NIST Technical Note 1923

Perspectives of Occupants with Mobility Impairments on Fire Evacuation and Elevators

Kathryn M. Butler
Susanne M. Furman
Erica D. Kuligowski
Richard D. Peacock

This publication is available free of charge from:
http://dx.doi.org/10.6028/NIST.TN.1923

National Institute of Standards and Technology
U.S. Department of Commerce

NIST Technical Note 1923

Perspectives of Occupants with Mobility Impairments on Fire Evacuation and Elevators

Kathryn M. Butler
Fire Research Division
Engineering Laboratory

Susanne M. Furman
Information Access Division
Information Technology Laboratory

Erica D. Kuligowski
Fire Research Division
Engineering Laboratory

Richard D. Peacock
Fire Research Division
Engineering Laboratory

This publication is available free of charge from:
http://dx.doi.org/10.6028/NIST.TN.1923

August 2016

U.S. Department of Commerce
Penny Pritzker, Secretary

National Institute of Standards and Technology
Willie May, Under Secretary of Commerce for Standards and Technology and Director

National Institute of Standards and Technology Technical Note 1923
Natl. Inst. Stand. Technol. Tech. Note 1923, 81 pages (August 2016)
CODEN: NTNOEF

This publication is available free of charge from:
http://dx.doi.org/10.6028/NIST.TN.1923

Abstract

Safe evacuation during a fire or other catastrophic event is crucial for the safety of the building's occupants. Since the tragic loss of life in the World Trade Center disaster, efforts have refocused on the provision of safe and efficient evacuation procedures, especially for occupants who cannot negotiate exit stairs without assistance. Several evacuation options have been designed specifically for people with mobility impairments, including occupant evacuation elevators (OEEs). The purpose of this report is to provide guidance to assist designers, facility managers, and fire emergency personnel on how they might improve designs, technologies, and emergency procedures for safer evacuation of occupants with mobility impairments during fire emergencies.

Face-to-face interviews were conducted with 51 participants with mobility impairments working in buildings located in five major metropolitan areas within the U.S. The dual goals in this study were to gain an understanding of how building occupants with mobility impairments evacuate multi-story buildings during fire emergencies and to identify the concerns about using elevators during fire evacuations. To gain insight toward these two goals, the following three main questions were asked:

1. How do participants describe their everyday mobility while at work?
2. What experiences have the participants had during fire drills or fire emergencies while at work?
3. What do participants currently think about using elevators as a means to evacuate a building during a fire evacuation?

The results of this study lead to guidance on evacuation planning and procedures, the use of existing elevators for evacuation of people with mobility impairments, and the use of occupant evacuation elevators. This guidance highlights the importance of reducing anxiety about fire evacuation and increasing trust in the occupant evacuation elevator system via a variety of means, including education and consultation in preparation for the evacuation, information and attention to occupant needs while the evacuation is taking place, and two-way feedback and discussions afterwards. Key to all of these issues is the need to include those with mobility impairments in the planning and execution of fire evacuations and to facilitate their ability for self-evacuation as much as is practicable.

Keywords: fire evacuation, elevators, people with mobility impairments

Executive Summary

Natural or human-influenced disasters can have devastating consequences for individuals in multi-story buildings, including injury or loss of life. Safe evacuation during a fire or other catastrophic event is crucial for the safety of the building's occupants. The World Trade Center (WTC) disaster in New York City on September 11, 2001, where more than 2 000 building occupants perished, provided important lessons on the evacuation of multi-story buildings, including evacuation procedures and practices, initiation and length of time for evacuation, and the effects of building construction and technical conditions on evacuation.

