restricted to just 1 and 2 family homeowners. This would allow for the opportunity of a more diverse range of responses that cover more than just the homeowners' perspective.

Public Opinion on Economic Incentives for the Installation of Residential Sprinklers

The research area covered in this section is the lack of a substantial economic incentive/ disincentive for installing residential sprinkler systems and the resulting misconceptions and biases the public holds against residential sprinklers as a result of that. The first article, (Evaluation of the justifiable investment in residential sprinkler system installations using the J-value methodology), talks about the cost-benefit analysis of residential sprinkler system installations. Sprinklers have a long record of property and life protection, but there is a cost associated with their installation and ongoing maintenance (Spearpoint & Hopkin, 2018). This study was first published by Michael Spearpoint and Danny Hopkin in the year 2018 with the purpose of identifying whether it would be worth it to mandate residential sprinkler systems in some or all buildings within a jurisdiction. The study looks at multiple previous Cost-Benefit Analysis (CBA) reports, along with establishing a "j-value methodology" (a method used to assess the degree of life expectancy, average income, and work-life balance) to determine the cost-benefit analysis of sprinkler systems with consideration to the economic value of human life

(Spearpoint & Hopkin, 2018). The study was conducted in the UK, and observed three different studies, the Welsh, New Zealand, and Australian cases, all of which contained a wide range of demographics (single occupancy homes, flats, hostels, care-homes).

The intervention for this study sought out to examine the three previous CBA case studies (Welsh, New Zealand, and Australia) and compare the data to their local fire department's performance and fire demographics to determine whether a mandate for residential sprinkler systems would be beneficial. The three different studies measured the effectiveness of residential sprinkler systems in the expression of the reduction in fatalities as a result of them being installed. The data was analyzed in relation to the j-value analysis, which measured the benefit-cost ratio associated with preserving human life in terms of injury and fire death. The results indicated that in all three cases there was no cost-benefit for mandating sprinklers in domestic dwellings. The reduction in fatalities for each study due to introduction of sprinklers in single occupancy dwellings averaged around 83 people (90 for Wales, 80 for New Zealand, and 79 for Australia). It was because of these reasons that the UK researchers determined that it was not financially viable for them to go along with mandating residential fire sprinkler systems as well.

Conclusions made about this study are as follows: First, the amount of fire fatalities among the UK and other three areas to begin with were already low when compared to the United States, for instance, the New Zealand Fire Service statistics noted that over the 5 years period from 1993-1997 there were only 36 fatalities and 239 injuries per year. Secondly, the UK made their decision based on the sole fact that since residential sprinkler systems in the three studies didn't lessen the death toll by much it was deemed to be non-beneficial. Since the study also shows no other economic incentive for installing sprinklers, the public has no reason to believe that residential sprinkler systems are worth the investment. This research is important to

the current study because it shows that from the public's perspective, if residential sprinklers don't save property then they have no inclination to consider installing them. Unfortunately for the public, the preservation of life is not good enough of an economic incentive to want to buy sprinklers. The limitations of this study are that instead of conducting their own CBA, the UK Fire Department studied three different ones to determine whether they wanted to implement a mandate for residential sprinklers. This meant that they applied little to none of their own data into the research study, leaving nothing but the possibility of unfavoring sprinklers. This can be addressed by conducting a CBA of their own local communities to see if the cost-benefit would be different.

The second article, (A review of Sprinkler System Effectiveness Studies), looks at different sprinkler system effectiveness studies. This includes observing how well sprinkler systems provide a cost-effective mitigation of the risk to life and or property (Frank, Gravestock, Spearpoint, Fleischmann, 2013). The research was done by Kevin Frank, Neil Gravestock, Michael Spearpoint, & Charles Fleischmann in the year of 2013. The purpose of this study was to examine the two main approaches for estimating sprinkler cost-effectiveness to determine the reliability of these sprinkler systems in the development of performance-based fire safety design methods (Frank, Gravestock, Spearpoint, Fleischmann, 2013). The setting and sample were based on a study conducted in New Zealand on sprinkler performance, so most of the data comes from that region. The intervention conducted was based on the International Fire Engineering Guidelines, similar to the performance-based approach called the New Zealand Verification Method (Frank, Gravestock, Spearpoint, Fleischmann, 2013). The data was measured through a typical event tree to represent mutually exclusive outcomes from individual events, kind of like a measure of risk. It collected data from relatively important structure fires and looked at

information such as fire containment, number of sprinklers activated, amount of damage to structure and property, required amount of fire service intervention, and occupancy injuries and or fatalities.

