Door Messaging Strategies Workshop Proceedings

FINAL PROCEEDINGS BY:

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Executive Summary

These are the proceedings of the “Door Messaging Strategies Workshop”. The event was held on 9 July 2019 in Linthicum Heights, Maryland. This workshop was conducted as part of a one-year research project on “Door Messaging Strategies” supported by the DHS/FEMA Assistance to Firefighters Grant Program. This topic is of direct interest to the fire service, engineers, scientists, public education specialists, researchers, smoke alarm manufacturers, and other fire and life safety experts; most of these stakeholder groups were represented at this event.

The goal of this workshop was to assess the impact of a closed sleeping room door on smoke alarm early notification and home escape in the modern fire environment of homes and evaluate how these findings can inform public education messaging around this issue.

The fundamental concern with clarifying door position messaging is the balance of the door acting as an obstacle for rapid audible notification of occupants compared to the door serving as a fire barrier to maximize critical escape times. Research has documented that compartmentation, including room doors, is an effective means to slow the spread of fire and smoke in home fires and thus increases the available egress time for home occupants. However, smoke alarm effectiveness is another important factor in home fire safety and safe occupant egress which may be impacted by the barrier to sound created by these doors. The workshop discussion focused on both factors within the context of public education messaging.

The workshop presentations and group discussions considered all the influencing factors for door messaging strategies, including both scientific (i.e., technical) and education-based (i.e. non-technical) factors. The workshop discussion highlighted the importance of considering fire dynamics, notification, and human behavior factors when developing messages around this issue. The technical “Door Messaging Strategies” analysis from Combustion Science & Engineering indicated that there may be a benefit to closing a sleeping room door at night, from a fire dynamics and notification standpoint. When considering all factors, however, it was observed that the workshop attendee’s interpretation of actual door messages still lacks consensus,
Acknowledgements

This workshop was supported by:

![FEMA Logo](image1.jpg)  
FEMA Assistance to Firefighters Grant

This workshop summary report has been prepared by Victoria Hutchison, Research Project Manager at the Fire Protection Research Foundation. The information contained herein is based on the input of numerous professionals and subject-matter-experts. While considerable effort has been taken to accurately document this input, the final interpretation of the information contained herein resides with the report author. The content, opinions and conclusions contained in this report are solely those of the authors and do not necessarily represent the views of the Fire Protection Research Foundation, NFPA, Technical Panel or Sponsors. The Foundation makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

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About the Fire Protection Research Foundation
The [Fire Protection Research Foundation](https://www.fprf.org) plans, manages, and communicates research on a broad range of fire safety issues in collaboration with scientists and laboratories around the world. The Foundation is an affiliate of NFPA.

About the National Fire Protection Association (NFPA)
Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach and advocacy; and by partnering with others who share an interest in furthering the NFPA mission. [All NFPA codes and standards can be viewed online for free.](https://www.nfpa.org/Standards-Online) NFPA's [membership](https://www.nfpa.org/Membership) totals more than 65,000 individuals around the world.

**Keywords:** door position, fire safety, egress, NFPA 72, fire dynamics, human behavior, detection, notification, alarm audibility

**Report number:** FPRF-2019-11
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1) Background and Overview

Most adults in the United States and around the world decide, consciously or subconsciously, to either close their bedroom door or keep it open every night before going to sleep. While this may seem like a simple decision, its complexity intensifies when viewed through the lens of fire and life safety.

The fundamental concern with clarifying door position messaging is the balance of the door acting as an obstacle for rapid audible notification of occupants compared to the door serving as a fire barrier to maximize critical escape times. Research has documented that compartmentation, including room doors, is an effective means to slow the spread of fire and smoke in home fires and thus increases the available egress time for home occupants. However, another important factor in home fire safety and safe occupant egress is smoke alarm effectiveness which may be impacted by the barrier to sound created by these doors.

According to a NFPA Research Report on Home Structure Fires, U.S. Fire Departments responded to approximately 355,400 home structure fires per year between 2012 and 2016. During this period, approximately 27% of all fires reported occurred in homes. Home fires have caused an estimated annual average of 2,560 civilian deaths (80% of all fire deaths) and 11,670 civilian injuries (74% of all civilian fire injuries). While people typically feel safe in their homes, civilians are at high risk to fire in residential dwellings. These risks are heightened while sleeping.

The modern fire environment largely consists of lightweight construction and synthetic contents which produce fast-burning fires. These intense fires can cause the lightweight construction materials to fail much faster than traditional solid wood materials. Collapse is possible within seconds of fire department arrival. This significantly rapid progression to flashover creates severe hazards for residents and fire fighters alike, making this a leading concern among firefighters and safety advocates.

Various codes, such as, NFPA 72® National Fire Alarm and Signaling Code and NFPA 101® Life Safety Code address the modern fire environment of homes. NFPA 101® requires new and existing one- and two-family dwellings to have smoke alarms in every bedroom, outside each sleeping area, and on every level. It is recommended that the smoke alarms also be interconnected for the best protection. However, most homes do not yet have the level of protection required in recent code editions. A survey done for NFPA found that roughly two out of five households had smoke alarms in all bedrooms. Only one-quarter of all homes had interconnected smoke alarms. In 2012-2016, fires in homes with no smoke alarms caused an average of 1,020 deaths per year (40% of home fire deaths). Additionally, homes where smoke alarms were presented but failed to operate caused an additional 440 deaths per year (17% of home fire deaths).

Furthermore, a nationwide telephone survey found that almost 5 million households still have no smoke alarms. In the face of the modern fire environment and gaps in smoke alarm installation and usage, sleeping with the bedroom door closed has been examined as an additional layer of defense to increase an occupant’s chances of surviving a fire. This workshop provided a forum for the fire service and other fire and life safety experts to evaluate the scientific basis of a door’s impact on occupant notification and safe escape.

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1 Marty Ahrens, Home Structure Fires. Quincy, MA: NFPA. 2018
This workshop is conducted as part of a one-year project "Door Messaging Strategies" funded by a DHS/FEMA Assistance to Firefighters Grant (AFG) Program. The goal of this project is to assess the impact of a closed sleeping room door on smoke alarm early notification and home escape in the modern fire environment of homes. Considering this goal, this workshop further assesses how these findings can inform public education messaging around this issue. The workshop discussion considered both (1) the door acting as an obstacle for rapid audible notification of occupants and (2) the door serving as a fire barrier to maximize critical escape times within the context of educational messaging.

The agenda for this one-day workshop is shown in Table 1 below:

<table>
<thead>
<tr>
<th>Time</th>
<th>Presentations/Activities</th>
<th>Speakers</th>
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<tbody>
<tr>
<td>8:00 – 8:30 am</td>
<td>Breakfast (Coffee and Pastries)</td>
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<tr>
<td>8:30 – 8:35 am</td>
<td>Call to Order; Meeting Preliminaries; Workshop Objectives &amp;</td>
<td>Casey Grant, FPRF</td>
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<td>Deliverables</td>
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<td>8:35 – 10:15 am</td>
<td><strong>1) Overview of baseline materials and influencing factors</strong></td>
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<td></td>
<td>A. Home fire statistics</td>
<td>Marty Ahrens, NFPA</td>
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<td></td>
<td>B. Fire dynamics in modern home fires</td>
<td>Steve Kerber, UL</td>
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<td>C. NFPA 72 – Smoke alarm requirements over the years</td>
<td>Laurence Dalaire, Architect of the Capitol</td>
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<td>D. CPSC smoke alarm survey, audibility, &amp; other hazards</td>
<td>Arthur Lee, CPSC</td>
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<td></td>
<td>E. The impact of human behavior on safe egress</td>
<td>Rita Fahy, NFPA</td>
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<td></td>
<td>F. Overview of public education messaging</td>
<td>Lisa Braxton, NFPA</td>
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<td>G. Open Discussion; Q&amp;A</td>
<td>All Attendees</td>
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<td>10:35 – 10:45 am</td>
<td>Morning Break</td>
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<td>10:45 – 12:00 pm</td>
<td><strong>2) Overview and Update on Current Research Projects</strong></td>
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<tr>
<td>10:45 – 11:45 pm</td>
<td>A. Findings from Door Messaging Strategies Research Analysis</td>
<td>Stephen Olenick, CSE</td>
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<td>11:45 – 12:00 pm</td>
<td>B. Brief Update: Audible Alarm Waking Effectiveness Project (Low Freq)</td>
<td>Josh Dinaburg, Jensen Hughes</td>
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<tr>
<td>12:00 – 12:25 pm</td>
<td>C. Open Discussion; Q&amp;A</td>
<td>All Attendees</td>
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<td>12:25 – 12:30 pm</td>
<td>**3) Working Lunch</td>
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<td>12:25 – 1:00 pm</td>
<td>Lunchtime Presentations</td>
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<td></td>
<td>• Overview of Breakout Groups and Process</td>
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<td>• Presentation by Stephen Kerber on UL’s “Close Before you Doze” Campaign</td>
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<td>• Presentation by Kevin Sehlmeyer on Michigan’s Fire Incident Data Collection on “Door Position”</td>
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<tr>
<td>1:00 – 2:30 pm</td>
<td><strong>4) Breakout group discussion</strong></td>
<td>All Attendees</td>
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<td>2:30 – 2:45 pm</td>
<td>Afternoon Break</td>
<td>All Attendees</td>
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<td>2:45 – 3:15 pm</td>
<td><strong>5) Reports from breakout groups</strong></td>
<td>Breakout group leaders</td>
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<tr>
<td>3:15 – 3:30 pm</td>
<td>Wrap Up and Summary</td>
<td>Casey Grant, FPRF</td>
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Figure 1: Door Messaging Strategies Attendees
2) Presentations Overview

Casey Grant of the Fire Protection Research Foundation initiated the event by providing an overview of the background of the “Door Messaging Strategies” research project and the purpose, goal, and agenda for the workshop. The morning session consisted of a series of 15-minute presentations from industry experts addressing key issues that impact door messaging strategies. A short summary of these presentations is provided within this section. For more information on the presentations, please see the slides attached in Annex B.

**Presentation: Home Fire Statistics**

*Presenter: Marty Ahrens, NFPA Applied Research*

Marty Ahrens, Fire Analysis Research Manager at NFPA, reported on the home fire statistics between 2012 and 2016. From the analysis, it was found that U.S. Fire Departments responded to approximately 355,400 home structure fires per year between 2012 and 2016. The term “home” includes one- and two-family dwellings, including manufactured housing, and apartments or other multi-family housing. Homes fires have caused an estimated annual average of 2,560 civilian deaths and 11,670 civilian injuries. The statistics indicate that 20% of home fires are reported between 11pm and 7 am; these fires caused approximately 50% of the home fire deaths.

Only 7% of home fires originated in a bedroom, however, these fires led to 23% of home fire deaths. In bedrooms, two out of every five fires spread beyond the area of origin. Over half of the home fires had working smoke alarms (53%), however 42% of the deaths were in homes with working smoke alarms. Forty percent of home fire deaths were in homes without a working smoke alarm, and 17% had a smoke alarm but it did not operate.

The statistics indicated that fire victims in the bedroom of origin were often involved with ignition. The elderly and any population that is unable to exit on their own were also highlighted as the most vulnerable populations in home fires.

For more information, please refer to the slides in Annex B.

**Presentation: Fire Dynamics in Modern Home Fires**

*Presenter: Steve Kerber, UL Firefighter Safety Research Institute (FSRI)*

Steve Kerber, Vice President of Research at UL and Director of UL FSRI, discussed how today’s home fires have changed. Research shows that residential home fires develop more aggressively and pose greater dangers than they did in the past. Fire propagation is faster and time to flashover, available escape times, and collapse times are all shorter, leaving residents a fraction of the time to escape and less time for rescue. Studies have concluded that modern homes and their contents can burn significantly faster than homes built 50 years ago. Tests from UL FSRI show that a person can have under 4 minutes to escape. Increasingly, fire fighters are arriving on scenes in which the fire has transitioned to flashover before arrival; this is an important factor for occupants and fire fighters.

Modern homes are larger with more open spaces, evolving fuel loads, increasing void spaces, changing building materials, smaller lots, and new technologies. The average home size in the US has increased from 1600 ft² to 2,687 ft². However, in addition to the increased size of homes,
open concept floor plans have gained popularity creating large open compartments within homes. While the ceiling height in older traditional homes was often around 8 ft, the ceiling height in modern homes now range from 9 to 14 ft. The lack of compartmentation in modern homes has led to more rapid fire spread and shorter escape times.

The fuel loads in modern homes have had a significant impact on safe egress as well. Most products in homes today are made of synthetic materials. It is common to see wood furniture be made of pieces of wood held together by a resin. Products that residents buy and put in their homes are increasingly made of plastic and other synthetic materials – resulting in an increased fuel load. The changing fuel loads is impacting the time to flashover in modern homes; Traditional homes typically reached flashover in approximately 30 minutes, however, modern homes can reach flashover in less than four minutes.