Since the tragic loss of life in the WTC disaster, efforts have refocused on the provision of safe and efficient evacuation procedures, especially for occupants who cannot negotiate exit stairs without assistance. Several evacuation options have been designed to address people with mobility impairments, including occupant evacuation elevators (OEEs). The International Code Council (ICC) and the National Fire Protection Association (NFPA) provide requirements for the use of elevators for both occupant evacuation and fire fighter access into tall buildings. To support the development of these codes and standards, previous research on elevators, performed at NIST and elsewhere, has primarily focused on the technical aspects of ensuring safe and reliable evacuation for the occupants of tall buildings. However, little guidance is currently available on how occupants, particularly those with mobility impairments, can most effectively evacuate buildings during fire emergencies. There is a need for research on the ways in which elevator technologies could be appropriate and should be considered for evacuation.

To address this gap, face-to-face interviews were conducted with 51 participants with mobility impairments working in buildings located in five major metropolitan areas within the U.S. The causes of mobility difficulties for the participants included congenital conditions, progressive diseases, and injuries, and the vast majority use wheelchairs at work. The dual goals in this study were to gain an understanding of how building occupants with mobility impairments evacuate multi-story buildings during fire emergencies and to identify the concerns about using elevators during fire evacuations. To gain insight toward these two goals, the following three main questions were asked:

1. How do participants describe their everyday mobility while at work?
2. What experiences have the participants had during fire drills or fire emergencies while at work?
3. What do participants currently think about using elevators as a means to evacuate a building during a fire evacuation?

A qualitative approach was chosen to carry out this research project. The goal of qualitative research is to uncover the range of behavior of a group of people related to some topic or issue and to understand the thoughts and emotions that drive the behavior.

During the interviews, participants were asked about their experiences with building evacuations and evacuation training, their comfort level and concerns regarding the evacuation options with which they were familiar, and their thoughts about the use of elevators for evacuation during fire emergencies. The semi-structured interview protocol consisted of a list of basic questions to be covered by the interviewer plus optional probing questions to draw out more detailed information and encourage the recounting of anecdotes. The questions included demographics, background information on the workplace and on mobility issues, and in-depth questions on everyday activities, fire evacuation experience, fire evacuation procedures and training, and fire evacuation by elevator. Near the end of each interview, participants were shown a short video describing technical and operational improvements in the development of OEEs that could allow OEEs to be implemented for evacuation. After the video, participants were asked for their comments.

Results of this study provided insight on participants' evacuation experiences, perspectives on existing evacuation methods, experience with evacuation plans and training, and perspectives on the benefits of and concerns with OEEs. Overall, this study identifies a wide range of issues surrounding the evacuation of occupants with mobility impairments.

A variety of evacuation experiences were described by the participants, some of which are briefly summarized in the report. Characteristics of evacuations that left participants with a positive feeling about the experience included continuing communication about the situation and the efforts that were being made on their behalf, planning that included the input of the participant, regular training on what to do in an emergency, authoritative leadership during the event, appropriate assistance from a familiar colleague or respectful assistance from firefighters and building management staff, and rapid and safe evacuation from the building. Experiences that were recalled negatively were those in which participants were left isolated, treated more carelessly (in a physical way), provided with conflicting information, or simply provided with little or no communication. Overall, participants expressed a preference for self-evacuating the building rather than waiting for assistance for some period of time.

Participants also provided their perspectives on the benefits and their concerns with evacuation strategies/methods they experienced at their workplaces with which they were familiar. These strategies/methods included using existing passenger elevators; using freight or service elevators; using emergency stair travel devices; walking, crawling, or sliding on the stairs; negotiating the stairs in a wheelchair; being carried down the stairs; or using areas of refuge.

While there are positives and negatives associated with each evacuation strategy/method described above, the following important characteristics of beneficial evacuation strategies/methods for people with mobility impairments emerged:

- the strategy/method selected provides a feeling of safety,
- the strategy/method selected provides independence and control,
- the strategy/method selected allows the person to remain with their wheelchair or other mobility aid,

- the strategy/method selected provides a means to evacuate quickly, and
- the strategy/method selected provides a means for communication with security and/or rescue personnel.