The data in this study was analyzed by using a specialized software for evaluating fire risk based on probability estimates of sprinkler effectiveness and or reliability within several fire incident reports. Results from this study confirmed that on average, sprinklers increased the probability that flame damage was confined the room of origin to 95% compared with 74% for fires with no sprinklers, and the fatality rate (83% reduction) and property damage (40%-70% reduction) was lower depending on occupancy (Frank et al., 2013). Several conclusions can be drawn from this; The first being that sprinkler systems have proven time and time again to be a good investment from an economical standpoint. What this means is that sprinklers have in some way proven to save lives and mitigate fire loss better than those buildings that had no sprinkler systems. The issue now that relates to the current study is the question of is that enough?

The problem is that people of the public attribute sprinkler efficiency based on how its cost benefits them, when in actuality, they should be focusing on how well the system performs and what it achieves. Of course, a sprinkler system does not equate to a 100% reduction in loss, but based on its design and functionality it is 100% effective at doing its job. Therefore, the research proves that sprinkler systems do have economic benefits, but the question is does the public view that as an incentive to install sprinklers. Better yet, how can they view that as an incentive when they misunderstand the true goal of sprinkler systems? The limitations of this study are that it doesn't consider the potential for sprinkler systems to fail when there is no fire present; Such situations are at a low chance of occurring and may occur due to rupture from freezing or mechanical damage, but can essentially lead to water damage (Frank et al., 2013).

Also there should be a more clear definition of what effective sprinkler systems achieve in terms of property damage and life safety, not so much of the numbers of sprinklers activated during a fire.

The third article, (Sprinkler Systems and Residential Structure Fires-Revisited: Exploring the Impact of Sprinklers for Life Safety and Fire Spread), talks about the impact of sprinklers for life safety and fire spread in residential structures. The purpose of this study is to "examine fire-related casualties, fire outcomes, and casualty behavior for fires that occurred in residential properties, and to compare fires that occurred in buildings completely protected by sprinkler systems with those fires that occurred in buildings without any sprinkler protection" (Garis, Signh, Clare, Hughan, & Tyakoff, 2017). The authors of this research study are Len Garis, Apreet Singh, Joseph Clare, Sarah Hughan, and Alex Tyakoff. The study was published in the year of 2017. The setting and sample for this study were based on the 439,256 fires reported combined in the Provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and New Brunswick between 2005 and 2015 (Garis et al., 2017). The intervention involved a close study of fire incidents with a focus on structure fire characteristics and the related casualties. This involved research procedures observing things like the frequency of fires in all residential buildings, outcomes for life safety in the presence of sprinkler systems, and fire performance and casualty behavior in the presence of sprinkler systems (Garis et al., 2017).

According to the various authors, the among data sets retained and classified as residential contained the records of 140,162 fires, 1,440 deaths, and 9,142 injuries (Garis et al., 2017). This information was queried and retained, then further classified as either completely sprinkler protected or completely without sprinkler protection. Data was analyzed mostly by taking most of the data retrieved from previous studies and was eventually attempted to be

replicated in order to determine how the findings might've compared to the provinces in the main study (the Garis et al. study). The results indicated that "across all residential fires, in the absence of sprinkler protection, the death rate per 1,000 fires increased by 3.3 times and the injury rate per 1,000 fires increased by 0.9 times" (Garis et al., 2017). The research also identified that fires in sprinkler-protected homes were smaller and better controlled than those without sprinklers. "Fires controlled by sprinklers were confined to the object, part of room, or room of origin 88.4% of the time, which was 1.3 times more frequent than for fires in buildings without sprinklers (65.1%)" (Garis et al., 2017).

Conclusions made from the results of this study are that residential sprinkler systems prevent a large loss of life and property, especially when combined with smoke alarms. The research also suggests that campaigns to target fire prevention should be directed towards the highest-risk members of the community: the elderly, impoverished, and vulnerable (Garis et al., 2017). The limitations of this study are that it avoids addressing or explicitly explaining the economic benefits of residential fire sprinkler systems. Sure it talks about the benefits of life safety and property loss, but without a dollar sign attached, it doesn't mean much to the homeowner. This study is important to the current research because it provides good information on the effectiveness of residential sprinklers, but it also sheds light on the lack of information on the economic benefits of residential sprinklers. There may be studies done on economic performance of sprinkler systems, but not far enough to compare to the number of studies done on sprinkler effectiveness. The possible consideration of completing more studies on the economics of residential sprinkler systems could be what pushes people to buy them.