Shipping cost (i.e. the weight of products) is also driving this change in materials; this is encouraging the increased use of expanded polystyrene and other lightweight synthetic materials.

The building materials used in modern homes have undergone a significant transformation. Use of engineered lumber is becoming increasingly common in modern homes; while it is acceptable from a structural perspective, it performs poorly under fire conditions. The resultant increase in void spaces has led to more rapid-fire spread. Expanded polystyrene is now being put into cement board, air bubbles are being pumped into drywall to create ultra-lightweight drywall, and spray insulation is being put in typically “unconditioned spaces” to create additional living space. All these changes in building materials are impacting fire dynamics in modern homes, leaving home owners with less time to escape safely.

For more information, please refer to the slides in Annex B.

**Presentation: NFPA 72: Smoke Alarm Requirements Over the Years**

*Presenter: Laurence (LJ) Dallaire, Architect of the Capitol*

LJ Dallaire, Fire Marshal at the Architect of the Capitol, provided an overview of the smoke alarm requirements in NFPA 72 over the years. For context, LJ noted the importance of recognizing that NFPA 72 assumes the following: (1) occupants are capable of self-rescue, and (2) occupants intimate with ignition are not protected.

Prior to 1993, NFPA 72 only required one smoke alarm on each level of the home. In 1993, the requirements were expanded to require smoke alarms in all bedrooms, and new installations were also required to be interconnected. At this time, grandfathering was still permitted for existing homes. In 2007, the allowance for grandfathering was eliminated, interconnected alarms could be wireless or hardwired, and homes exceeding 1,000 ft² required the installation of additional smoke alarms to achieve adequate coverage. In 2019, the requirement for carbon monoxide detectors was added.

Prior to 1993, the average home age in the United States was 37 years old, thus, the average home age is likely higher today. With the aging home profile, it is important to understand how many homes are in compliance with the current codes to understand the risk factors of the US housing profile. Another key challenge was identified regarding how to enforce the requirement for home owners to replace smoke alarms every 10 years.

For additional information on this presentation, please refer to the slides in Annex B.
Arthur Lee, in the Engineering Sciences division at CPSC, provided an overview of direct and indirect consequences of the door position on smoke alarm audibility and other hazards and a status update on the on-going CPSC survey. The direct consequences addressed included smoke alarm audibility, smoke progression, and heat and fire spread within a home. Other indirect consequences (e.g. unrelated to the fire event) were identified, such as an overheated room from portable heaters, smoke detection from occupants not in the room of origin, and distress notification from young children or handicapped occupants in the room of origin.

**Direct Consequences of a Closed Sleeping Room Door**

The waking effectiveness of a smoke alarm varies between different population groups. An 85-dB alarm typically wakes most adults (under no other influences of alcohol, drugs, etc.) However, children under the age 16 are more difficult to wake up to an 85-dB alarm. This alarm may also not be effective for senior adults who are hearing impaired.

Arthur reviewed the evolution of smoke alarm requirements and presence in homes over the years. As LJ also highlighted in his previous presentation on NFPA 72 requirements, prior to 1989 existing homes typically had single-station, battery-powered smoke alarms, but new homes were required to have hardwired interconnected alarms. However, a 1993 study indicated that one-fourth of households with smoke alarms had fewer smoke alarms than floors, which indicates that smoke alarms were not installed on every level. From an audibility perspective, Arthur discussed how interconnected smoke alarms can improve audibility effectiveness and provide earlier warning of fire. The allowance of wireless interconnected smoke alarms has improved audibility throughout the home and has eliminated the need to hardwire smoke alarms throughout the home.

In 2005, CPSC conducted a study on “The Audibility of Smoke Alarms in Residential Homes”, which conducted sound-loss measurements in three homes ranging from 1000 ft² to 3,300 ft² with single station alarms. From this study, it was found that:

- The complexity of the travel path impacts the sound reduction of the alarm signal. Compartmentation and changes in direction of hallways has a significant impact on the attenuation of the alarm signal.
- A closed door can attenuate a smoke alarm signal by 10 – 20 dBA.
- Each level that sound travels through a home attenuates the sound by about 20 dBA.
- A single-station smoke alarm may be sufficient to alert occupants (even with doors closed) in a small, single level home; However, the sound level will most likely be inadequate in all areas of a two or three-story home. Parts of a two-story home may receive sound levels as low as 50 dBA, and a three-story home may experience sound levels as low as 30 dBA, which would not provide adequate protection.

**Indirect Consequences of a Closed Sleeping Room Door**

While the hazards of fire and smoke are the most obvious consequences to protect against, there are other factors that should be considered when considering door messaging strategies. An
example was presented on the hazard of hyperthermia when a bedroom door is closed. CPSC conducted a study, titled “Preliminary Analysis of Hyperthermia Deaths Associated with Electric Room/Space Heaters” in March of 2019. To date, four children and one adult have died from hyperthermia effects caused by space heaters. Through the data analysis and calculations, it was found that a heater can maintain a 110 F room temperature without the heater turning off. In one deceased occupant, it was found that their body temperature was between 110-120 F when the first responders arrived. The results of this analysis identified that a heater in a small room with a closed door has the potential to sustain elevated room temperatures above the safe long-term exposure levels, posing a hyperthermia risk to occupants. Although, these temperatures fall below the risk of fire, this identifies an additional hazard that a closed door could pose to occupants.

Another case study was presented where a portable heater caught fire in a bedroom. The fire continued to smolder until the portable heater was completely melted. The bedroom did not have a working smoke alarm, and the bedroom door was closed. The 3-yr old child died from smoke inhalation, and the other occupants within the home were unaware of the smoke in the child’s bedroom. This case study highlighted the hazard posed to the occupant of the room of origin, when the door is closed and there is no working smoke alarm.

For additional information on this presentation, please refer to the slides in Annex B.

**Presentation: The Impact of Human Behavior on Safe Egress**  
**Presenter: Rita Fahy, Ph.D., NFPA Applied Research**

Rita Fahy, expert on human behavior in fire and Applied Research Manager at NFPA, provided an overview of the impact of human behavior on safe egress in home fires. This presentation highlighted that most of the existing human behavior research has been on larger commercial structures, rather than homes. Therefore, the general understanding of how people behave in home fires is limited, and the knowledge from behavior in public spaces may not be directly applicable. The currently available data on human behavior in home fires is largely anecdotal. The focus of the existing research has primarily been on risk factors (i.e. risk of having a fire, being injured in a fire, or being killed in a fire all present different risk factors).

This presentation highlighted the factors that differentiate home fires from non-home fires, which included the following:

- There is a greater attachment to the structure, occupants, and valued possessions in home fires.
- Occupants typically respond more quickly to cues due to feelings of responsibility, ownership, control, presence of loved ones, lack of informative social influence, no fear of social embarrassment, and less attachment to activity.
- People are more likely to attempt to fight a fire in their home than in public places.
- People are more likely to re-enter the home after evacuation (e.g. to save someone else or retrieve possessions).
- Wayfinding is easier within a home due to familiarity with the surroundings.
- There is a higher likelihood of young children, elderly adults, or disabled persons to be present in the home (e.g. those who may need assistance with egress)

All the above factors have a significant influence of the occupant’s behavior during a home fire. However, there are other complicating factors, including poverty, occupant age, intoxication, among others. It is important to note that impoverished communities often do not have smoke
alarms in their homes and they commonly face security concerns (leading to actions that may block their means of egress), among other related risk factors.

When discussing how human behavior impacts safe egress in homes, Dr. Fahy identified a variety of factors, which include:

- People are sleeping and need to be woken. Some population groups may be more difficult to wake.
- People misinterpret initial cues
  - There typically must be at least two cues for people to react – people typically do not react to only one cue. It is also important to note that people do not assign every cue as a threat. When cues are not perceived to be a threat, people will relax, and not investigate or react immediately.
- People require confirmation of a fire’s existence through additional cues, prior to responding to the cues or deciding to evacuate. It is important to note that recognition of the fire does not always mean the occupant will evacuate.
- Families tend to want to gather and leave together. The fire may separate occupants, which can lead to delays in evacuation of everyone. Some evacuate, then re-enter to save another family member, and some never evacuate at all.

While the human behavior research in home fires is limited, case studies conducted by Kent Fire and Rescue Services in the UK were presented, which focused on post-fire surveys in dwellings. These case studies analyzed people’s behavior, response, and sequence of actions during the fire events. A few key take-aways from these case studies include the following:

- A considerable number of occupants investigated the source of the cues, with more than 50% entering the room of origin, and approximately 20% re-entering the building at least once.
- Many residents undertook a series of actions to fight the fire themselves before calling the fire brigade. The situation was typically out of control, before the fire brigade was called.
- Occupants commonly focused on one aspect of the situation instead of seeing the alternative options available to them (e.g. escaping through a bedroom window).
- Occupants did not truly understand the risk of fighting the fire themselves. The fire was perceived to be like a camp-fire, fire in a fireplace, or another familiar association of fire that is typically able to be controlled.
- Many felt that calling the fire brigade would be an “over-reaction”. There was an associated feeling of embarrassment in calling the fire brigade.
- Knowledge of the fire brigade being called, influenced occupant’s egress decisions. The size of a family group also influenced egress decisions.

From these case studies, most interviewees indicated that they would do nothing differently, despite being injured in the fire. These findings raised the question of if and how safety messages can be used to help change behavior.

This presentation highlighted the need for more human behavior research in residential dwellings. For additional information on this presentation, please refer to the slides in Annex B.
Lisa Braxton, Public Education Specialist and Staff Liaison of the Educational Messaging Advisory Committee at NFPA, provided an overview of public education messaging development strategies, outreach tactics, and campaigns at NFPA.

Lisa discussed how the goal of the Public Education division at NFPA is to create a safe, informed and activated public. They want people to be aware of the risks, to take appropriate action to prevent fire and related hazards, invest in safety and advocate for safety measures in their homes to champion and share safety messages and practices. This goal is achieved through their fire and burn safety messaging, which is contained in the Education Messages Desk Reference where there are 27 chapters of safety messages on various important topics.

The NFPA Educational Messaging Advisory Committee creates messages that are affirmative, behavior focused, clear, consistent and customizable. It should be noted that the EMAC desk reference messages are intended to be the base messaging that fire and life safety educators can use and tailor them to fit the needs of specific target audiences in terms of age, ability, language, and other matters.

Regarding the issue of door position, the EMAC desk reference currently states the following: “A closed door may slow the spread of smoke, heat, and fire. Have interconnected smoke alarms if you sleep with the door closed. Install smoke alarms inside and outside of each bedroom.” This information can be found within Chapter 1: Smoke Alarms and Chapter 4: Home Fire Escape of the EMAC Desk Reference.

NFPA’s outreach strategies are expanding through collaboration with more organizations, involvement in more after school programs, health groups, and utilizing different avenues to reach diverse audiences, either in person or online (e.g. via social media, webinars, NFPA Xchange, and other platforms).

For additional information on this presentation, please refer to the slides in Annex B.

Open Discussion

Following the presentations in the morning session of the workshop, there was significant open discussion and several knowledge gaps identified. Considering all of the issues identified, the attendees generally agreed that it is important for everyone to be sending a consistent message. While messages can be adapted to specific audiences, the core message needs to be consistent.

A few key knowledge gaps that were identified were:

- How to measure the impact and receptivity of messages to stimulate behavior on certain populations?
- Human behavior in home fires
- How can door messaging be used to initiate conversations about smoke alarms?
- Is there a benefit of having a closed door, if no alarms are present?
- What is the overall societal benefit of a closed door?
Overview and Update of Current FPRF Research Activities

Stephen Olenick, Combustion Science & Engineering

Presentation: Door Messaging Strategies Research Analysis

Stephen Olenick, Principal Engineer at Combustion Science & Engineering and project contractor for the FPRF project on Door Messaging Strategies provided a detailed overview of the findings from the Door Messaging Strategies research analysis. This project aimed to provide an enhanced understanding of the impact of a closed sleeping room door on occupant notification and home escape. It is well understood that closed doors reduce the spread of smoke, heat and fire. However, the impact of a closed door on detection and notification were not fully understood. This project sought to provide scientific information on the impact of door position on fire safety and other affiliated issues. This presentation provided an overview of the following:

- Current messaging on door position
- An assessment of the magnitude of the problem
- An assessment of fire dynamic and detection issues
- An assessment of notification and audibility issues

Current Messaging

Stephen provided an overview of the messages currently being distributed to the public on the issue of door position. The primary messages that exists on this topic are from the NFPA's Educational Messaging Advisory Committee (EMAC) Desk Reference and UL’s “Close Before you Doze” campaign. It was found that the existing messaging often pairs the message of closing the bedroom door with messaging about having smoke alarms inside and outside the bedrooms and having them interconnected. However, it is common for the full context of the messages to get lost when they are picked up by media outlets or others.