In response to the questions on what they are supposed to do in a fire emergency and whether they had received any type of training on evacuation procedures during fires, study participants reported a wide range of evacuation plans and training – from none at all to regular discussion and practice. An interesting finding from these discussions was the number of participants who admitted to having an alternative evacuation plan in mind. Additionally, it was noted that many participants admitted that they would rather avoid fire drills because of the physical discomfort and stress of participation even if warned in advance. One of many possible remedies to this is to include people with mobility impairments in the entire emergency planning process, from beginning to end.

Finally, participants were asked their opinions and perspectives about using OEEs for evacuation, including benefits, concerns, and recommendations for improving the design, after seeing a video highlighting the design features of these systems. The video on OEEs presented several features that addressed the safety and anxiety issues associated with waiting for and using existing elevators for fire evacuation. This includes protection against heat, smoke, and water from fire suppression, communication, and direct transport to the exit floor. In addition, people with mobility impairments can evacuate at the same time as everybody else, using the same elevator they use to enter and exit the building during their normal workday (which has been designated an OEE) while remaining in their mobility device. Participants identified the benefits of OEE's as providing safety, feelings of comfort or relief, communication capabilities, speed, independence, and efficiency. Remaining concerns included continuing anxiety about physical danger, policy issues such as priority evacuation for those with disabilities, and certain aspects of elevator design that were not addressed in the video. The past understanding that elevators must never be used in a fire emergency will need to be countered by explanations showing that the design of OEEs makes them safe to use in a fire.

The results of this study provide input to the development of guidance on the use of elevators for people with mobility impairments. This guidance is intended to assist designers, facility managers, and fire emergency personnel to improve designs, technologies, and emergency procedures for safer evacuation of occupants with mobility impairments. Specific insight is provided on evacuation planning and procedures, the use of existing elevators for evacuation of people with mobility impairments, and the use of occupant evacuation elevators. This research highlights the importance of reducing anxiety about fire evacuation. Trust in evacuation procedures, including the use of elevators in appropriate applications, can be increased through education and consultation in preparation for the evacuation, information and attention to occupant needs while the evacuation is taking place, and two-way feedback and discussions afterwards.

Key to all of these issues is the need to include those with mobility impairments in the planning and execution of fire evacuation strategies/methods used and to facilitate the ability for self-evacuation by people with mobility impairments as much as is practicable.

Table of Contents

Figures

Tables

Perspectives of Occupants with Mobility Impairments on Fire Evacuation and Elevators

Kathryn M. Butler, Susanne M. Furman, Erica D. Kuligowski, and Richard D. Peacock

National Institute of Standards and Technology

1 Introduction

> "If you make a good design for everyone, then *everyone* will be happier." (Participant AO[a])

> "With the time it takes to get me out of the wheelchair into the stair chair [and] get me down the steps – just the process involved and then the time, and then the danger of doing that to me and the people that are trying to help me – going down the elevator is a way, way better way to do it if it can be done." (Participant CA)

Natural or human-influenced disasters can have devastating consequences for individuals in buildings, including injury or loss of life. Safe evacuation during a fire or other catastrophic event is crucial for the safety of the building's occupants. Since passage of the Americans with Disabilities Act (ADA) of 1990, multi-story buildings have become more accessible to people with disabilities [1]. Improved design, technology, and procedures assist building designers, planners, and managers in minimizing any added risks during catastrophic events that are faced by occupants due to their disabilities.

The evacuation of people from buildings during fire or other emergencies has been of interest since the early 1900s [2]. The study of human behavior eventually began to more fully consider the needs of people with disabilities, including mobility impairments [3]. Development of high-rise[b] buildings added a new imperative to providing effective avenues for emergency evacuations. Therefore, the evacuation strategy/method chosen for multi-story buildings must incorporate a means to safely evacuate all building occupants, including people with mobility impairments.

[a] Study participants were assigned individual tracking identifiers. The two-letter code assigned to each participant does not indicate building, city, or any other identifying information.

[b] A high-rise building is defined here as a building with 7 or more stories above grade. This is generally consistent with the NFPA 101 Life Safety Code definition of high-rise as 75 feet (23 meters) in height, measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story.