Section 2 Summary

The research literature indicates that despite all of the studies done on residential sprinkler systems and their performance among a wide range of fires, there still seems to be negative feelings towards them. The three research articles that were evaluated in this section support the argument that there is a lack of a driving economic incentive to motivate homeowners to buy sprinklers. This might be due to the fact that the word "effectiveness" is used so fluidly throughout studies without a strong interpretation of what it's actually supposed to mean. What makes a sprinkler system "effective" isn't just how well it economically benefits a homeowner, but more importantly how well it does its job. A homeowner of a sprinklered residence can theoretically go their entire life without having to utilize their sprinkler system, and as a result some will say that it was a bad investment. This partly contributes to the reason why homeowners are reluctant to install sprinklers in their homes, another reason why is due to the fear of false activation.

To combat these fears and misconceptions, the studies must overcome their limitations by refuting misinformation, clearly demonstrating the goals of sprinkler systems, advertising larger economic incentives for sprinkler installation like insurance discounts and tax deductions, and lastly, by conducting studies on something other than sprinkler effectiveness. It is clear from the research that residential sprinkler systems are effective, and there is plenty of information on that, but what the public needs to know is the economic benefits. Yes, there still is a lack of knowledge on sprinkler systems from the majority of the public; however, their perception will remain the same if they don't see a dollar value associated with the effectiveness sprinklers provide. The only other way to achieve the goal of protecting all homes with sprinklers would be to mandate them through a stricter fire and building code or forcing them to be required in new construction buildings.

Lack of Residential Sprinkler Mandate

The research area covered in this section is the lack of enforcement and development of fire and building codes that require the installation of sprinkler systems in homes. The first research article, (Standardizing NFPA 13), looks at the different changes between the 2013 and 2016 editions of NFPA 13. NFPA 13 is the standard for sprinkler system design approaches, system installation, and component options. The study was conducted by Raymond Grill in 2018, with the purpose of discussing the changes in the NFPA code from the years 2013-2016 and the recent design process in developing the 2019 version of NFPA 13. The setting and sample are not limited to a specific area because the NFPA is a national code-making agency. The issue that is explored is that usually once the most recent edition of the code is published, not everyone reviews it and gets familiar with the changes. The researcher states that it's important to know what criteria the adopted standard changes because it will help them prepare training material for their employees and review and change any outdated procedures in the sprinkler design process (Grill, 2018).

The research procedures include reviewing both the NFPA 13 design for 2013 and 2016 and analyzing them for differences to determine what changes need to be made in the current sprinkler design process. The variables that were measured were the various direct changes in the code. Data analysis was done on the qualitative level by measuring the improvements and possible deterioration of certain processes in the code. The results of this study yielded many changes to the NFPA 13 code from 2013 to 2016; Some of the most significant changes were, the removal of sprinkler heads in revolving doors, a new definition of concealed spaces, and the change of minimum requirements for distancing from obstructions (Grill, 2018).

Conclusions that can be drawn from this study is that there is still a lack of requirement in the building/fire code for residential sprinkler systems. In the research article it states that: “most authorities adopt NFPA 13 as a part of their building code adoption process, there are some authorities that adopt the most current edition of NFPA standards regardless of the edition of building code that is applied” (Grill, 2018). This is unfortunate because within this research article it discusses the 2013, 2016, and 2019 code for NFPA 13. This code is usually updated roughly every three years, and still there is no requirement for the installation of sprinklers in residences. This is important to the current research study because it proves that there is still a lack of mandated requirement for installing sprinklers in residential buildings. The researcher suggests that NFPA 13R might have a requirement since it is the standard for the installation of sprinklers for low-rise occupancies. The limitations of this research study is that it compares two different sprinkler codes but neither addresses the need for fire sprinklers in homes.

The next article called (Fire Extinguishing Installation for Residential Buildings), is a research study that talks about the idea of a new sprinkler system that is connected to the internet and can be operated by any electronic device. The purpose of this study is to propose a change in the fire service technology that is the automatic sprinkler system. This would be an extinguishing system that will use the Iot (Internet of things) concept. This research was written and published by Mihai Cipran Mitrea and Andrei Burlacu in the year of 2019. The study is based on the NFPA’s desire to equip new housing construction with sprinkler installations as well as the British standard for designing the Iot model. The issue that was addressed in this study was the lack of mandate for residential sprinkler systems, and tries to come up with a solution to improve the existing NFPA sprinkler requirements. The procedures used to develop this Iot model required searching for studies in the field on residential sprinklers and common issues they

experienced in the development process. The research study observed four different interpretations of the Iot model to determine which one would be most effective in residential structures.