Magnitude of the Problem

The magnitude of the problem was identified through the statistic that only 30.7 – 43% of homes have an alarm in the bedroom, according to 2005 and 2010 surveys, and only 25% of homes have interconnected smoke alarms, according to the 2010 survey. Since most homes do not have adequate smoke alarm protection, the impact of door position on safe escape in home fires can be significant.

Fire Dynamic and Detection issues

Two primary scenarios were evaluated in this analysis: Scenario 1: Bedroom-origin fire and Scenario 2: Outside-bedroom fire. These scenarios also considered door position, alarm presence and interconnection.
A variety of scenarios were considered, however the primary scenario of concern from a fire dynamic perspective is a bedroom origin fire with no bedroom alarm. Fire test data (with doors open and closed) were analyzed from both a hallway alarm and a bedroom alarm perspective, particularly focusing on egress times. Calculations were conducted for these scenarios to predict the number of expected adverse outcomes. The analysis utilized in this study resembles the work conducted by the NFPA 72 task group but considers non-72 compliance alarm protection scenarios. The findings were as follows:

- If you have an alarm in the bedroom, closing the bedroom door could result in a drop of successful escapes from bedroom fires from 96.6% to 66.7%.
- If you are in the bedroom and do not have an alarm in the bedroom, an adverse outcome is likely to result. In this instance, closing the bedroom door could result in a drop of successful escapes from bedroom fires from 96.6% to 0.0%.
- When bedroom-origin fire statistics are included in the analysis, it was found that only 0.6 – 0.9% of home fires are expected to have an adverse outcome by closing the door. Thus, a closed door is expected to have an overall positive benefit from the fire dynamics perspective.

**Notification and Audibility Issues**

To quantify the notification and audibility issues associated with door position, the scenario in the figure below was considered. Two calculation methods from Butler, Bowyer, and Kew (1981) via Schifiliti et. al. (2016) and Halliwell and Sultan (1986) were used to assess the impact of door position on smoke alarm notification and audibility. The drop in the sound pressure level through a closed hollow core interior door, within the context of awakening studies and code requirements were analyzed. Based on this analysis and review of fire statistics, the expected number of adverse outcomes from closing a bedroom door were estimated. Figure 3 below shows the audibility scenario considered in this analysis for both open- and closed-door positions.
Fire science literature was referenced when evaluating the effect of a closed bedroom door on the number of adverse outcomes that may result from fires originating in the bedroom. Additionally, calculations on the effect of a closed bedroom door on the audibility of a smoke alarm were also utilized in this analysis. The increased non-success rates from these situations were combined with statistics on smoke alarm presence, the prevalence of residential fires, and occurrences of fatalities in residential fires to quantify the overall number of expected adverse outcomes due to closing the bedroom door. These were compared with the number of fire fatalities where a closed bedroom door may offer a benefit.

According to the calculations, when the door was open, and the alarm was located directly outside the bedroom door, the audibility requirement of 75 dBA at the pillow was met for both alarms with an 85 and 90 dBA sound pressure level at 10 feet. For an 85-dBA alarm at 10 feet with the door closed, the sound pressure level at the pillow was 72 dBA when the alarm was just outside the closed bedroom door (0 ft). This measurement is less than the required sound pressure level of 75 dBA. The sound pressure level at the pillow dropped to 64 dBA when the alarm was located the maximum distance of 21 feet from the closed bedroom door. Stephen also pointed out that the average awakening threshold for sober adults was approximately 72.5 dBA.

When an alarm that sounded at 90 dBA was tested, the sound pressure level at the pillow was met when the alarm was placed within 5 ft of the door (according to the Butler, Bowyer, and Kew method). However, it should be noted that UL 217 allows alarms to sound as low as 85 dBA at 10 ft, therefore the positive results from this 90-dBA scenario should be used with caution.

Based on this analysis and review of fire statistics, the number of adverse outcomes from a closed bedroom door were relatively small and the potential benefit of closing a bedroom door was significantly greater. The calculations specifically indicated that 2 – 4% of residential fires may have an adverse outcome and 5-7% of fatalities may result from a closed door. However, since 77% of fatalities occur in non-bedroom origin fires and approximately 51% occur at night, it is estimated that approximately 39.3% of home fire fatalities could benefit from a closed bedroom door, if the occupant is sleeping in the bedroom.

Summary of Findings

Based on this analysis and review of fire statistics, the number of adverse outcomes from a closed bedroom door were relatively small and the potential benefit of closing a bedroom door was greater. The calculations specifically indicated that 2 – 4% of residential fires may have an adverse outcome and 5-7% of fatalities may result from a closed door, compared to 39.3% of home fire fatalities that could benefit from the closed bedroom door.

The findings of this research analysis indicated that from a purely technical basis, a closed bedroom door is likely to provide a net-positive benefit to the public. However, a few additional concerns were identified with closing the bedroom door, such as a closed bedroom door giving residents a false sense of security, concerns with the public being able to process multiple messages, and other related human behavior issues. However, despite these concerns and other situations where a closed bedroom door may hinder detection and notification of a fire, it was still found that there was a greater overall benefit of closing the bedroom door versus leaving it open.

For additional information on this presentation, please refer to the slides in Annex B.
Josh Dinaburg, Research Engineer at Jensen Hughes and Contractor for the FPRF Project on “Audible Alarm Waking Effectiveness: Low Frequency Alarm Perspective” presented an update to the workshop attendees on the Audible Alarm Waking Effectiveness project.

Research has proven that the 520 Hz tone is more effective at waking people up and the sound more easily penetrates through walls and doors. However, there has been little change to the sound pressure requirements in the relevant codes and standards. A detailed evolution of the low frequency requirements in various codes and standards is provided within the slides in Annex B.

The current challenge is that the amount of power required to produce a 520 Hz tone cannot be done with battery power. This begs the question of if we can require a lower amount of power to produce a 520 Hz tone, which is the objective of this FPRF research project.

The preliminary findings of this project indicate the following:

- Original requirement of 85 dBA at 10 ft from 1967 is still the standard. This is based on alarms located outside of the bedroom, an estimated sound attenuation through closed doors of 15 dBA, and that 65-75 dBA is effective at waking normal populations.
- Using an A-weighting scale, it was determined that there was a 6-dBA difference in physical sound pressure from 3200 Hz or 520 Hz tone.
- Waking experiments of Levere 1972 indicate that there is improved waking effectiveness to low frequency 125 and 250 Hz tones and that waking in deep slow wave sleep is a function of physical sound pressure level, not dBA.
- Combining the idea of sound pressure with the attenuation of the wave, fullness of the sound, and demonstrated wakefulness, could possibly help justify a reduction in sound pressure level.
- According to data by D. Bruck, et. al in the development of 520 Hz requirements, it was demonstrated that there is an equivalent waking performance to high frequency alarms at ~15 dBA reduction in the sound pressure level.
- While a low frequency alarm may be able to overcome the attenuation of a closed door, it is still unclear as to whether a low frequency alarm at a lower sound pressure level will be adequate or negate the benefit of the low frequency tone.

A promising avenue for reducing the sound pressure level to enable a low frequency alarm to be battery powered, is to establish a benchmark level of performance and find a sound pressure level that exceeds that benchmark.

For additional information on this presentation, please refer to the slides in Annex B.
Steve Kerber, Vice President of Research at UL and Director of the Firefighter Safety Research Institute, provided an overview of UL’s “Close before you Doze” campaign and its origins. The fire dynamic research at UL on home fires with the bedroom door closed versus opened highlighted the significant difference in the tenability and survivability of the space behind the closed door compared to the room with the open door. Steve indicated that UL felt this information needed to be communicated to the public, to educate them on the impact of a closed door on the spread of fire, smoke, and heat. When trying to develop a message around this issue, UL reviewed other successful messaging campaigns. The three components identified as being essential for the message to be successful and capable of behavior change was that the message needs to be 1) memorable, 2) actionable, and 3) free. A key example of this was the “stop, drop, and roll” campaign; this message was short (4 words), people remembered it, the message told them what to do, and it didn’t cost anything.

The team at UL felt that distributing this message was important because home fires are getting faster. When developing the “close before you doze” message, the team asked themselves “what is the harm in this message”? After evaluation, it was felt that this message generated the most positive impact for the greatest number of people, so the decision was made to proceed with this campaign.

For the most effective outreach, the team at UL tried to leverage the power of digital tools. In year two of this campaign, they distributed a video titled “Close Before You Doze – See the Dramatic Difference a Door Can Make” which was shown to the workshop attendees. Marketing channels are being used for this campaign to help encourage behavior change.

A rap video, titled “Brad the Dad – Close Before You Doze” went live in July of 2019. The video was shown to the workshop attendees. While the video conveys the “close before you doze” message, it is supported by other fire and life safety concepts and recommendations such as installing and checking smoke alarms, creating a fire escape plan, and closing the door on the way out.

Kevin Sehlmeyer, the State Fire Marshal of Michigan, provided a short overview of the current efforts in the state of Michigan to collect better fire incident and prevention data. The information is based off NFIRS data but expanded to collect additional information that will enhance their understanding of fire fatalities in Michigan. Variables that are essential to understanding the impact of the position of the sleeping room door on home escape are now being collected in Michigan’s new fire incident data collection system, such as location of fire victim, door position, etc. From the data that has been collected, it was found that 87% of the homes that had a fire had an inadequate number of working alarms, and that most of the people that died in home fires, were trying to escape.

For additional information, see the handouts in Annex B.
3) Discussion – Summary from Breakout Sessions

The door messaging strategies workshop had a diverse group of attendees, representing a range of backgrounds and technical areas including fire service, public educators, engineers, consultants, scientists, fire authorities, government representatives, researchers, among others. Table 2 provides a summary of the workshop attendees. Each attendee was assigned to one of four breakout groups to facilitate a focused discussion on key issues. The groups were identified as Red, Yellow, Green, and Blue.

Table 2 Workshop Attendees and Breakout Group Assignments

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Red Group</strong></td>
<td></td>
</tr>
<tr>
<td>Arthur Lee</td>
<td>CPSC</td>
</tr>
<tr>
<td>Elizabeth Bubel</td>
<td>American Red Cross</td>
</tr>
<tr>
<td>Haavard Boehmer</td>
<td>Combustion Science &amp; Engineering, Inc.</td>
</tr>
<tr>
<td>Kevin Sehlmeyer</td>
<td>Michigan State Fire Marshal</td>
</tr>
<tr>
<td>Marty Ahrens</td>
<td>NFPA</td>
</tr>
<tr>
<td>Mike Lowe</td>
<td>Delaware State Fire School</td>
</tr>
<tr>
<td>Teresa Crisman</td>
<td>Prince George’s County Fire and EMS</td>
</tr>
<tr>
<td>Wendy Gifford</td>
<td>Nest/Consultant</td>
</tr>
<tr>
<td>Amanda Kimball</td>
<td>Fire Protection Research Foundation</td>
</tr>
<tr>
<td><strong>Yellow Group</strong></td>
<td></td>
</tr>
<tr>
<td>Emily Witty</td>
<td>Maryland Office of the State Fire Marshal</td>
</tr>
<tr>
<td>Andy Lynch</td>
<td>The Fire Solutions Group</td>
</tr>
<tr>
<td>Laurence Dallaire</td>
<td>Architect of the Capitol</td>
</tr>
<tr>
<td>Meredith Hawes</td>
<td>NFPA</td>
</tr>
<tr>
<td>Scott Ayers</td>
<td>CPSC</td>
</tr>
<tr>
<td>Teresa Neal</td>
<td>United States Fire Administration</td>
</tr>
<tr>
<td>Michael Kozo</td>
<td>FDNY</td>
</tr>
<tr>
<td>Dick Roux</td>
<td>NFPA</td>
</tr>
<tr>
<td>Victoria Hutchison</td>
<td>Fire Protection Research Foundation</td>
</tr>
<tr>
<td><strong>Green Group</strong></td>
<td></td>
</tr>
<tr>
<td>Amanda Swenson</td>
<td>Minnesota State Fire Marshal’s Office</td>
</tr>
<tr>
<td>David Shapiro</td>
<td>Safety First Electrical</td>
</tr>
<tr>
<td>Josh Dinaburg</td>
<td>Jensen Hughes</td>
</tr>
<tr>
<td>Ernest Grant</td>
<td>EMAC Chair</td>
</tr>
<tr>
<td>Stephen Kerber</td>
<td>UL FSRI</td>
</tr>
<tr>
<td>Rohit Khanna</td>
<td>CPSC</td>
</tr>
<tr>
<td>Lisa Braxton</td>
<td>NFPA, EMAC Staff Liaison</td>
</tr>
<tr>
<td>Casey Grant</td>
<td>Fire Protection Research Foundation</td>
</tr>
<tr>
<td><strong>Blue Group</strong></td>
<td></td>
</tr>
<tr>
<td>Andrew Lock</td>
<td>CPSC</td>
</tr>
<tr>
<td>Eileen McDonald</td>
<td>Johns Hopkins Center for Injury Research and Policy</td>
</tr>
<tr>
<td>Kathy Clay</td>
<td>Jackson Hole Fire and EMS</td>
</tr>
<tr>
<td>Madelynn McCormick</td>
<td>Tennessee State Fire Marshal’s Office</td>
</tr>
<tr>
<td>Keith Palumbo</td>
<td>Ceasefire Door Hinge</td>
</tr>
<tr>
<td>Rita Fahy</td>
<td>NFPA</td>
</tr>
<tr>
<td>Stephen Olenick</td>
<td>Combustion Science &amp; Engineering</td>
</tr>
<tr>
<td>Dave Newhouse</td>
<td>Gentex</td>
</tr>
<tr>
<td>Milosh Puchovsky</td>
<td>Worcester Polytechnic Institute</td>
</tr>
</tbody>
</table>

As shown in Table 2 above, the attendees within each break-out group was well balanced based on their respective organizations and subject matter expertise.
The breakout group discussions were a key part of the Door Messaging Strategies Workshop. All attendees broke up into four pre-assigned break-out groups to further discuss key issues. The group questions were established prior to the workshop to facilitate certain key points of discussion.