One of the nation's largest evacuations occurred at the World Trade Center (WTC) in New York City on September 11, 2001. More than 2 000 building occupants perished in the disaster. An investigation of the events preceding the collapse of the building was carried out by the National Institute of Standards and Technology (NIST) [4], resulting in a list of recommendations to improve the safety of high-rise buildings, their occupants, and emergency responders. The Final Report recommended that tall buildings be designed for timely full-building evacuations during building-specific and large-scale catastrophic events [5].

The 2001 WTC disaster provided important lessons on the evacuation of tall buildings. In addition to the NIST investigation, several other studies have looked at evacuation procedures and practices, initiation and length of time for evacuation, and the effects of building construction and technical conditions on evacuation [6] [7] [8]. In the WTC, traveling on the stairs challenged occupants with certain conditions, such as wheelchair use, pregnancy, asthma, visual impairment, physical impairment, obesity, arthritis, and old age. About six percent of the WTC survivors described themselves as having some mobility impairment that slowed their evacuation. The most commonly reported mobility impairments included recent pre-existing injuries, medications, or medical treatments, while a small number were pregnant, elderly, or used a wheelchair. During the 2001 evacuation, almost half of the occupants interviewed in the NIST Investigation noted that injured and disabled occupants were a constraint to evacuation. However, it is also true that many occupants were quick to aid these individuals or to simply move aside to let those injured and others in need pass by. Some survivors reported occupants with mobility impairments who were waiting on the stairs or landings for others to help them or to be rescued by the fire department. The NIST Investigation showed that having a mobility impairment or assisting someone who did were among the factors that increased the likelihood of death in the WTC disaster. Despite this, many occupants and emergency responders risked their lives assisting colleagues with mobility impairments who successfully evacuated. [5].

Since the tragic loss of life in the WTC disaster, engineering efforts have refocused on efficient evacuation procedures, especially for occupants who cannot negotiate exit stairs without assistance. Several evacuation strategies/methods have been designed to address people with mobility impairments, including emergency stair travel devices, areas of refuge, and occupant evacuation elevators (OEEs) [9]. Emergency stair travel devices permit assistants to transport someone down (or up) the stairs, either by guiding the device (if in contact with the stairs) or by carrying it. They are sometimes referred to as evacuation chairs or stair chairs. An area of refuge is a location within the building where a person can safely wait for evacuation assistance. OEEs are elevator systems designed to enable safe occupant evacuation during fires [10].

Both emergency stair travel devices and areas of refuge pose some potential problems from the evacuee's perspective. Transferring into the emergency stair travel devices

means giving up the independence granted by the person's mobility aid[c] and relying on the help of others during the evacuation process – possibly longer if the mobility aid is left behind. And in at least one incident, emergency stair travel devices were found to have slowed down evacuation speeds of others using the same set of stairs [5]. Researchers have studied attitudes toward areas of refuge and found that many respondents were uncomfortable with the idea of remaining in them for more than 10 minutes without assistance. They expressed concerns about being forgotten, not knowing how long they would have to wait, and being isolated [11].

A more promising means to improve evacuation capability of people with mobility impairments, at least in new construction, is the OEE. Simulation studies with a mix of occupants have shown that the use of elevators improves evacuation times and allows people with mobility impairments to evacuate at the same time as other occupants [12]. OEEs allow people with mobility impairments to self-evacuate, with their mobility aids and without depending on the assistance of others. While many of the technical challenges regarding the safe use of elevators during evacuations have been overcome, others are still being addressed [9].

For occupants to actually use OEEs during a fire evacuation, they must perceive the OEE to be a safe option. For decades, people have been educated that elevators are not acceptable evacuation paths during a fire emergency. Studies on attitudes of employees and members of the general public toward using elevators for fire evacuation suggest that countering this message and convincing people that elevators are safe to use may be the larger part of the challenge [13] [14]. Note that these studies do not specifically address people with mobility impairments, whose response may be different.