The data was analyzed by observing those studies and using the information found to help in identifying solutions to the problems in design of regular sprinklers. The results of the study indicated that there were issues in the current design process of residential sprinklers that could be fixed through implementation of the new Iot method. The research found that a common issue with fire sprinklers is that they use a lot of water and so they developed a new misting system for the Iot sprinkler system. Conclusions made from this study are that there is a need to implement sprinklers in residential buildings; however, there isn't a fire or building code requiring sprinklers to be installed yet. This directly relates to the current study because it provides further promotion of the fire issue and supports the need for increasing fire safety in the homes. This also gives endorsement for the implementation of some kind of building or fire code requirement for the installation of residential sprinklers in all homes. The limitation of this study is that it focuses on highly technological advancements such as robotics and cell phone technology to extinguish fires. The idea of having a centralized hub for a sprinkler system at the foothold of technology could pose problems in the future like malfunctions or possible security breaches. Also, the robot fire extinguisher system might work from a logical standpoint but could also have flaws when completely relied on without further testing.

The third research article, written by the National Fire Protection Association, talks about NFPA 13R, the standard for the installation of sprinkler systems in low-rise residential occupancies. This document was formed, written, and published in the year 2021 by members of the National Fire Protection Association (NFPA) as being a part of the Technical Committee On

Residential Sprinkler Systems. The purpose of this document is to update the national code requirements for the installation of residential sprinkler systems in low-rise occupancies. Low-rise buildings are classified as those that are four floors and under. The main goal of this research is to provide a high degree of life safety and property protection to the inhabitants of low-rise multifamily dwellings (NFPA, 2021). The research took place amongst various areas around the world since the NFPA is a National Agency, and their data is compiled from various sources. The issue this code addresses is the problem of fires in residential occupancies and the requirements for installing sprinklers in hopes to provide a means for increasing the amount of protected residences.

The procedures for gathering this information were done by observing fire reports among different states. The variables measured in these reports were the common issues occurring in residential fires with sprinklers. Data was then analyzed to reflect the majority of the nations common fire issues involving residential sprinklers, and then aimed at developing an updated standard to mitigate those issues. The results of this study indicated that there was a need to address and revise methods for freezing or damaged systems and other operational tests, including things like new protection criteria, but nowhere in the updated code does it explicitly state a requirement for mandating residential sprinklers in low-rise buildings (NFPA, 2021). Conclusions made based on these findings are that the national fire protection association uses the NFPA 13R code to provide information to those who intend on installing sprinklers in their homes; however, there still lacks a mandate requiring them to be in all residential buildings. This means that the NFPA deems it unnecessary to require sprinklers in home structures even though home fires are the main leading cause for the majority of civilian deaths.

This is important to the current study because it proves that there is still a lack of mandated sprinkler requirement in homes despite the fire services' claim to combat fire safety in homes by taking a proactive approach to fire. The limitations of this study are for the same reason that it focuses so much on providing information to people who want to install sprinklers in their homes, but doesn't attempt to reach out to the remainder of the public who could definitely benefit from such a technological innovation. As Frattaroli et al., 2015 stated: Only about 80% of people bought homes with RSS already in place, and only 11% of which indicated that they had installed their sprinklers to comply with a local policy mandate that required RSS as part of a substantial renovation. Where does that leave the rest of the public? The solution is educating the public of the benefits sprinklers provide, then developing a code that requires sprinklers in all residences, and providing a good economic incentive or disincentive for following that code requirement.

Section 3 Summary

The research literature indicates that the United States and other countries continue to struggle with developing and implementing a residential sprinkler system mandate for all homes. The three research articles that were evaluated in this section provide supporting evidence that proves two things: one, that there is a need for a residential sprinkler system mandate, and two, that there is a lack of support and development for that mandate from delegates of the code making process. These findings provide rationale for an intervention and reconsideration of the proactive fire prevention methods the fire service once stood for. The current study aims to understand how the fire service came to neglect the sole duties they have constructed. There is lack of implementation on some end of the fire service, and the current research attempts to restate and enforce the original 5 E's of Fire Prevention to find out where the fire service went

wrong, seeking to create a better method of addressing this fire problem. There were several weaknesses that limit previous studies that the current research makes an effort to avoid. These limitations included having the wrong target audience and creating fire sprinkler code without actually requiring any sprinkler mandate.

