

Information Needs of Vulnerable Populations

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Abstract

Vulnerable populations have different information needs, both in terms of content and delivery, than the remainder of the population. A wide variety of vulnerable populations are considered including those with sensory or cognitive disabilities as well as those that are very old or very young, in large groups or alone, untrained, asleep, intoxicated or experiencing similar symptoms, non-native speakers, committed to a task, or are unable or unwilling to evacuate. Members of these populations can be found in all types of buildings. Thus it is important to ensure that fire alarms meet their needs.

Studies involving the information needs of vulnerable populations during other evacuations are examined to identify key components that should be included in fire alarm systems. There is considerable overlap in the needs for different populations and the recommendations should not adversely alter the ability of the remainder of the population to safely evacuate. It is found that fire alarms meet some of the needs that are unmet during other emergency evacuations. However there are additional needs that need to be considered when developing emergency messages. The development of these messages should be done in consultation with members of the vulnerable populations.

Introduction

Notification of people for an evacuation due to a fire can involve any combination of audible and visual messages. These are intended to ensure that people with vision and hearing impairments are made aware of the fire and then able to evacuate. These alarms notify the general building population about emergency conditions and, in many cases, allow the majority of the population to evacuate.

Unfortunately, the alarms do not ensure that all vulnerable populations are provided with a message that they can comprehend and subsequently follow. Depending on the exact criteria used, over 50 % of the people in any building could be considered part of a vulnerable population [1]. Members of vulnerable populations are integrated into society and they need to be informed of the emergency and provided with a means of egress, just like everyone else that is

present in the building. The information needs of these individuals can range from the same basic needs as the rest of the population to a significant change in how the information is delivered.

For a variety of emergency evacuations, disaster preparedness and emergency response systems are typically designed for people that are able to quickly and easily self-evacuate by walking, running, or driving and can easily follow emergency messages. Fire alarms have gone further than some other types of emergency warning systems in that they combine both visual and audible notification. This ensures that a wide spectrum of the population is made aware of the need to evacuate.

While most of the population is notified about the need to evacuate, there are subpopulations that may have difficulty understanding and following the warnings that are provided. This is especially true if the system uses voice messages or text to provide occupants with information about the cause of the alarm or instructions pertaining to evacuation. As an example, Gwynne [2] has identified several groups of people that are at high risk for not being able to respond to alarms. These include individuals with sensory or cognitive disabilities, or those that are very old or very young, in large groups or alone, untrained, asleep, intoxicated or experiencing similar symptoms, non-native speakers, or committed to a task. Other vulnerable groups include people that are situationally disabled or have mobility impairments. Examples of these latter groups include people connected to medical equipment that cannot be moved or people that do not have the physical endurance to evacuate the building unaided. While these individuals will be aware of the danger and the actions that the rest of the population are supposed to take, they do not have the means to follow those instructions.

Understanding the needs of these populations can aid in the development of better notification systems. To date, little research has been conducted on messages delivered to vulnerable populations during evacuations due to fire alarms. While more research needs to be done, there are some findings in the literature that can be used to shape the development of evacuation signals and messages. Similar types of messages have to be provided to vulnerable populations when there is the need to evacuate due to tornados, hurricanes, tsunamis, earthquakes, chemical spills, terrorist attack, and other disasters. Research has been conducted on the information needs of these populations in such other emergencies. Using the lessons learned for other evacuations can lead to better messages provided by fire alarms.

Studies of human behavior in other emergencies indicate that vulnerable populations will behave differently than the rest of the population during an emergency. These populations received emergency messages through different communication methods, were less likely to evacuate during mandatory evacuations, and were less likely to be prepared for an emergency [3]. Additionally, the risk of death or injury from fire is greater for people that are part of the vulnerable populations [4]. These factors highlight the importance of making sure that vulnerable populations receive effective emergency messages.

This paper will look at the existing literature of how vulnerable populations respond to emergency messages. The vulnerable populations considered will be more than just the traditional visually and hearing impaired populations. Instead, the focus will be on a wide range of people that may experience difficulty in understanding the warnings that are provided.

Vulnerable Populations

People that are part of one or more of the vulnerable populations will be present in buildings where evacuations due to fire are required. In some instances, they may receive the information that they require from people that are around them or the notification appliances that are present.

The traditional horn and strobes are effective at alerting many people that there is a fire and that an evacuation is required. While some of the vulnerable populations need horns and strobes at prescribed levels just to become aware of the need for evacuation, a portion of the vulnerable populations will be aware of them, but will be unable to respond or will understand the actions that they are required to perform. In these instances, voice or text notifications are required and how the information is delivered will make a difference in the response of the individuals.