In recent years, several projects have been established to improve occupant safety during fire evacuation of tall buildings. One of these projects is to examine the use of elevators for occupant evacuation. The International Code Council (ICC), the National Fire Protection Association (NFPA), and the American Society of Mechanical Engineers (ASME) have developed requirements for the use of elevators for both occupant evacuation and fire fighter access into buildings [15] [16] [17]. To support the development of these standards, research on elevators by NIST and others has primarily focused on the technical aspects of ensuring safe and reliable evacuation for the occupants of tall buildings. Limited data or understanding is available on how occupants, particularly those with mobility impairments, can most effectively evacuate buildings during fire emergencies. There is a need for research on the ways in which elevator technologies could be appropriate and should be considered for fire evacuation.

Numerous social, organizational, and human factors challenges remain for self use of elevators during evacuations. Additional research is needed on the question of how building occupants will respond to using elevators during fire emergency evacuations.

[c] A mobility aid is a device designed to assist an individual in moving from one location to another. Examples of mobility aids include manual and power wheelchairs and scooters, walkers, crutches, and canes.

This question is particularly pressing for the population that may benefit the most from this option. What are the perspectives of occupants with mobility impairments on using elevators during the fire evacuation process?

The focus of this paper addresses part of that research need: 1) to gain an understanding of how building occupants with mobility impairments currently evacuate multi-story buildings in the United States during fire emergencies, and 2) to learn about the concerns of persons with mobility impairments with using elevators during fire evacuations. The results can assist architects, engineers, and facility managers to further improve evacuation strategies/methods and the experience for those with mobility impairments, including the use of elevators designed for safe evacuation.

2 Methodology

A qualitative approach was chosen to carry out this research project. The goal of qualitative research is to uncover the range of behavior of a group of people related to some topic or issue and to understand the thoughts and emotions that drive the behavior [18]. This is accomplished through in-depth study of a small group of people using methods such as interviews, direct observation, and analysis of archival data [19]. The results of qualitative research are descriptive rather than quantitative.

The dual goals in this study were to gain an understanding of how building occupants with mobility impairments evacuate multi-story buildings during fire emergencies and to identify the concerns about using elevators during fire evacuations. To gain insight toward these two goals, the following three main questions were asked:

1. How do participants describe their everyday mobility while at work?
2. What experiences have the participants had during fire drills or fire emergencies while at work?
3. What do participants currently think about using elevators as a means to evacuate a building during a fire evacuation?

2.1 Data Collection

In-depth interviews were conducted by NIST researchers with 51 participants with mobility impairments. All interviews were carried out in person between May 2014 and June 2015, in locations that allowed for private conversation. The duration of each interview was typically between one and two hours. The format was semi-structured, with a set of brief background questions followed by open-ended questions that allowed the flexibility to follow the participants' leads during the interviews. More details about the interview questions are provided in Section 2.2.

Although the data obtained using this approach covered the same topics for all participants, the amount of information collected on each topic varied widely. Each participant was encouraged throughout the interview to elaborate on their thoughts. This resulted in the rich and detailed stories that provided some of the most illuminating insights.

The research instrument was piloted with a small group of participants in order to ensure the clarity and validity of the questions. The interview questions successfully elicited the desired information, so only minor changes were made to the protocol after the pilot study. As a result, these initial interviews were incorporated into the main study.

As the interviews were completed, an independent contractor transcribed the audio recordings into data files. For the small number of interviews that were not audiotaped, the interviewer wrote extensive field notes.

2.2 Interview Questions

During the interviews, participants were asked about their experiences with building evacuations and evacuation training, their comfort level and concerns regarding the evacuation options with which they were familiar, and their thoughts about the use of elevators for evacuation during fire emergencies. The semi-structured interview protocol consisted of a list of basic questions to be covered by the interviewer plus optional probing questions to draw out more detailed information and encourage the recounting of anecdotes. The questions included demographics, background information on the workplace and on mobility issues, and in-depth questions on everyday activities, fire evacuation experience, fire evacuation procedures and training, and fire evacuation by elevator. Near the end of each interview, participants were shown a short video describing technical and operational improvements in the development of OEEs that could allow OEEs to be implemented for evacuation. After the video, participants were asked for their comments.