Following the lunchtime presentations, all attendees broke up into the four groups in four separate areas of the meeting room to independently answer the questions. The break-out group questions are provided in Tables 3, 4, 5, and 6 below, which address the following topics (1) Word Cloud, (2) Baseline Issues, (3) Message Development, and (4) Message Delivery.

**Table 3: Break Out Group Questions (1 of 4)**

<table>
<thead>
<tr>
<th>1. Word Cloud (5 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In addition to the words provided for the word cloud individually, please also address this question as a group.</td>
</tr>
<tr>
<td>1.1 What <em>single words</em> are the most essential in a message around this issue?</td>
</tr>
<tr>
<td>1.2 What <em>single words</em> come to mind when addressing/communicating these topics:</td>
</tr>
<tr>
<td>1.2.1 Fire Dynamics</td>
</tr>
<tr>
<td>1.2.2 Notification/Alarm</td>
</tr>
<tr>
<td>1.2.3 Human Behavior</td>
</tr>
</tbody>
</table>

**Table 4: Break Out Group Questions (2 of 4)**

<table>
<thead>
<tr>
<th>2. Baseline Issues (20 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Occupant notification/audibility</td>
</tr>
<tr>
<td>2.1.1 Identify and prioritize the risks and benefits of <em>closing</em> the bedroom door, with respect to occupant notification or audibility?</td>
</tr>
<tr>
<td>2.1.2 Identify and prioritize the risks and benefits of keeping the bedroom door <em>open</em>, with respect to occupant notification or audibility?</td>
</tr>
<tr>
<td>2.2 Human Behavior</td>
</tr>
<tr>
<td>2.2.1 Identify and prioritize the risks and benefits of <em>closing</em> the bedroom door, with respect to human behavior and egress?</td>
</tr>
<tr>
<td>2.2.2 Identify and prioritize the risks and benefits of keeping the bedroom door <em>open</em>, with respect to human behavior and egress?</td>
</tr>
<tr>
<td>2.3 Fire Dynamics</td>
</tr>
<tr>
<td>2.3.1 Identify and prioritize the risks and benefits of <em>closing</em> the bedroom door, with respect to modern home fire behavior?</td>
</tr>
<tr>
<td>2.3.2 Identify and prioritize the risks and benefits of keeping the bedroom door <em>open</em>, with respect to modern home fire behavior?</td>
</tr>
<tr>
<td>2.4 Knowledge Gaps and Next Steps</td>
</tr>
<tr>
<td>2.4.1 Based on the information provided in the morning session, identify existing gaps in information and recommended actions needed for further review.</td>
</tr>
<tr>
<td>2.4.2 Is there a priority to address identified knowledge gaps?</td>
</tr>
</tbody>
</table>
### Table 5: Break Out Group Questions (3 of 4)

#### 3. Message Development (45 min)

3.1 **Existing Messages**: To our knowledge, the three messages listed below are the primary messages that currently exist in the mainstream around the open/closed door issue. Considering these messages, answer the following questions.

- **EMAC Message**: “A closed door may slow the spread of smoke, heat and fire. Install smoke alarms in every sleeping room and outside each separate sleeping area. For the best protection, make sure all smoke alarms are interconnected.”

- **UL Message**: “Close before you doze”

- **America Burning (1973)**: “Sleep with bedroom doors closed. In the event of a fire, you will gain precious minutes”

3.1.1 **Additional Messages**: Other than the three messages identified above, do you know of any other existing messaging on this issue? If so, please identify the message and the source.

3.1.2 **Key Elements**: What elements are important to be included in messaging around this issue? (e.g. does there need to be actionable items? Does there need to be explanation? Etc.)

3.1.3 **Populations**: Considering the messages above, and any other identified messages, are there any concerns with the following high-risk populations? If so, please identify them and explain.

- 3.1.3.1 Elderly
- 3.1.3.2 Disabled
- 3.1.3.3 Impaired
- 3.1.3.4 Young children
- 3.1.3.5 Impoverished communities
- 3.1.3.6 Non-English-speaking populations and other cultures

3.1.4 **Scenarios**: Considering the messages above, and any other identified messages, are there any concerns with the following scenarios? Explain.

**Scenario #1: Interconnected operational alarms**

- a) Smoke alarms are in **both the hallway and all bedrooms**: Alarms are interconnected.
- b) Smoke alarms are **only in the bedroom** (no alarms in the hallway); Bedroom alarms are interconnected.
- c) Smoke alarms are **only in the hallway** (no alarms in the bedroom); Hallway alarms are interconnected.

**Scenario #2: Non-interconnected operational alarms**

- a) Smoke alarms are in **both the hallway and all bedrooms**: Alarms are not interconnected.
- b) Smoke alarms are **only in the bedroom** (no alarms in the hallway); Bedroom alarms are not interconnected.
- c) Smoke alarms are **only in the hallway** (no alarms in the bedroom); Hallway alarms are not interconnected.

**Scenario #3: No working alarms present in the home**

3.1.5 **Do these messages deliver the information needed to ensure life safety? Explain.**

3.2 **Other Factors**: Identify other factors (e.g. message length, etc.) that should be considered in the development of public education messages around the issue of keeping the sleeping room door opened or closed at night? Explain how these factors could be incorporated into messaging.

3.3 **Technology**: Identify and prioritize technological devices (e.g. automatic door closers, etc.) and approaches that could support messaging strategies.
Table 6: Break Out Group Questions (4 of 4)

4. Message Delivery and Outreach (20 min)

4.1 Development: Who needs to be involved in the development of consistent messaging around the impact of a closed/open bedroom door on home escape?

4.2 Number of Messages: Identify the advantages and disadvantages of:
   4.2.1 Having a universal, singular, concise, and catchy message
   4.2.2 Having multiple messages targeted at specific audiences/risk groups

4.3 Delivery Approach:
   4.3.1 Who (what organizations, groups, etc.) should be delivering the message?
   4.3.2 How should the message(s) be delivered?
      4.3.2.1 What platforms/channels should this message be delivered through?
      4.3.2.1.1 How do we effectively reach different audiences?
   4.3.2.2 To who should this message(s) be delivered?

At the end of the break-out group sessions, a representative from each group presented the group’s findings. A general discussion on key issues and take-aways followed the break-out group reports. The findings from the break-out groups are provided within this section and are summarized in the key findings section of these Proceedings.

Word Cloud

Question 1 asked all breakout groups to identify single words that are most essential for messages around this issue, and for addressing/communicating this issue with respect to fire dynamics, notification, and audibility. The words provided in response to this question were submitted by those in attendance at the workshop and resulted in the word clouds below. Note: The size of the words is related to their frequency.

Messaging

Figure 4: Messaging Word Cloud
Fire Dynamics

Figure 5: Fire Dynamics Word Cloud

Notification

Figure 6: Notification Word Cloud

Human Behavior

Figure 7: Human Behavior Word Cloud
Baseline Issues

Section 2 asked participants to identify and prioritize the risks and benefits of closing the bedroom door or keeping it open with regards to occupant notification and audibility, human behavior and fire dynamics. The responses from all groups are summarized below:

<table>
<thead>
<tr>
<th>2.1 Baseline Issues – Occupant Notification/Audibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2.1.1 Occupant Notification/Audibility – Closed Door</strong></td>
</tr>
<tr>
<td>Identify and prioritize the risks and benefits of closing the bedroom door, with respect to occupant notification or audibility?</td>
</tr>
<tr>
<td><strong>Risks</strong></td>
</tr>
<tr>
<td>• Parents not hearing/seeing children. As a parent, if your child’s door was closed, you would not be aware of what is going on inside your child’s bedroom.</td>
</tr>
<tr>
<td>• Occupant is more likely to be unaware of a fire in another room of the house if the bedroom door is closed.</td>
</tr>
<tr>
<td>• Sleeping areas are not always “only” in bedrooms. Alarms may not be required where residents are sleeping (There can be many people living under one roof)</td>
</tr>
<tr>
<td>• If you’re in the room of origin, you are more likely to have an adverse effect.</td>
</tr>
<tr>
<td>• People may not think smoke alarms are necessary if a closed door will save them.</td>
</tr>
<tr>
<td>• Audibility can be limited to occupants not in the room of origin (e.g. if a fire starts in the hallway, the occupant in the bedroom would have a lower audibility of the alarm in the bedroom and may not waken.</td>
</tr>
<tr>
<td>• Disabled persons may need assistance from someone outside the room of origin; a closed door could limit audibility to the caretaker if they are not in the room where the alarm is sounding.</td>
</tr>
<tr>
<td>• The risks are very dependent on scenarios (e.g. are alarms interconnected? is there an accessory available?) Scenarios where alarms are not installed properly, and other anomalies could present additional risk factors.</td>
</tr>
<tr>
<td><strong>Benefits</strong></td>
</tr>
<tr>
<td>• When you are not in the room of origin</td>
</tr>
<tr>
<td>• A closed door could buy time for occupants that are outside the room of origin (e.g. not in the bedroom).</td>
</tr>
<tr>
<td>• Provides additional “line of defense” if there are anomalous or counterfeit alarms.</td>
</tr>
<tr>
<td><strong>2.1.2 Occupant Notification/Audibility – Open Door</strong></td>
</tr>
<tr>
<td>Identify and prioritize the risks and benefits of keeping the bedroom door open, with respect to occupant notification or audibility?</td>
</tr>
<tr>
<td><strong>Risks</strong></td>
</tr>
<tr>
<td>• None identified from a notification perspective.</td>
</tr>
<tr>
<td><strong>Benefits</strong></td>
</tr>
<tr>
<td>• Beneficial when you are in the room of origin (i.e. longer time to reach untenable conditions)</td>
</tr>
<tr>
<td>• Can hear kids and other fire cues</td>
</tr>
<tr>
<td>• More likely to hear an alarm that is sounding in another part of the home (i.e. not in the bedroom)</td>
</tr>
<tr>
<td>• Earlier notification for others if the home does not have interconnected alarms (e.g. If fire starts in the bedroom and the door is open, the fire could set off the hallway alarm as well)</td>
</tr>
<tr>
<td>• More alert to surroundings; can hear issues in other rooms</td>
</tr>
</tbody>
</table>
- Allows parents to pay attention to their kids, provides access for pets, enables occupants to hear glass break if there is a break-in, more able to engage with the hazards, able to hear teenagers or elderly sneaking in or out
- Might be aroused from sleep by another cue

<table>
<thead>
<tr>
<th>2.2 Baseline Issues – Human Behavior</th>
</tr>
</thead>
</table>

### 2.2.1 Human Behavior – Closed Door

Identify and prioritize the risks and benefits of closing the bedroom door, with respect to human behavior and egress?