Visually Impaired

By providing an alarm sound, the visually impaired people have the same notification as other building occupants. The same holds for systems that provide voice messages. The main limitations for this vulnerable population will then lie in navigating the egress system and responding to any text or written messages. Also, any verbal messages that rely on visual cues will be problematic.

Hearing Impaired

Strobes, pillow shakers, and other similar devices are effective at relaying the information that an emergency has occurred. However they lack additional contextual cues. For example, a single strobe does not provide differentiation between the different types of emergencies. Also, any information delivered via voice message will not be delivered. Information that is delivered audibly should also be delivered visually [1].

In addition, it is important to ensure that the information is delivered effectively. For example, during severe weather television stations often have important information scrolling along the bottom of the screen. This is the same location where closed captioning is provided, thus obscuring the scrolling information from the view of people that are hearing impaired [5]. For this reason it is important to consider the context in which the information will be accessed when designing the message delivery system.

Cognitive Disability

There are a wide range of potential cognitive disabilities that could impair the ability of the person to give desired responses to an emergency message. People with cognitive impairments might not recognize cues and/or understand the meaning of them [6]. This could lead to a lack of response or a response that is counter to the desired actions. Furthermore, the startling sounds and presence of strangers can cause negative stress reactions [6]. The increased stress level also has the potential to lead to undesired actions. To meet their needs, messages should be simple and repeated frequently.

Elderly

The effects of aging do not strike all individuals equally. Instead, this vulnerable population can suffer from a range of issues (cognitive, sensory, or both) that can make understanding and following an emergency message difficult.

For the cognitive disabilities, an older person with moderate memory loss could do quite well in their home or other familiar environment, but become disoriented or confused in an unfamiliar location [1]. This confusion could then lead to undesired responses to the alarm. Also, older adults are less able to draw inferences from warnings [7]. This requires that the language used in the message be as simple and direct as possible. Furthermore, they are less able to recall as much information and require messages with relatively few instructions and simple sentences [8]. Repeated, simple messages that provide explicit details of what is required will be most beneficial to this subpopulation.

In terms of sensory perception, background noise can severely limit the ability to understand the message and higher frequencies (above 4 kHz) can be harder to hear [7]. The ability to distinguish sounds with volumes close to ambient levels is typically lower than that for younger adults. For visual alarms, older adults can have trouble perceiving flashing stimuli in the range of 10 to 45 Hz [8]. In each case, the sensory perception of older adults is for a narrow band than the rest of the population.

Children

While children may not have the sensory difficulties of older adults, they can lack the knowledge, confidence, or ability to perform the required actions. It is commonly assumed that children will be with their parents in the event of an emergency and that the parent will ensure that the child is able to evacuate [6]. For example, during evacuation of aircraft, parents have delayed their own evacuation in order to evacuate as a family [9]. However there are many instances where children are separated from their parents. The main limitations here are a lack of familiarity with alarms, the environment, and the threat posed by the emergency. An audible alarm that only provides a tone will not provide sufficient instruction in this case. As with cognitive disabilities and the elderly, repeated, specific instructions will aid in ensuring that the child responds in a more appropriate manner.

Large Groups

Large groups of people present can hinder an evacuation in two ways. First, the primary egress routes could become crowded, prompting some individuals to seek alternate routes. This requires that the notification system be designed to allow people readily learn about what other routes are available. Second, people that do not clearly comprehend the message will follow others. This can lead to people behaving in ways other than they were instructed.

Isolation

For people that are alone, there are additional problems. One of the steps that people take during an emergency is to verify the cues that they are receiving [10]. This confirmation that other people are experiencing the same thing can lead to better responses. People that are alone do not have this ability to seek confirmation from others. For people with disabilities and other vulnerable populations, personal networks are often used for relaying messages [11]. However, if the person is alone in the building or the people assigned to help them are not present, then the reliance on other people could lead to the inability of the person to reach safety. Because of this, messages should convey sufficient information to let the vulnerable population know about what their range of alternative egress routes are.

Unfamiliar with Surroundings

People that are unfamiliar with the building face multiple challenges. First, they must be able to comprehend what the emergency notification means. This could be a matter of being unprimed for the message. Then, after personalizing that the message applies to them, they must be able to react in an appropriate manner. Both of these issues make the people unfamiliar with the building at risk for not being able to effectively evacuate.

The sounding of a horn or the flashing of a strobe do not inherently make a person aware of what needs to be done. Proulx [12] found that the temporal-three signal was not rated as conveying urgency. People must be trained to understand what it means and there are many buildings that are equipped with different sounds. The same effect is seen in warning tones for other disasters (e.g. tsunamis [13]). For notifications that do not rely on voice messages, the only solutions are training the people expected in the building (ideally the public at large) and having a standardized signal. The provisions in NFPA 72 [14] are potentially allowing for the standardization to occur.