The requested demographic, workplace, and mobility information is shown in Appendix A. It consisted of:

- Demographic questions: Age category, gender
- Workplace information: Number of stories in the building where the workplace is located, floor(s) worked on, length of time that they have been working in the building
- Mobility information: Method of vertical movement throughout the building, ability to go up and down stairs during a normal day using a mobility aid and without assistance from another person, type(s) of mobility aid used in the workplace, length of time that they have been using a mobility aid, need for assistance during a fire evacuation

Open-ended interview questions requested information on everyday workplace activity, fire evacuation experience, procedures, and training, and elevator use. The questions, listed in Appendix B, asked for details on the following:

- Everyday workplace activities: Normal pattern of movement at work
- Fire evacuation experience: Fire alarm, response, method and timing of evacuation, assistance, concerns, problems, issues
- Fire evacuation procedures and training: Fire evacuation plan, type and frequency of training, degree of satisfaction with training, fire drill experience
- Fire evacuation by elevator: Thoughts about using the existing elevators (including the freight elevator) in an emergency, including benefits, concerns, and ideas regarding changes in procedure or design; thoughts (following the video) about using OEEs, including benefits, concerns, and ideas regarding changes in procedure or design

Although the interview questions specifically asked about fire evacuation procedures and training, the participants also volunteered information about their experiences in other emergency situations. This resulted in a considerable amount of information on the

benefits and concerns associated with various evacuation strategies/methods, which is presented in Section 5.

The video about the design features of OEEs highlighted the following features [20]:

- Programmable elevator lobby signage, including time to next car
- Direct access to stairwells from elevator lobby
- Elevator lobbies and shafts that are protected from heat and smoke
- Priority elevator service from the fire floor to the main lobby
- Water kept away from elevator components
- Two-way communication between the lobby and fire command center

Because this study was focused on the perspectives of building occupants, independent confirmation of building design and policies were not sought.

2.3 Qualitative Analysis

The purpose of the analysis phase of a qualitative study is to organize the information from the interviews and develop insights. An organized list of themes – a coding structure – was developed based on the data. Narratives and statements from each interview were collected under the appropriate code, and the contents under each code were analyzed for common and individual elements.

The analysis phase of this study began after all interviews had been completed. The first step was to import all interview transcriptions and notes into NVivo 10 for Windows. NVivo is a software platform that provides tools to collect, organize, and analyze qualitative source materials. All coding and analysis for this study were carried out using this qualitative analysis tool.

After the researchers on the project team completed reading the full set of transcriptions, an initial *a priori* code list based on the research questions was constructed. The team discussed and refined the codes in multiple meetings. In these meetings, each code was operationalized, such that its definition distinguished it from other concepts and allowed interview text to be assigned under it with as little ambiguity as possible. Issues regarding the usage of each code were identified and resolved, and the effectiveness of the entire code set in categorizing the full range of data of interest was assessed. Examples were developed for each code to help maintain coding consistency across researchers. The final set of codes, along with their operationalized definitions and examples, are given in Appendix C.

Once agreement had been reached on the code list, two researchers individually coded the entire set of interviews. Each coder went through the transcript or notes for each interview carefully, assigning the text to codes as relevant. Some text was assigned to multiple codes; some text was not assigned to any specific code. Some codes, particularly those that related directly to basic questions, received text from every interview, but other codes were addressed by only a subset of participants.

At the end of this process, material had been collected under each code. When accessed in NVivo, each individual code displayed the text listed under the code, the interview from which each text was taken, and the researcher who had coded it. A brief review of the results indicated that the teamwork on developing a consistent coding process had resulted in considerable overlap between the researchers, as designed. The remaining differences in coding were ignored – material that had been assigned a code by only one of the two researchers was treated the same as material assigned the same code by both.