<table>
<thead>
<tr>
<th>Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Door can serve as an obstacle for an easy egress route (e.g. could have a larger impact in older homes with doors that are sticky, when the occupants are disabled, etc.)</td>
</tr>
<tr>
<td>- Kids often misbehave behind closed doors.</td>
</tr>
<tr>
<td>- If using A/C there could be energy issues (lack of air circulation within the house if the door is closed)</td>
</tr>
<tr>
<td>- If door is closed, less aware of what is on the other side of the door. This takes time to decide what to do when you open the door.</td>
</tr>
<tr>
<td>- Having a practiced escape plan is important, but most people do not have an escape plan.</td>
</tr>
<tr>
<td>- The decision for residents to keep their door open or closed could vary according to whether the occupant is in a one-family dwelling vs high rise.</td>
</tr>
<tr>
<td>- People don’t think about fire safety in their everyday life.</td>
</tr>
<tr>
<td>- Different generations have different reasons for keeping doors opened or closed.</td>
</tr>
<tr>
<td>- Occupants often take the familiar pathway when trying to escape, instead of using second exit. (e.g. if door feels hot, may still try to open it because they often don’t think of the window and a second escape route).</td>
</tr>
<tr>
<td>- A closed door can provide a false sense of security.</td>
</tr>
<tr>
<td>- A closed door could cause delayed action – moving outside the room eventually into worse conditions</td>
</tr>
<tr>
<td>- Having a message to close the door may contradict the message to get out immediately. It is important to still have messaging for other safety behaviors (e.g. crawl low, feel the door, etc.)</td>
</tr>
<tr>
<td>- Common perception that a closed door will have minimal impact (e.g. a wooden door will burn through anyway and won’t slow the fire).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Assuming the fire started behind closed door, the door could provide remote occupants more time to react and escape.</td>
</tr>
</tbody>
</table>

### 2.2.2 Human Behavior – Open Door

Identify and prioritize the risks and benefits of keeping the bedroom door open, with respect to human behavior and egress?

<table>
<thead>
<tr>
<th>Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Because of personal factors, some people refuse to close the door because they are concerned about their children, pets, etc.</td>
</tr>
<tr>
<td>- Without kids, people may close the door. With kids, people tend to keep it open. Children cause behavior change in adults.</td>
</tr>
<tr>
<td>- Potentially less time to escape for occupants outside of or remote to the room of origin.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefits</th>
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<tbody>
<tr>
<td>- If the door is open, occupants are more aware of what is going on outside the bedroom (e.g. able to hear children, elderly, pets etc.)</td>
</tr>
</tbody>
</table>
• Convenience or other personal factors.
• An open door will also provide a greater sense of awareness that the event is an actual fire (second cue).
• People are most likely going to open the door anyway.

<table>
<thead>
<tr>
<th>2.3 Baseline Issues - Fire Dynamics</th>
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<table>
<thead>
<tr>
<th>2.3.1 Fire Dynamics – Closed Door</th>
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</thead>
<tbody>
<tr>
<td>Identify and prioritize the risks and benefits of closing the bedroom door, with respect to modern home fire behavior?</td>
</tr>
</tbody>
</table>

**Risks**
- Could hinder escape for a disabled person in the room of origin who are forced to shelter in place due to mobility issues.
- Could delay fire department if they are not trained to vent/enter/isolate/search
- Lower probability of successful escape if door is closed, fire ignites within room with closed door, and there is no alarm present.
- Hyperthermia issues (from space heater)
- Communicating the fire dynamics side to the public can be a challenge.

**Benefits**
- Provides compartmentation and can contain the fire (i.e. slows growth and spread of fire and smoke), within or outside area of origin.
- Impact of closing the door is clear from a fire dynamics perspective. A closed door can enable occupants to take shelter in rooms which allows the fire service to employ tactics for an outside search.
- Provides enhanced escape and rescue time
- Enables “sheltering in place” option for those who can’t escape
- Provides improved air quality in protected room (not in the room of origin)
- Limits property loss in rooms beyond the area of origin

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<thead>
<tr>
<th>2.3.2 Fire Dynamics – Open Door</th>
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<tr>
<td>Identify and prioritize the risks and benefits of keeping the bedroom door open, with respect to modern home fire behavior?</td>
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</tbody>
</table>

**Risks**
- Prevents the benefit of compartmentation, allowing the spread of fire, smoke, and heat within the home; can enable spread beyond the room of origin.
- Better ventilation – stimulating fire growth
- Could endanger other areas of the home and other occupants.

**Benefits**
- For a bedroom fire without a smoke alarm in the bedroom, it could provide additional protection to the occupant in the room. However, it could endanger others in the home.
- If the door is open, it can still manually be closed when the fire is recognized.
2.4 Knowledge Gaps and Next Steps

Based on the information provided in the morning session, identify existing gaps in information and recommended actions needed for further review.

- Human behavior studies on where there is the largest population of fire casualties (i.e. residential fires). Human behavior in residences is a highly understudied area of research that we need more work on.
  - Need more information on human behavior in fatal, injured, and escaped fires in residences not just major facilities; behavior in unreported fires; incidences where decision making affects life and death or injury; events where someone lives to talk about it.
- Audibility in the bedroom. Tests are needed to see if higher dB rating inside the room with doors closed (with alarm in the room) could be beneficial.
- In an exterior fire, does a closed-door impact spread?
- There are large gaps in the data. It is hard to make decisions with the currently available data. More and better data is needed.
- Application of this messaging to high rise occupancies.
- What is the most important message to send? If we must send one message, we need to make sure it is the most important message.
- Demographics of existing and future housing stock and where is it going.
- Measuring the impact of messages (e.g. does fewer words make the message more likely to go viral?)
- Need to understand the impact of affordable technological solutions. But we also need to understand what happens when Wi-Fi connections fail.
- Better understanding of enforcement and compliance with alarm installation and building codes
- More targeted smoke alarm distribution
- Knowledge and understanding of fire dynamics by public.
- Does “closing the door” and “shelter in place” messaging apply to manufactured housing?
- Impact of the complexity of scenarios on proper messaging (doors open/closed, alarms in/out of room, legacy/modern furniture, type of housing)

Message Development

To our knowledge, the three messages listed below are the primary messages that currently exist in the mainstream around the open/closed door issue. The following questions are answered within the context of the existing messages identified below.

**EMAC Message:** “A closed door may slow the spread of smoke, heat and fire. Install smoke alarms in every sleeping room and outside each separate sleeping area. For the best protection, make sure all smoke alarms are interconnected.”

**UL Message:** “Close before you doze”

**America Burning (1973):** “Sleep with bedroom doors closed. In the event of a fire, you will gain precious minutes”

3.1.1 Additional Messages

Other than the three messages identified above, do you know of any other existing messaging on this issue. If so, please identify the message and the source.

- Many organizations take the information from the EMAC and tailor it to their communities.
- “Close your door to fire” (Jackson Hole Fire & EMS – on back of truck)
- “Comprehensive plan” (Ceasefire Door Hinge);
- “#900 degree difference” (Being considered by TN FM’s office)
### 3.1.2 Key Elements

What elements are important to be included in messaging around this issue? (e.g. does there need to be actionable items? Does there need to be explanation? Etc.)

- Need to consider the door being closed in escape plan (need to have consistent messages) - push for escape plans that include the door being closed, need the why/context behind messages as a follow-up, including feeling the door.
- Message needs to resonate with single family home residents, apartment dwellers, high-rise dwellers (or be able to be tailored).
- The message needs to stimulate behavior change.
- Must be presented with emotion to make them care.
- It must be memorable.
- Ancillary messages around prevention, detection, sprinklers, etc.
- How fast fires are is not well understood; this must be communicated effectively.
- Work with other groups with safety pamphlets (e.g. Red Cross, SynGage, Shriners etc.)
- Installation and maintenance of smoke alarms and escape planning is essential to include in messages.

### 3.1.3 Populations

Considering the messages above, and any other identified messages, are there any concerns with the following high-risk populations? If so, please identify them and explain.

- Elderly
- Disabled
- Impaired
- Young children
- Impoverished communities
- Non-English-speaking populations and other cultures

**Elderly**

- The elderly is one of the most vulnerable populations
- The elderly often “age in place”. However, they may not necessarily be staying in the bedroom.
- Doors can become sticky in older homes and hinder escape.
- Message needs to be simple for this population
- Elderly may be more resistant to changing behavior; Present manageable changes
- Blanket statements won’t work
- Closed door may be a hindrance, may take time to get door open. The elderly typically moves slower, so time is critical.
- Ability to communicate from inside the space, available phone, more reason to have closed door for people who can’t affect their own evacuation and need more time.
- Issues with dexterity, mobility, opening doors may be challenge and they want to get out
- More homes with multi-generational occupants
- Older people may be less likely to hear the alarms (hearing loss)

**Disabled**

- May want doors open to allow for easier egress and to be able to get around and get out; Rooms may be retrofitted without doors.
- Message should be dependent on the situation (e.g. disability). It is often difficult to receive a message that is very tailored. Thus, it is important for the fire service to be involved at the local level to work with and have one-on-one conversations with disabled populations.
- Having a practiced escape plan is essential for this population.
- May be more effective for messaging to focus on the caregiver (i.e. able-bodied people living with them).
• This population is typically unable to self-rescue and are being asked to shelter in place. Various scenarios with varying fire origin locations, smoke detector coverage, and door position may impact their safety.

Impaired
• When impaired (e.g. under influence of alcohol or drugs) occupants may not be able to hear a traditional alarm. It may be beneficial to keep the door open for other cues.
• Concerned that the impaired may not listen to these messages.

Young Children
• Fear factor – kids are commonly scared of the dark.
• Parents are often afraid of kids locking their doors.
• Some families remove doors in their homes.
• Common for parents to not be willing to close their children’s bedroom door.
• A closed door could protect the kids – to give them time. But could also hinder their escape if the fire initiates in their room.
• Kids are generally more receptive to messages, which more easily leads to behavior change.
• Cannot be expected to escape or wake or behave properly, no correct message to provide them, should have doors closed and stay in place for rescue, even training and escape plan is risky, even expecting parent to save them is dangerous, door message is most important here.
• Delivering messages to kids in school can be an effective way to proliferate the message home to parents to improve fire safety knowledge that can create behavior change.
• Messaging should be targeted towards both parents and children.
• Telling children to close the door for safety might conflict with message that they shouldn’t hide in a fire.

Impoverished Communities
• Many people may live in the same house in impoverished communities. People are not just sleeping in bedrooms, they are sleeping in attics, basements, and other places.
• These groups may need to keep the doors open for air circulation reasons.
• College students should also be included in this group.
• Entire neighborhoods may not have smoke alarms. This is a very high-risk population.
• The basic concepts for safe infrastructure cost money; door closing is one free solution. This is key for this population group.
• Multiple risks across this population that need to be considered.

Non-English-speaking populations
• Non-traditional uses of space (tiny houses)
• Getting the message to them is harder (e.g. cooking practices from other cultures as an example)
• Important to help them understand what a smoke and CO alarm is.
• It is common for immigrant communities to have never had smoke alarms in their homes in their native countries.
• Some may be afraid people are watching them through a smoke detector.
• Different cultures react differently; Some cultures will not talk about having a fire. Some will freak out if a fire ignites;
• The relevance of specific messages to certain communities can vary significantly among different cultures. Cultural nuances vary significantly among different populations.
• Cultural issues, such as mistrust of authority or present concerns for overall safety. It is common for various groups to think free alarm giveaways are cameras and spy attempts, so smoke alarms are commonly covered with foil.
• Training might need to be highly targeted to what they already know.
### 3.1.4 Scenarios

Considering the following messages, and any other identified messages, are there any concerns with the following scenarios? Explain.

**EMAC Message:** “A closed door may slow the spread of smoke, heat and fire. Install smoke alarms in every sleeping room and outside each separate sleeping area. For the best protection, make sure all smoke alarms are interconnected.”

**UL Message:** “Close before you doze”

**America Burning (1973):** “Sleep with bedroom doors closed. In the event of a fire, you will gain precious minutes”

#### Scenario #1: Interconnected operational alarms

a) Smoke alarms are in **both the hallway and all bedrooms**; Alarms are interconnected.

- Closing the door in this scenario is okay.

b) Smoke alarms are **only in the bedroom** (no alarms in the hallway); Bedroom alarms are interconnected.

- This would only occur in very limited situations. Occupants would not be notified of a fire outside the bedroom, if the door was closed.
- Interconnection is the important piece here. If all bedroom alarms are interconnected, closing the door may be okay, assuming occupants are all sleeping in actual bedrooms, and that the fire does not occur during other times of the day when occupants are in communal spaces.
- Open door would cause an alarm to activate and occupants should then close their door if they can’t escape.

c) Smoke alarms are **only in the hallway** (no alarms in the bedroom); Hallway alarms are interconnected.

- Not hearing the alarms in the bedroom if the door is closed
- Not detecting a fire inside the bedrooms (or delayed activation)
- Audibility in the bedrooms is a concern.
- Shutting the door would impact hearing the alarms and would write off the occupant(s) of that bedroom; Would also lose the second cue (confirmation that fire exists)

#### Scenario #2: Non-interconnected operational alarms

a) Smoke alarms are in **both the hallway and all bedrooms**; Alarms are not interconnected.