Even when people unfamiliar with the building do comprehend the alarm, they then need to be able to know what they are expected to do. For an evacuation, NFPA 101 [15] requires that half of the means of egress discharge through the main entrance for assembly buildings (the type of buildings where it is most likely to have people that are unfamiliar with the building). This is based on the assumption that most people will only know of the entrance that they used to enter the building. If it is desired to have people head to different exits (whether static or dynamic and

through signage, voice messages, or text messages), it is important to deliver the message in terms that the person will understand. Using cardinal directions (e.g. head to the North stair) or names without contextual cues (e.g. head to Stair A) will not be effective for people that are unfamiliar with the building and/or do not have an exact knowledge of their current orientation. Providing instructions centered on the person (e.g. an arrow or instructions to head to the right) or using landmarks (e.g. head to the stair next to the main elevator) can allow people to more effectively navigate their escape route.

Asleep

Sleeping individuals must first be awake before they can comprehend and follow an emergency message. Research has found that certain sounds are more effective. A 520 Hz square wave is more effective at waking people that are asleep [16]. Also, there can be differences in the thresholds required. While older adults were found to require louder volumes while awake, louder volumes have been found to be required to wake young adults [17].

Intoxicated

Similar to being asleep, people that are intoxicated or suffering from similar conditions can have greater requirements in order to respond to the alarm. Alcohol consumption causes people to be more likely to sleep through an alarm [18]. The same is true for people that are sleep deprived [19]. While no studies have looked at compliance to instructions in emergency messages by people that are intoxicated, those responses could be similar to people that have cognitive disabilities.

Non-Native Speakers

Non-native speakers are typically not as fluent in the language the rest of the population. This has several implications for the design of messages. First, written text (when the space is limited and lines are removed to show the remainder of the message) must be displayed long enough for the person to be able to read and comprehend the information. On traffic signs, drivers found 2.0 s an appropriate amount of time to read a message [20]. Second, for audible messages, the ability of the person to recall and follow instructions is less when the message is in the non-native language. While native speakers were found to be able to follow three commands given in a set, non-native speakers were only able to recall and follow two commands [21]. If more commands must be given, the critical components should be at the beginning and end of the message [22].

Word selection in voice messages is also important. In order to improve comprehension, auditory messages should have lower syntactic complexity and be repeated [23]. Also, the non-native speakers can revert to their native language when cognates are given. Thus, false cognates can cause confusion [24].

The environment also plays a role in the ability of non-native speakers to understand the message. The message should be delivered with as little interference as is possible. As with other vulnerable populations, messages should be delivered slowly and with little or no background noise [25].

The findings regarding messages related to non-native speakers presented so far has been based on the assumption that the population understands the language that the message is given in. For people that do not understand the language, alarms relying on language are likely unsuitable [17]. In this case, the reliance on alarms that do not deliver messages are required.

Committed to Task

Some people will not heed warnings because they are committed to their current task. This is likely caused from not yet having personalized the threat to themselves (one of the required steps in responding to an emergency message [10]). They are either calculating that they will have sufficient time to evacuate, do not comprehend the emergency, or view the task more important than their own safety.

In order to help the person understand the amount of time that they have to evacuate and the threat that they are facing, precise and accurate information must be provided. An example would be identifying the location of the fire. Also, repeated information will be beneficial in ensuring that the person understands that the threat is still present.

Situationally Disabled and Mobility Impairments

Situationally disabled people are ones that are not able to completely evacuate on their own. Examples include people that are dependent on medical equipment in their apartment and, people recovering from a mobility injury, people with chronic respiratory or heart problems, women that are pregnant, etc. Some of these people will not be able to leave the room that they start in and others will attempt to evacuate and not be able to reach the exit discharge. While evacuation elevators will enable more of these people to self-evacuate, the code provisions allowing for them have only been added in recent years [26].

For people that are being expected to wait, instructions should be provided about the location of areas of refuge and any other actions that they are required to take to arrive there [4]. Once at the area of refuge, they are expected to wait. Being forced to wait increases the stress level that a person is under [27]. To alleviate the stress and ensure better compliance with the instructions, there are four primary pieces of information that must be provided [26]. First, the source of the message needs to be provided. If the people know that the message is coming from someone that they trust or think is knowledgeable, then they are more likely to comply with the instructions. Second, what actions the people need to take must be provided. For the situationally disabled population, the instructions should be to wait with safe locations for waiting identified as well as alternative options if the first option is no longer viable. Third, the people must be

informed of the cause of the emergency. This will allow them to understand what the risk that they are facing is. Finally, they need to know how long the expected wait will be. The time should be as accurate as possible, but the upper range of the expected time should be provided. Knowing how long is required for waiting helps to ease the stress because there is an end that is identified.