The material under each code could now be further analyzed. At this point, some codes were ready for a systematic exploration of the issues that were common across many participants, as well as issues that were important to only a few or only under certain circumstances. Other codes required development and operationalization of subcodes in order to further separate the material into appropriate categories, thus reducing the complexity of a large amount of text to a manageable level. The subcodes included the various evacuation methods discussed by participants and the benefits, concerns, and recommendations regarding using elevators for evacuation. Appendix D displays the subcodes, along with their operationalized definitions.

Material collected under concerns and recommendations was particularly useful in developing the guidance presented in Section 8 in this report.

To assist with the analysis, data was organized into a spreadsheet by participant. Summaries were developed for various categories, including demographic and disability information; evacuation experiences, plans, and training; and attitudes toward various evacuation options. The spreadsheet facilitated the determination of themes that were common across many participants, as well as those that were more dependent on individual situations. It also assisted with the selection of relevant experiences for this report and in finding quotes that provided the desired range of viewpoints.

The following section describes the sample of people who participated in this study, including their demographics, geographic location, disability status, and other important participant characteristics.

3 Participants

NIST researchers recruited participants from major metropolitan areas in five different U.S. geographical areas with the assistance of advocates for the disability community. Disability advocates from each metropolitan area were identified through a chain of referrals and asked if they would be willing to help with recruitment. NIST researchers worked with the disability advocates to identify potential participants. NIST researchers then contacted each potential participant via email or phone to describe the purpose and goals of the study and request his or her participation. Interested individuals were scheduled for a face-to-face interview with NIST researchers. To be eligible, individuals were required to be at least 18 years of age and to have experience with either a permanent or temporary mobility impairment during evacuations using stairs. Participants with a range of mobility impairments were sought.

The focus of the study was on workplaces located in multi-story buildings. Although the initial thinking was to recruit most heavily from occupants working in tall buildings, 14 stories and higher in height, it became clear from the initial interviews that a single flight of stairs, and in many cases a few steps, were enough to limit the evacuation options of the participants.

3.1 Number and Demographics

Fifty-one participants took part in the study. Of those, 27 were male and 24 were female, with ages ranging from mid-20s to over 60 years. The distribution over age groups is shown in Table 1. Age and sex distributions are illustrated in Figure 1.

Table 1. Age distribution of participants

Age Range (years)			
26 to 35	**36 to 45**	**46 to 55**	**56+**
10	14	11	16

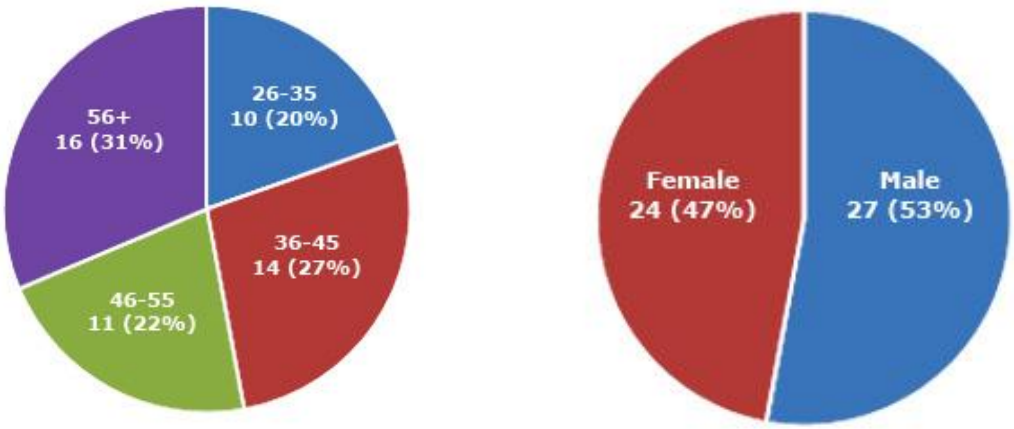

Figure 1. Age and sex distributions of participants

3.2 Geographic Areas

This recruitment method provided access to participants from different urban settings and different regions in the United States. The distribution of participants over five U.S. geographic areas is shown in Table 2 and Figure 2.