- Audibility is an issue outside the area/room of origin when the door is closed.

b) Smoke alarms are **only in the bedroom** (no alarms in the hallway); Bedroom alarms are not interconnected.

- Fire outside the bedrooms – not detected (or delayed detection) and no notification

c) Smoke alarms are **only in the hallway** (no alarms in the bedroom); Hallway alarms are not interconnected.

- Delayed notification for fire in bedrooms plus audibility
**Scenario #3: No working alarms present in the home**

- Closing doors while sleeping could be of benefit here
- Try to talk with home owners. We need to recognize that telling homeowners without working smoke detectors to close their door could potentially provide a false sense of security. We need to ensure that this message does not replace the perceived need for other fire safety measures such as smoke alarms, escape plans, etc.
- This is common and a special problem, may want to engage but can’t afford alarms. Other folks have actively chosen to ignore fire safety, the issue of “working” alarms is also a difficult question

**3.1.5 Do these messages deliver the information needed to ensure life safety?**

- The context of closing the door in fire situations is not always conveyed. “Close the door on fire” is suggested
- Want to have a closed, *unlocked* door.
- Closing door does not mean shelter in place – need to get this message across.
- The presence of smoke alarms, having a practiced home escape plan, and door position can all impact life safety. All messages take a certain amount of bandwidth from the public, we need to ensure that the message sent is the most important for overall life safety.

**3.2 Other Factors**

Identify other factors (e.g. message length, etc.) that should be considered in the development of public education messages around the issue of keeping the sleeping room door opened or closed at night?

- The use of the term sleeping areas instead of bedrooms, could be more applicable to all populations (since everyone does not sleep in bedrooms).
- The message needs to have an emotional component.
- Potential hyperthermia hazard should also be considered.

**3.3 Technology**

Identify and prioritize technological devices (e.g. automatic door closers, etc.) and approaches that could support messaging strategies.

- Auto door closers could be beneficial (listed as an accessory)
- Smart devices for alarms during the day (instead of connection to a bed shaker)- codes need to allow for these
- Could be beneficial to have technologies tie into smoke alarms.
- Affordability, ease of use, and automation is key.
- This issue is not particularly a technology problem.
### Message Delivery

#### 4.1 Development
Who needs to be involved in the development of consistent messaging around the impact of a closed/open bedroom door on home escape?

- Everyone (e.g. EMAC, Fire Service, Scientists, public education groups, engineers, etc.)
- Public educators, disabled community, people who deal with cultural and limited literacy groups, state 211 system (or information system), fire related organizations, AARP, senior centers, Red Cross, insurance companies, rental associations, smoke alarm industry (and accessories), utility companies, public health groups/agencies
- Red Cross, Shriners, SynGage, Burn Prevention community (already on EMAC), Fire Service, Public health, CPSC, USFA, legislators or bureaucrats, insurance reps (on EMAC), product manufacturers (liability, could ref EMAC or 72), others.

#### 4.2 Number of Messages
Identify the advantages and disadvantages of (1) having a universal, singular, concise, and catchy message, versus (2) having multiple messages targeted at specific audiences/risk groups.

- Need both – need an overarching simple message as well as specific tailored messages.
- A single, concise message will be remembered and be more effective in changing behavior, however, it may be lacking information and could drown out more important messages.
- A single, concise message is typically the most effective because it presents no confusion and is reliable. It can create numbness and get people to internalize and not even think about it.
- Having a universal message is challenging because there are too many different scenarios, populations, and variations in smoke alarm installation locations.
- Having multiple messages may make it difficult to deliver them all. Additionally, it is important to recognize that delivering a message that has a decision point could negatively impact effectiveness.

#### 4.3.1 Delivery Approach
Who should deliver the message?

- Need someone that understand the issues.
- Trusted members of the communities (fire service, church groups, etc.)
- This could vary depending on the audience receiving the message.

#### 4.3.2 Delivery Approach: How should the message(s) be delivered?
How should the message(s) be delivered?

- Needs to be introduced into schools.
- Work with corporate partners (e.g. McDonalds)
- Delivery approach needs to be tailored to the audience (accounting for generational factors, cultures, etc.). Need to first look at who fits the profile target audience
- Delivery approach could utilize social media, videos (rap, cartoon, personal, etc.), distribute messaging on public transportation, etc.
- Approach should vary for different audiences (including rural landscapes versus dense cities)
- You must make someone want to do something. It has been effective to show people videos to get them excited about change.
4) Summary Observations

The information gathered at the Door Messaging Strategies Workshop has been synthesized, reviewed, and summarized. This workshop has supported relationship building between diverse stakeholder groups, while allowing the technical substantiation for this issue to be further assessed.

A few key findings from the workshop, include the following:

- It is important to consider fire dynamics, notification, and human behavior when developing messaging around this issue.
- The fire service is an important stakeholder, not only in support of outreach and message delivery, but also for tactical fireground coordination.
- Affordable technological solutions can have noteworthy influence on messaging strategies.
- Messaging regarding door position makes it even more important to have working smoke alarms and a practiced home escape plan.
- More research is needed on certain sub-topics, such as:
  - Human behavior in residential dwellings
  - Demographics of existing and future housing
  - How to measure the impact and receptivity of messages to specific populations (i.e. testing messages over time with target groups to understand its impact on behavior change).

The “Door Messaging Strategies” project (i.e. see slides by CSE) has provided a detailed assessment using relevant and established scientific methods to evaluate this topic. A few key findings from this technical assessment are as follows:

- There is merit to closing a sleeping room door at night.
- A closed bedroom door has the potential to reduce the number of fatalities in home fires.

The workshop discussion considered all the influencing factors for door messaging strategies, including both scientific (i.e., technical) and education-based (i.e. non-technical). In summary, the attendee’s interpretation into actual door messages was observed as lacking consensus.

For additional information on the workshop presentations, please refer to the slides in Annex B. The final report for the “Door Messaging Strategies” project discussed herein will be available at www.nfpa.org/foundation, for additional information on this study.
# Annex A: Workshop Participants and Attendees

The following were the workshop presenters on “Door Messaging Strategies”, held in the Sheraton Baltimore Washington Airport Hotel, Linthicum Heights, MD on July 9th, 2019.

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
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<tbody>
<tr>
<td>Stephen Kerber</td>
<td>Vice President of Research at UL, Director of UL FSRI</td>
</tr>
<tr>
<td>Laurence (LJ) Dallaire</td>
<td>Fire Marshal at the Architect of the Capitol</td>
</tr>
<tr>
<td>Arthur Lee</td>
<td>Consumer Product Safety Commission</td>
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<tr>
<td>Rita Fahy</td>
<td>National Fire Protection Association, Applied Research</td>
</tr>
<tr>
<td>Lisa Braxton</td>
<td>National Fire Protection Association, Public Education Specialist</td>
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<tr>
<td>Stephen Olenick</td>
<td>Research Engineer at Combustion Science &amp; Engineering</td>
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<tr>
<td>Josh Dinaburg</td>
<td>Research Engineer at Jensen Hughes</td>
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<tr>
<td>Kevin Sehlmeyer</td>
<td>Michigan State Fire Marshal</td>
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<td>CPSC</td>
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<tr>
<td>Elizabeth Bubel</td>
<td>American Red Cross</td>
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<tr>
<td>Haavard Boehmer</td>
<td>Combustion Science &amp; Engineering, Inc.</td>
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<td>Kevin Sehlmeyer</td>
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<tr>
<td>Marty Ahrens</td>
<td>NFPA</td>
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<tr>
<td>Mike Lowe</td>
<td>Delaware State Fire School</td>
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<tr>
<td>Teresa Crisman</td>
<td>Prince George’s County Fire and EMS</td>
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<tr>
<td>Wendy Gifford</td>
<td>Nest/Consultant</td>
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<tr>
<td>Amanda Kimball</td>
<td>Fire Protection Research Foundation</td>
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<tr>
<td>Emily Witty</td>
<td>Maryland Office of the State Fire Marshal</td>
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<tr>
<td>Andy Lynch</td>
<td>The Fire Solutions Group</td>
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<td>Laurence Dallaire</td>
<td>Architect of the Capitol</td>
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<tr>
<td>Meredith Hawes</td>
<td>NFPA</td>
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<td>Scott Ayers</td>
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<td>Teresa Neal</td>
<td>United States Fire Administration</td>
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<td>Michael Kozo</td>
<td>FDNY</td>
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<tr>
<td>Dick Roux</td>
<td>NFPA</td>
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<tr>
<td>Victoria Hutchison</td>
<td>Fire Protection Research Foundation</td>
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<tr>
<td>Name</td>
<td>Affiliation</td>
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<tr>
<td>Amanda Swenson</td>
<td>Minnesota State Fire Marshal’s Office</td>
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<td>Safety First Electrical</td>
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<td>Josh Dinaburg</td>
<td>Jensen Hughes</td>
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<td>Ernest Grant</td>
<td>EMAC Chair</td>
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<tr>
<td>Dave Newhouse</td>
<td>Gentex</td>
</tr>
<tr>
<td>Milosh Puchovsky</td>
<td>Worcester Polytechnic Institute</td>
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</table>
Who is at Highest Risk?

- Adults at least 65 years old
- 1 of every 3 fatal home fire victims
- Groups unable to exit on their own, even if working smoke alarms are present

America Burning, 1973, p. 115

- "Sleep with bedroom doors closed. In the event of a fire, you will gain precious minutes to escape."
- 1977 survey done for USFA found that 22% of households had smoke detectors/smoke alarms

For smoke alarms to be useful,

- Smoke must reach them
- They must be working
- They must be heard or noticed
- Occupants must be able to take action

Smoke alarm status in reported home fires: 2012-2016

Risk of dying in a reported home fire is cut in half in homes with working alarms.

- Fires:
  - Fire too small to operate: 13%
  - Operating smoke alarm: 53%
  - Present but did not operate: 7%
  - No smoke alarm present: 26%

- Deaths:
  - Fire too small to operate: 1%
  - Operating smoke alarm: 42%
  - Present but did not operate: 17%
  - No smoke alarm present: 40%

Fatal fire victims with working smoke alarms, were more likely to have...

- Been in the area of origin
- Even more likely to have been in area and involved in ignition
- Tried to fight the fire themselves
- A disability that made self-rescue difficult
- Been at least 75 years old
- And were less likely to have been sleeping than those without working smoke alarms

Smoke alarm performance and effectiveness in CPSC’s 2004-2005 survey of unreported residential fires

- On all floors: 12%
- Not on all floors: 2%
- In all bedrooms: 3%
- Not in all bedrooms: 27%
- Interconnected: 53%
- Not interconnected: 27%

About the data

- 2012-2016 estimates derived from USFA’s National Fire Incident Reporting System (NFIRS) and NFPA’s annual fire experience survey
  - Unknowns were allocated proportionally
- See NFPA reports
  - Home Structure Fires
  - Smoke Alarms In US Home Fires
  - Home Fire Victims by Age and Gender

Thank you!
Modern Home Fire Environment
Presenter: Steve Kerber, UL FSRI

The Evolution of the Residential Fire Environment

Larger Homes

Average and Median Square Foot for New Single Family EK Homes. Average 1.5 Household Home, not by area.

Evolving Fuel Loads

The corner of a single-family home. New materials by synthetic materials.

Open Spaces

Great Rooms

3-14 St. Cultrins

Comparison of Room Furnishings

Natural Room

Synthetic Room

Changing Building Materials – Structural Comps.

Old Growth Lumber < New Growth Lumber < Engineered Lumber (JE) (Class, Trusses, Cables)

Changing Building Materials – Structural Comps.
NFPA 72 – Smoke alarm requirements over the years
Presenter: Laurence Dallaire, Architect of the Capitol
Learning Objectives

- Describe NFPA 72
- Outline basic spacing requirements for household smoke alarms.
- Provide a brief history of code changes related to detection.
- Highlight potential considerations for the Door Messaging Workshop.

What Is NFPA 72?

- Describes what must be included in fire and smoke detection design and installation.
- Includes smoke and carbon monoxide alarms.
- Applies to residential, commercial and industrial buildings.
- Has specific requirements that apply to residential occupancies, including apartments, hotels and houses.
- Requirements are based on best practices based on current knowledge.
- NFPA 72 does not “grandfather” existing conditions.

NFPA 72 Assumptions

NFPA 72 contains assumptions in framing the protection requirements for alarm installations. (Section 29.6)
- Occupants are capable of self-rescue.
- Occupants intimate with ignition are not be assumed to be protected.
- Occupants have an escape plan.
- Escape route available and unobstructed.
- Escape route along the normal path of egress.