Compounded Effects

The challenges listed above are presented as if a person would have only one of these vulnerabilities. While that may be true for some individuals, it is not true in many instances and this only magnifies the difficulties of the person in receiving emergency messages [28]. For example, consider a tourist. The tourist would likely have to deal with being both a non-native speaker and being unfamiliar with the building [13]. Even if instructions are given that clearly identify which stair is to be used, the words could be spoken too quickly for the individual to comprehend. Similarly, an elderly person may have both diminished hearing and a mobility impairment. A message that addresses a single need will still leave the person with the stress of not knowing what is happening or what they are expected to do. This leads to the need of combining the recommendations for the different vulnerable populations that are expected to be present in the building.

Discussion

The literature regarding fourteen different vulnerable populations and their information needs during emergencies have been analyzed. Some or all of these populations could be found in any building. It is essential that emergency messages be designed to ensure that the entire population is aware of the emergency and the actions that they are required to take.

Several of the findings for different vulnerable populations overlap and could also be beneficial for the general population. For example, both elderly and non-native speakers start to have difficulty when the number of commands exceeds two. Limiting instructions to only two commands would not be detrimental to the rest of the population that could remember more. Recommendations for the different populations include:

- All information should be provided both visually and audibly
- Standard audible and visuals alerts should be used
- Delivery of information should not depend on people being present
- Different means of delivering information should not conflict
- Alarms should be distinct for each type of emergency
- Messages should be simple in terms of both vocabulary and number of instructions
- Message should have most important information at beginning and end
- Messages should be repeated frequently and at a slow pace
- Messages should provide information that is readily accessible to the population

- Messages should be displayed long enough for people to be able to comprehend them
- Messages should provide instructions for all evacuation options for all populations
- Details of the emergency should be provided
- Background noise should be eliminated

The response to other disasters is lacking in all of these areas. During other types of disasters, less than 10 % of emergency managers surveyed reported changing their policies due to concerns for people with special needs [29]. In most cases, there is little consideration given to the information needs of vulnerable populations.

Fire alarms are already incorporating many of these features. Horns and strobes are found in combination and code requires that background noise be turned off once the fire alarm is activated. The rest of the recommendations are typically related to the development of voice and text messages to be delivered. By preplanning message content and delivery, relatively few changes would be required for systems that provide voice and text instructions. In this way, fire alarms are ahead of many other areas for emergency communications.

For systems that rely on just an audible tone or flashing strobe, there is the potential for the vulnerable population to not receive the information that they need during an evacuation. Alarms are a means of notifying people that there is an emergency, but they do not ensure that people can or will take prescribed actions [4]. It may require using alternative delivery methods (e.g. text messages), but those methods would also be beneficial for providing the rest of the population with more information about the nature and scope of the emergency.

The development of messages or delivery methods should not be done without significant consideration of both the technical capabilities of a system and how people will use the system. Members of the vulnerable populations should be included in the planning and disseminating of messages [30]. Also, the messages must be delivered by people that the community trusts [30]. Without these considerations, the intended systems may not work effectively.

When systems are designed that do not ensure that vulnerable populations receive timely and accurate information, the start of their evacuation can be delayed. Vulnerable populations typically benefit by being able to evacuate early [11], so an early start to their evacuation is essential; they should be made aware of the need to evacuate at the same time as the rest of the building occupants.

Conclusions

There are a wide variety of vulnerable populations that are found in all occupancies. The information needs of these populations are often not considered in the design of emergency notification systems for a wide range of disasters. Fire alarms are ahead of other areas in this regard due to their inclusion of both audible and visual alarms. However, without voice or text instructions, members of vulnerable populations may not be able to effectively evacuate.

The different vulnerable populations each have their own diverse needs. This necessitates designing messages that provide information in a manner that most people will be able to comprehend exactly what is expected of them. While each of the vulnerable populations identified have specific requirements, many of the changes benefit multiple.

When designing a system, it is important to consider how the different populations will use it. This necessitates involving members of the different vulnerable populations in the testing process and not assuming that they will use a system as other people would. Some members of vulnerable populations have reported being told to ignore the drill because there was no plan for them to be able to evacuate [11]. In the event of an actual fire, this would not be allowed.

The additional information required by the vulnerable populations will require that emergency messages are well thought out and contain more information. While the intent would be to benefit members of the vulnerable population, all people will benefit or see no difference. More details about the event will not hinder their evacuation nor will ensuring that text is easily readable.

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