Chapter Summary

To ensure that the public is safe within their homes, the fire service must take a proactive approach to fire safety. What this means is that they must strictly adhere to the fire prevention plan called "The 5 E's of Fire Prevention." The plan includes things like Education, Engineering, Enforcement, Economic Incentive/Disincentive, and Emergency Response. When properly executed, all of these things make up a solid plan to administer a high level of care to the community. The issue that the fire service now faces today is that most civilian deaths occur from fire in the home, and there still remains no solution to reduce that statistic. The research studies that were reviewed in this chapter indicated that the percentage of homes protected by residential sprinklers was low due to a: lack of knowledge on sprinkler benefits, lack of economic incentive, and a lack of residential sprinkler mandate. Research also proved that there was a plethora of information regarding sprinkler benefits; however, a majority of low-income homeowners had no incentive to read it. There was also a lack of clarification on what economic benefits residential sprinklers provided, and it was discovered that there have been no efforts from code making delegates to pass a mandatory sprinkler installation law for all residential buildings. The limitations of these studies were mainly issues with clarifying information, whether that be definitions of sprinkler effectiveness, or further explaining the economic incentives for installing sprinklers. Additionally, some of the studies used small sample sizes and relied on self-reporting from participants in the study. This current study contributes to the

existing research literature by researching and analyzing the current issues the fire service face when trying to get sprinklers installed in residential buildings. The current study found that because of a deviation in the 5 E's Prevention Plan and a lack of transparency it has left gaps that allow for misunderstanding and wariness from the public and others within the building code-making process.

Chapter Three: Discussion & Analysis

Introduction

In a world where the fire service aimed at becoming more productive in fire prevention and safety, they have created the 5 E's of Fire Prevention Model. This model aimed at rooting out all potential behaviors and knowledge that worked against fire safety as a whole. In the beginning, this model was effective at reducing the number of fire related deaths; however, the issue the fire service now faces is that most civilian deaths occur from fire in the home, and that's still the hardest place to get fire protection systems installed in. This occurred partly due to the lack of utilization of the 5 E's of Fire Prevention method, and as a result there has been a whole slew of issues that have occurred in residences around the nation. The issues raised in chapter one was the lack of knowledge & education of the public, lack of economic incentive/disincentive for the installation of sprinklers, and lack of enforcement and development of fire & building codes that require sprinklers in residential buildings.

The literature review of this paper further discussed these three different subject areas that when combined, create the fire problem that the United States faces today. This researcher conducted a mixed-method and research-based study that involved close analysis of previous fire studies, current code information, public information and opinion on sprinklers, and the economic benefits and reliance of sprinklers. The purpose of this study was to explore the current

perceptions of Residential Fire Sprinklers by homeowners who have suffered from fire, and also building code officials who participate in developing important construction regulations in an effort to increase the installation of residential fire sprinkler systems with hopes to reduce the number of fire deaths in homes in Massachusetts. The design of this study solely focused on discovering and analyzing current data and information on residential sprinklers and the public's opinions along with the problems that arose because of those opinions.

Discussion

In the beginning of this study the researcher sought to understand and answer the following questions: What are the current perceptions on residential fire sprinklers that Massachusetts homeowners have? What is the relationship between residential fire death and lack of sprinkler systems? Has this formed an economic incentive to install sprinklers in homes? What are the current perceptions on residential fire sprinklers that building code officials have? What are the current fire/building codes on residential sprinkler systems in Massachusetts? And most importantly, what can be done to decrease the amount of fire deaths in residences, and incorporate a stricter code to enforce the installation of sprinklers in residential homes?

The research from the literature review found that despite all of the information provided on residential sprinkler effectiveness there still was a negative perception among some of the general public. Though both homeowners who have residential sprinkler systems (RSS), and homeowners who did not have RSS did show a level of concern for their personal home and life safety; however, this level of concern varied between the two groups because of their different demographics. The research found that homeowners with RSS were more likely to be better off financially, have higher educational achievement, and more disability than those living in homes without residential sprinklers. Because of these traits, these homeowners looked more into

compliance with safety standards than homeowners without RSS. This meant that support for preventative measures may be most effective in those populations already predisposed to health prevention behaviors. It also showed that income and education were a direct connection to groups that invest time and resources to protect their property and families from fire in the home.