Pre-1993

- Outside of Sleeping Rooms and on Every Level

1993-2002

Current (Since 2007)

- No “Grandfathering” Existing Dwellings
- New - Large Homes and Dwellings Require Additional Alarms
Cooking Nuisances

- In addition, cooking nuisances were updated and specifically addressed in 2013.
  - Nothing within 6 ft.
  - Alarms must be at least 10 ft away from cooking appliance, unless listed for use near the appliance.
  - Alarms between 10 ft and 20 ft from a cooking appliance must have alarm silence or use photoelectric detection.
  - Alarms using photoelectric detection are permitted between 6 and 10 feet in small spaces.
  - Effective January 1, 2022, alarms between 6 ft and 20 must be listed for resistance to nuisance sources from cooking.

Nuisance Distances (2013)

Kitchen Detector Spacing – 2013 onward

2019 – Added CO Alarms

US Housing Profile

- 2017 Median House Age: 37 years
  - Up 6 years since 2005
  - New Homes in 2017: 1,113,000
    - 795,000 single family
    - 358,000 multi-family units

Adoption Time

Takeaways

- NFPA 72 requires smoke alarms.
- Newer codes require more smoke alarms, nuisance resistance, CO alarms, improved power supplies.
- Codes take time from development to adoption.
- Housing stock is old, and takes time to meet new code requirements.
- NFPA 72 assumes occupants are capable of self-rescue, and have an escape plan.
Considerations to Door Messaging (Doors open or doors closed)
- Direct and Indirect consequences of door messaging
- Direct are related to the event
  - Smoke alarm audibility
  - Smoke progression
  - Heat and fire spread
- Indirect are not related to the event
  - Overheated room from space/portable heaters
  - Smoke detection from occupants not in the room of origin
  - Distress notification from young children or handicapped occupants in the room of origin

Smoke Alarm Audibility – Children and Older Adults
- Children under the age of 16 have longer periods of deep sleep compared to adults.
- Current smoke alarms may not reliably wake children under the age of 16.
- Current smoke alarms (85 dB) are effective in waking most adults not under the influence of drugs, alcohol, and sleep deprivation.
- Current smoke alarms (85 dB) may not reliably notify or alert seniors who are hearing impaired or have high-frequency hearing loss.

Older Homes Use Single Station Smoke Alarms
- Prior to 1989, existing homes typically installed single-station, battery-only-powered smoke alarms.
- After 1989, the code included provisions for new homes to have interconnected (hardwired) smoke alarms.
Smoke Alarm Audibility – Sound Loss

- The Audibility of Smoke Alarms in Residential Homes, September 2005 (www.cpsc.gov)
- The CPSC staff conducted sound loss measurements in three different test homes using single-station smoke alarms.
  - The homes were built between 1950 and 1989.
  - The sizes of the homes ranged from approximately 1,000 square feet to 3,300 square feet.

Smoke Alarm Audibility – Sound Loss

- Small, single-level home
  - Single-station smoke alarm may be sufficient to alert occupants, even if the bedroom doors are closed.
- Two-level homes
  - Sound levels may not be sufficient to alert occupants in all areas of the home, causing a delay for some individuals to respond immediately. The occupants may experience a sound level as low as 50 dBA from a smoke alarm sounding on a different level or floor.
- Three-level homes
  - May not be sufficient to alert occupants in all areas of a three-level home. The occupants may experience a sound level as low as 30 dBA from the furthest away smoke alarm.

Considerations When Developing Door Messaging Strategies

- Other factors besides smoke alarms audibility may need to be considered
  - Unintentional hazards besides fire and smoke
  - The age or physical abilities of the occupant(s) within the room
- All factors should be considered and the consequences that may impact on the life safety of the occupants.
- Two examples where closing the door presented a hazard to the occupant(s) within the room

Indirect Consequences
Electric Room/Space Heaters - Hyperthermia Deaths

- CPSC staff conducted a preliminary analysis to assess this hazard, starting with a data search for incidents involving heater-related deaths that occurred from January 1, 2008 to August 31, 2018.
  - Four children
  - One adult

Heater Testing in a Simulated Small Space

- Portable heater in a closed space (chamber)
- Door partially opened to allow mixed temperature air enter and exit the chamber.
- Under certain conditions, the heater can maintain a 110°F "room" chamber temperature without shutting off.
Evaluating Changes to Start Temperature and Room Size on Heating Requirements

- Portable heater in a closed space (chamber)
- Door partially opened to allow mixed temperature air enter and exit the chamber.
- Under certain conditions, the heater can maintain a 110°F "room" chamber temperature without shutting off.

Evaluating Changes to Start Temperature and Room Size on Heating Requirements

- Heat losses, which have a specific R-Value, occur through the walls, ceiling, floor, windows, and door.
- R-Values are used in describing effectiveness of insulation and in analysis of heat flow across assemblies (such as walls, roofs, and windows) under steady-state conditions.
- If given the R-Value, area affected, and temperature difference, the amount of heat loss in an hour can be calculated by the equation:

\[
\text{Heat Loss} \left(\frac{\text{BTUs}}{h}\right) = \frac{\text{Area} \times \text{Temp. Difference} \times 0.801}{R\text{-Value} \times 60}
\]

Electric Room/Space Heaters - Hyperthermia Hazard

- Staff's assessment revealed that room heaters may present an unaddressed hazard to consumers.
- Staff learned that a heater in a small room with a closed door has the potential to sustain elevated room temperatures above safe long-term exposure levels (but below the risk of fire), which may pose a risk of hyperthermia to occupants.
- Staff's review further concluded that children, people with disabilities, and senior citizens may be more susceptible to this hazard because of their limited ability to take action or react to sustained elevated ambient temperatures.

Indirect Consequences
Fire Origin in a Room with a Closed Door

- Incident involved a portable heater in a bedroom
- Smoldering fire in the room of origin
- The door to the child's room was closed.
- The electric heater in the room was placed on top of a 5 foot tall bookcase and turned on for the night.
- The heater was discovered completely melted in the morning.
- The smoldering heater caused the death of 3-year-old child from smoke inhalation.
- No working smoke alarm within the bedroom.
- Other occupants in the home were unaware of the smoke in the child's bedroom.

Incident heater melted
The impact of human behavior on safe egress
Presenter: Rita Fahy, Ph.D., NFPA

Questions?
Thank you for your attention
Arthur Lee
alee@cpsc.gov

The Impact of Human Behavior on Safe Egress
DOOR MESSAGING STRATEGIES WORKSHOP
July 9, 2019 | Rita F Fahy, PhD | Manager, Applied Research

Background
• Most research in recent decades has focused on larger,
designed (PCI) structures, rather than homes
  – Limited focus on understanding how people behave in house fires
  – Knowledge from PCI spaces can’t be assumed to apply
  – Focus has been on risk factors for fatalities
    • Difference between risk of having a fire vs injured in fire vs
      killed in fires

Factors that make behavior in home fires
different from that in non-home fires
• Greater attachment to the building, people and possessions
• Quicker response to cues*
• More likely to attempt to fight the fire
• Re-entry
• Easier wayfinding due to familiarity
• Higher likelihood of young and old to be present
• Higher likelihood of disabled occupants to be present

Quicker response to cues
• Due to feelings of responsibility, ownership and control
• Presence of loved ones
• No informative social influence
• No fear of embarrassment
• Less attachment to activity

Factors that make behavior in apartment fires
different from dwellings
• More ambiguous cues
• Less firefighting behavior when occupants are not in unit of origin

Complicating factors
• Poverty
  – Presence of alarms
  – Security issues
  – Related risk factors
• Age of occupants (young and old)
• Intoxication
Factors that affect evacuation

- People are asleep and need to be wakened
  - Children and elderly are at higher risk
  - Children - more deep sleep
  - Elderly - hearing loss, use of sleeping pills or prescription medications

Factors that affect evacuation

- People will generally require confirmation of a fire’s existence, through additional cues, before concluding that a signal is not a false alarm, and begin evacuation
  - Time might be spent
    - Finding fire, fighting fire and warning others.
    - Preparation - warm clothes, gathering children and pets, finding wallet/keys, putting away supper, looking over balcony, contacting building superintendent.

Factors that affect evacuation

- Families tend to gather and leave together – this can be a significant risk factor if the fire separates family members.
- Re-entry to attempt to save a family member (‘if they die, I die with them’)
- Some never attempt to evacuate at all

Some case studies from UK research

- Kent Fire and Rescue Services (UK) – based on post-fire surveys in dwellings
  - In one phase of the study, with mostly ‘moderate’ fires with serious damage but no serious casualties
    - Considerable percentage of occupants investigated the source of cues
    - More than half entered the room of origin
    - 20% re-entered the building at least once

Other findings from KFRS research projects

- High number of the injured could have avoided injury if they had undertaken ‘appropriate’ actions (withdrawn, moved to place of safety, called fire brigade earlier)
- Majority of those who called 999 did so after a sequence of activities – the decision to call 999 came at the end of what for some was a fairly long series of actions
- In cases where escape seems to have been possible yet people died, a narrowing of perception may have occurred – tunnel vision, with attention focused on a single aspect of the situation rather than the broader situation with alternatives.

Other findings from KFRS research projects

- Interviewees had limited understanding of the risks in fighting the fire
  - Frequently mentioned surprise at the speed with which fire and smoke developed – not like familiar fires in fireplaces and campfires
  - Some felt they had over-reacted in contacting the fire brigade
  - ‘Delay’ in calling the fire department implies that occupants were prevented from doing so, but actually they may not have felt it necessary until they found themselves unable to handle the situation themselves.
Other findings from KFRS research projects

- In spite of injuries, majority felt they had acted correctly and would not behave differently if they had the same experience again.

Does this have relevance in the formulation of safety messages?

Thank you!

Contact: rfaith@nfpa.org
Matching Messages to Audience

Core Message: Chapter 8, Cooking 8.4.1
Always keeps a lid nearby when you are cooking. If a small grease fire starts in a pan, smother the flames by sliding the lid over the pan. Turn off the burner. Do not move the pan. To keep the fire from rekindling, leave the lid on until the pan has cooled.

Target Audience??
Syrian Refugees

Customized Call to Action – Easy-to-Read
To put out a pan fire, slide a lid over the pan. Turn off the stove. Let the pan cool.

Representative Organizations
NFPA
AFSP
American Red Cross

ESF

Safe Kids Worldwide

“In Summary: Critical Issues”
- NFPA is currently reviewing the scientific and behavioral research for “shove the door” messaging and will formulate messaging based on the research findings.
- We stand by the message that if you sleep with your doors closed, interconnected smoke alarms cannot activate if a fire starts if all smoke alarms are interconnected. Additional devices such as “bed shakers” can improve the chance of being alerted to fire.

Smoke Alarm Installation:
1.2.1 Install smoke alarms in every sleeping room, outside each separate sleeping area, and on every level of the home. Install alarms in the basement. Larger homes may require additional smoke alarms to provide a minimum level of protection.
1.2.2 Interconnect all smoke alarms throughout the home for the best protection. When one sounds, they all sound. Make sure you can hear the sound of the smoke alarm.
1.2.2.1 It is especially important to have interconnected smoke alarms, if you sleep with doors closed.
1.4.4 Fire Escape:
- 1.4.1 A closed door may slow the spread of smoke, heat, and fire.
- 1.4.1.2 If you sleep with the bedroom door closed, install smoke alarms inside and outside the bedroom. For the best protection, make sure all smoke alarms are interconnected. When one smoke alarm sounds, they all sound.
The future of messaging
Increase our social media presence
Using digital and mass media to create a wide footprint for three key behaviors:
- Working smoke alarms in every home
- Safe cooking practices
- Creating a safe (non-combustible) 5-foot (1.5 metre) perimeter around the home

Getting our messaging out through FLS educators:
- Continue use & promotion of Desk Reference as the "go to" resource
- Support our stakeholders' use of tailoring messages
- Expand reach via new channels for use (community-based organizations)
- Living document
- Translations: French & Spanish

Social media co-branding

Phase I: Widening our base & expanding our reach
- We will increase the use of technology for mass reach of our messages and to maintain communication and educational opportunities with our expanding networks.

Questions?
Lisa Braxton
lbraxton@nfpa.org

THANK YOU!
Door Messaging Strategies Research Analysis
Presenter: Stephen Olenick, Combustion Science & Engineering

Motivation
- NFPA Position (EMAC 2016)
  - The current message in the 2016 Educational/Messaging Task Force is:
    - Prevent fire with the bedroom door closed, resisted smoke alarm inside, and extinguish the bedroom. For the best protection, make sure all smoke alarms are interconnected.

Objective
- Overall Objective – to provide technical information on these potential issues:
  - Should help to inform: How to utilize this information to best deliver the message, if at all, for maximum effectiveness?
  - Tasks
    - Document current messaging
    - Document problem overview and assess magnitude of the problem
    - Assess fire dynamics/detector issues
    - Put in context of benefit of a closed bedroom door
    - Assess notification/audibility issues
    - Put in context of benefit of a closed bedroom door

The Problem
- Scenarios of concern:
  - Scenario 1: Bedroom fire
  - Scenario 2: Out-of-bedroom fire

Benefit of a Closed Door
- Fire growth times (Bukowski et al., 2010)
  - Planing fires uncontrollability times
    - 17 minutes in 1970s
    - 5 minutes in 2000s
- Fire Department response time
  - Jarecki, Fire Technology, 2017
  - Almost always longer than 3 minutes in today's fire conditions
  - Buffalo and Erie, Fire Technology, 2010
  - 1-2 family residents in the United States
  - Often longer than 3 minutes
  - Only alarm to arrive
  - Further delay from time alarm and then shut up and actually attempt a rescue

Benefit of a Closed Door
- Kerber et al., Fire Technology, 2019
- Evaluating firefighter tactics
- Analyzed FED values in residence including in closed bedrooms
  - At ~3 foot height for crawling or using a ladder
Benefit of a Closed Door

- Kerber et al., Fire Technology, 2019

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Near bed</th>
<th>Door open</th>
<th>Far closed door</th>
<th>Far closed bedroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp 1</td>
<td>1.20</td>
<td>0.75</td>
<td>0.60</td>
<td>0.84</td>
</tr>
<tr>
<td>Exp 2</td>
<td>1.10</td>
<td>0.70</td>
<td>0.60</td>
<td>0.84</td>
</tr>
<tr>
<td>Exp 3</td>
<td>1.00</td>
<td>0.60</td>
<td>0.60</td>
<td>0.84</td>
</tr>
<tr>
<td>Exp 4</td>
<td>0.90</td>
<td>0.50</td>
<td>0.60</td>
<td>0.84</td>
</tr>
<tr>
<td>Exp 5</td>
<td>0.80</td>
<td>0.40</td>
<td>0.60</td>
<td>0.84</td>
</tr>
<tr>
<td>Exp 6</td>
<td>0.70</td>
<td>0.30</td>
<td>0.60</td>
<td>0.84</td>
</tr>
</tbody>
</table>

Benefit of a Closed Door

- Madczynkowsk and Weinschenk, Understanding and Fighting Basement Fires, UL Firefighter Safety Research Institute, 2018
  - Different set of experiments

<table>
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<td>0.70</td>
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<td>0.60</td>
<td>0.84</td>
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</tbody>
</table>

Current Messaging

- UL FSRI “Close Before You Doze”
  - Closesyourdoor.org
  - Fire department, police, and other fire officials on website
  - Door tags
  - Videos on how to message
  - Social media posts to share
  - Kids coloring books and songs

Current Messaging

- UL FSRI website also includes information on smoke alarms and fire safety plans
  - Both as educational materials from the NFPA
  - Many videos from UL FSRI pair the closing bedroom door message with smoke alarm messaging

Current Messaging

- What can happen with the message?
  - Found on Southern Living and Good Housekeeping websites
  - Southern Living – 6,875,000 unique users, 44 million pages views
  - FSRI video but provides own video without mention of smoke alarms
  - Good Housekeeping
  - Has link to UL FSRI video but no sides of its own
  - Website mentioning partner mentions and smoke alarms but no mention of location

Current Messaging - Products

- Thermal door hinge
  - Website has guidance on smoke alarms and fire escape plans
  - Website on smoke alarm locations on website
  - No mention of interconnection

- “Listening” door hinge
  - Have a media kit
  - Mostly just link to UL FSRI website/materials
Code Requirements

- NFPA 72, 2007 edition
  - Smoke alarms in sleeping areas, outside sleeping areas (hallways), and on all floors
  - Previously only in hallways outside sleeping areas
  - Interconnection required
    - Due to availability of wireless interconnected smoke alarms
  - Referenced by 2009 edition of the ICC codes

Magnitude of the Problem

- Since 2007 codes require smoke alarms to be interconnected, and in hallways and all bedrooms yet per Abrams (2019) and Greim and Andries (2009)
  - 60-63% of residences have an alarm in the hallway in 2005 and 2010 surveys
  - 30-34% of residences have an alarm in the bedroom in 2005 and 2010 surveys
  - Interconnection
    - NFPA 101 (2009) requires interconnection
    - NFPA 101 (2012) requires interconnection in all rooms above a 60% occupancy

<table>
<thead>
<tr>
<th>Year</th>
<th>Alarms in all bedrooms</th>
<th>Interconnected alarms</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>43%</td>
<td>35%</td>
</tr>
<tr>
<td>2015</td>
<td>25%</td>
<td>42%</td>
</tr>
</tbody>
</table>

The Problem

- But what if you do not have an alarm inside and outside the bedroom and interconnected?
- Scenarios of concern

Scenario 1: Bedroom fire

Scenario 2: Outside-bedroom fire

Fire Dynamics

- Approach
  - Assume non-bedroom origin fires will be first detected by alarm in the hallway (if present) and therefore that is an audibility/notification issue, not a fire dynamics issue
  - For bedroom-origin fires:
    - Analyze for best data for tests with door open and door closed
    - Analyze both from a hallway alarm and bedroom alarm perspective and determine number of adverse outcomes
  - Utilize statistics to determine percentage of residential fires and residential fatalities that may result from closing the bedroom door

Fire Dynamics

- References considered

- NFPA 72 SIG-HOU Task Group
  - Utilized transient moving tenability for ASET/RES calculation
  - Very conservative tenability criteria
  - Assumed NFPA 72 compliant smoke alarm configuration
  - Alarms inside and outside the bedrooms, on all levels, and interconnected
  - CSE represented on Task Group and participated in formulation of analysis
    - Data from Bukowski et al. (2008) is public
    - Spreadsheets from CSE utilized to analyze data
    - In original 103 Schirmer Engineering (now Jensen Hughes) also did some of the spreadsheet work
    - CSE remade these spreadsheets for the analysis here
Fire Dynamics

• For bedroom-origin fires
  — If you have an alarm in the bedroom, closing the bedroom door will result in a drop of successful escapes from bedroom fires from 96.6% to 60.7%.
  — A change of 25.9%
  — If you do not have an alarm in the bedroom, closing the bedroom door will result in a drop of successful escapes from bedroom fires from 96.6% to 0.0%
  — A change of 96.6%

Fire Dynamics - Adverse outcomes – fires standpoint

<table>
<thead>
<tr>
<th>Scenario Type</th>
<th>Success Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedroom fire</td>
<td>96.6%</td>
</tr>
<tr>
<td>Outside bedroom fire</td>
<td>25.9%</td>
</tr>
</tbody>
</table>

Table 1: Average Decibel Measurements

<table>
<thead>
<tr>
<th>Status</th>
<th>Decibels (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Alarm</td>
<td>35</td>
</tr>
<tr>
<td>Alarm with Door Open</td>
<td>95</td>
</tr>
<tr>
<td>Alarm with Door Closed</td>
<td>78</td>
</tr>
</tbody>
</table>

The Problem

• But what if you do not have an alarm inside and outside the bedroom and interconnected?

Notification/Audibility

• Test on UL FSRI website
  — Alarm just outside or close to bedroom door
  — UL FSRI audibility results

Auditability

• Approach
  — Consider a scenario with alarm as far as allowed by code from the bedroom
  — Utilize two calculation methods
    • Hallwell and Sultan (1995)
  — Open and closed door to assess impact
  — Compare to UL FSR test for verification/validation of calculation procedure
  — Assess drop in sound pressure level of alarm due to closed door in context of awakening studies and code requirements
  — Determine from fire statistics the number of estimated adverse outcomes from closing a bedroom door
Notification/Audibility – Additional Considerations

- Hearing impaired
  - Bruck et al., 2007
  - Hearing impairment reduces waking effectiveness
  - Low frequency more effective

NFPA RF Low Frequency Project

- Closed hollow core interior door attenuates –14-17 dBA
  - Open door in experiments – 95 dBA
  - Closed door in experiments – 78 dBA
  - 7 dBA more with low frequency
  - 8-10 dB difference between open door high frequency and closed door low frequency
  - Bruck et al (2007) for normal hearing under the influence of alcohol
  - 90% awake vs 80 dBA low frequency vs 89% at 78 dBA high frequency
  - So low frequency may completely offset any issues with a closed door
  - Related NFPA Research Foundation Project “Review of Audible Alarm Signal Waking Effectiveness” (Jensen Hughes – Josh Dinaburg, Principal Investigator)
    - Lowering low frequency requirements (75 dBA at the pillow in NFPA, 65 dBA at 10 feet in UL 217)
    - To save on battery backup and primary battery requirements
  - This may offset the advantage of the low frequency and will have to be considered
    - For instance, door 4 dB
  - 90% awake vs 78 dBA
  - 98% awake vs 75 dBA

Benefit of a Closed Door

- Additional successful outcomes – fatalities standpoint

<table>
<thead>
<tr>
<th>Method</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Strike</td>
<td>26.2%</td>
</tr>
<tr>
<td>Mag Lock Strike</td>
<td>18.9%</td>
</tr>
<tr>
<td>Mag Lock with Panic Bar</td>
<td>18.9%</td>
</tr>
<tr>
<td>Mag Lock with Panic Bar</td>
<td>28.3%</td>
</tr>
<tr>
<td>Mag Lock with Panic Bar</td>
<td>28.3%</td>
</tr>
</tbody>
</table>

Benefit of a Closed Door – Additional Considerations

- UL FSRI also recommends in their messaging to shut the bedroom door when escaping as well, not just when asleep
  - Harder to quantify effect on injuries and fatalities
  - Aware of a number of fires, though, where leaving a door open during escape resulted in fatalities remote from area of fire origin
  - Multi-family dwellings

Benefit of a Closed Door – Additional Considerations

- Could be a few human behavior issues with closing a bedroom door as well
  - False sense of security?
    - Leads to delayed escape due to lack of urgency from lack of smoke
    - Leads to delay in investigating instead of escape due to lack of smoke
    - Leads to desire to grab belongings
  - May be dealt with through current messaging
    - Upon hearing a smoke alarm, leave the residence and then call 911
    - Have an escape plan and practice it

Developing Recommendations (Ongoing)

- Closing your bedroom door at night has merit
  - Potential of preventing significant number of fatalities by closing the door (>25%)
  - Closing doors when escaping makes merit as well
  - Compare with (very conservatively):
    - ≤15% of fires may have an adverse outcome from closing the door
    - 20% of fatalities that may result from closing the door
Audible (Low Freq) Alarm Waking Effectiveness
Presenter: Josh Dinaburg, Jensen Hughes
Sound Pressure Levels

- Sound is an atmospheric pressure variation traveling as a wave.
- Humans can "hear" 20-20,000 Hz tones.
- Hearing is a complex process.
- Transport is complex.
- Reflection
- Absorption
- Interference
- Modulation
- Walls, floors, doors, corridors, carpets

Sound Pressure

Relative Scale of Decibels

- Based on minimum hearing threshold of humans - 0.00022 Pascal.
- Sound power is the square of the sound pressure.
- dB is related to sound power.
- A-weighting scale, connected to human ear.
- Used for alarm signaling.
- Biased toward mid frequencies.
- May not be entirely accurate for perceived "loudness." For waking ability.
- Not based on loudness (<40 dB).

Current Requirements for Smoke Alarm SPL

Evolution of Codes and Standards Based on Research

- Device Requirements:
  - 75 dB audible at a distance of 10 ft (UL 217 and UL 281).
  - Individual alarm system sounders can be 75 dBa at 10 ft (UL 285).
- Installation Requirements:
  - In residential occupancies, including one- and two-family dwellings.
  - 75 dB audible at the alarm location (IBC, NFPA).
  - 50 dB audible at the smoke alarm (IBC, NFPA).
- Sound Requirements:
  - Time to audible sound pattern to ISO 8251 and ANSI S3.41.
  - Low frequency, 20 to 40 Hz square wave pattern in sleeping areas and for hearing impaired.

Evolution of Codes and Standards

- Alarm shall be audible in all bedrooms with the doors closed.
- All alarm devices shall be rated not less than 75 dBa at 10 feet.


1980 - NFPA 72A adds Exception for appliances in bedrooms to be 75 dBa at 10 ft.
Appendix includes reference that 65 dBa outside bedrooms produces 70 dBa in a bedroom, or 15 dBa above 65 dBa ambient noise.
Michigan’s Fire Incident Data Collection on “Door Position”
Presenter: Kevin Sehlmeyer, Michigan State Fire Marshal

“WE”
Kevin Sehlmeyer SFM Michigan
sehlmeyerk@michigan.gov

July 2017
* Michigan Fire Inspector Society planning meeting
* 2018 Strategic Plan