The research found that residential sprinkler systems were very effective in reducing the amount of fire death and property loss. Results discovered from one study stated that across all residential fires, in the absence of sprinkler protection, the death rate per 1,000 fires increased by 3.3 times and the injury rate per 1,00 fires increased by 0.9 times (Garis et al., 2017). Also, on average the fatality rate when sprinklers were present in fire was reduced approximately by 83 percent, and property damage by 40-70 percent; however, unfortunately these findings did not pose a good enough reason for most homeowners to install sprinklers within their homes. The problem was that people misunderstood what sprinkler effectiveness was, and therefore attributed sprinkler efficiency based on how well its cost benefitted them personally. This proved that there was an economic incentive to buy sprinklers, but a more clear definition of what sprinklers are meant to achieve, along with an increase of insurance discounts for having a sprinklered home might have increased the level of support from homeowners.

Research collected during this study portrayed a need for a requirement of sprinklers in residences, and proved their effectiveness, yet somehow a national mandate has not been passed. After close examination of the current fire and building codes on residential sprinklers, the researcher has determined that the codes specify the requirements and process for installing sprinklers in homes, but do not generally require all homeowners to install sprinklers. This means that the NFPA and other building code enforcers deem it unnecessary to require sprinklers in home structures even though home fires are the main leading cause for the majority of civilian

deaths. These studies on fire incidents and residential sprinkler effectiveness can be used as the force to fight for creating a mandatory sprinkler system code for 1 and 2-family homes, and with the re-implementation of the 5 E's of Fire Prevention, can create a guiding coalition of what the fire service once stood for.

Limitations

The limitations of this study were that a majority of the research information utilized was found online, therefore it was collected from past studies that may have been slightly outdated. This is partly a limitation, but also a positive contribution to the researchers' argument that not enough research has been done on this direct topic. There was also no funding which created limited access to certain sources both online and offline. It was hard to find resources to support this specific topic from the online databases because there was so little information out there. The researcher was not able to utilize in person interviews or online surveys which could have given more recent information and opinion from Massachusetts homeowners. Lastly, the research was also restricted to a limited time period of one college semester so it left little time for a long and thorough data collection process and analysis.

Recommendations For Future Research

The next researcher should go out and collect data on their own that way it will be the most accurate and representative of the current views on residential sprinkler systems. It's also important that they take the time to conduct the research and analysis over a long period of time, most likely at least an entire year. The researcher should conduct surveys and interviews of the public and fire/building code organizations. Another possible improvement would be interviewing other organizations that conduct similar research under this topic such as the Home Fire Sprinkler Coalition and Massachusetts Fire Sprinkler Coalition. If another researcher wants

to expand upon the current research they can look at the different states that have stricter fire code and compare it to Massachusetts, to determine how that plays into the preservation of life and compliance to the installation of sprinkler systems in homes.

Conclusions

The three main lessons that are learned from this research study are that there is still a need for a sprinkler mandate requiring sprinklers in residences, the fire service needs to do a better job at enforcing the 5 E's of Fire Prevention method, and the public needs to be more open minded when it comes to accepting residential sprinkler systems in homes.

There needs to be a specific focus on making sure the public is educated on the fire risks they face and the importance of sprinklers. This would increase the number of people who favor sprinkler systems in homes and also provide support for the overall value of sprinklers. There also needs to be a focus on engineering more efficient and safe sprinkler systems that have a smaller fault rate to give the public more confidence in their reliability. There also needs to be the development of some sort of fire or building code that requires sprinkler systems to be installed in all residential buildings. This code also needs to be strictly enforced to ensure that homeowners are held responsible for following the rules and regulations. If no code is developed there should be a larger economic incentive or disincentive for those homeowners who do not have residential sprinkler systems. If all of these improvements are implemented, then there would be an increase in fire safety among all residential buildings and the total number of civilian deaths from residential fires would decrease a tremendous amount.

After this research has been done I would say that in order for all of these advancements to be made there has to be buy-in from all forces involved. This means that the fire service must have the support of all the people involved in the code-making process. The public must also

agree to actively participate in trying to understand the benefits of fire sprinkler systems, as well as being able to accept the idea of having them implemented in their homes. It will be tough to implement a sprinkler system mandate and it's not likely that there will be support from everyone in the beginning, so the best option is to work towards the goal in smaller increments. This will require actively educating the public, working on perfecting residential sprinkler system design, and developing great incentives for sprinkler installation, all until there is enough support to fully implement a code that requires them in every home.

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