Table 2. Geographical distribution of participants

U.S. Region	Total # Participants
Southeast	9
Northeast	8
Midwest	9
West	10
Southwest	15
Totals	51

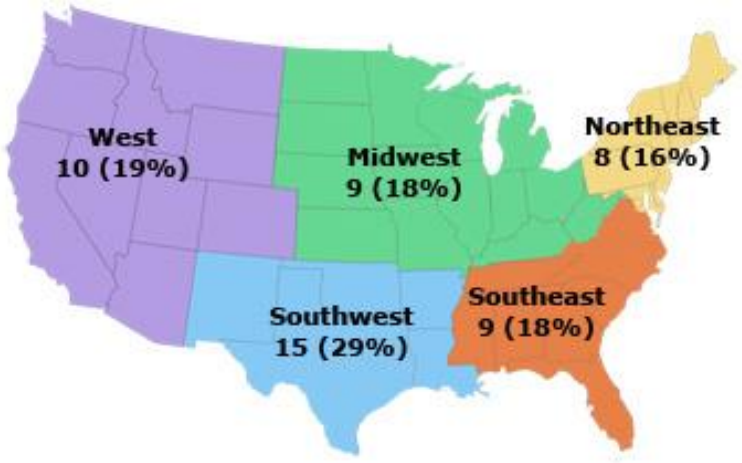

Figure 2. Geographical distribution of participants

3.3 Disability Status

The study protocol did not include questions about the nature of the disability, but many participants volunteered information about the cause of their mobility difficulties. The range was broad and included congenital conditions, progressive diseases, and injuries. Sixteen participants had used a mobility device to help them get around since early childhood. The range of capabilities in areas other than mobility was also broad. Several participants described limitations in their ability to press buttons with their fingers due to lack of strength or inability to reach. Others have weaknesses in core muscles, brittle bones, fragile skin, or problems with dizziness that make injury a real possibility if they are lifted by a person unfamiliar with their specific needs. For many, their capabilities have declined with time as the condition has progressed or as they have gotten older.

Conversely, the upper body strength for some is sufficient to allow them to control their (lightweight) wheelchairs on the stairs, or to allow them to pull themselves up or down the stairs. Thus, making assumptions about their capabilities and strengths from their appearances may be misleading.

In general, the study participants held a variety of attitudes toward the building evacuation strategies/methods implemented within their workplace. While many had trust in the assistance offered by their coworkers, facility management staff, and first responders, others were concerned about gaps in evacuation plans and difficulties during actual building evacuations. Many of these accomplished individuals expressed strong opinions about their desire for independence. The participants appreciated this opportunity to document their range of experiences.

3.4 Mobility Aids

The participants used a variety of mobility aids at work. As seen in Table 3, the vast majority (42 participants) used wheelchairs at work, evenly divided between power and manual wheelchairs. Our discussions also included people using crutches, canes, walkers, scooters, and a portable oxygen supply. One participant had a service dog that fetched items, steadied the owner, helped with transfers onto chairs and beds, and drew attention when help was needed.

Table 3. Mobility aids used by participants at work

Wheelchair (Power / Manual)	Crutches	Cane	Rollator / Walker	Scooter	Other
42 (21 / 21)	5	4	3	2	4

The sum of the number of mobility aids in Table 3 is greater than 51 because several participants used more than one aid while at work. Some kept an additional mobility aid at work with the thought that it would be useful in an emergency evacuation. Crutches can be used to walk down the stairs, and manual wheelchairs can be carried by a coworker when the power wheelchair is left behind. The selection of mobility aid may vary during the day depending on the range of travel within the building or a need to conserve energy.

About a quarter of participants had used a mobility aid since early childhood. Others started to use a mobility aid at a later age, due either to the progression of a medical condition or to an accident. Many had changed the type of mobility aid over time.

Participants were asked if they required assistance during fire evacuations. About 75 % of the participants answered that they ‘always’ need assistance during fire evacuations. Among the rest, five worked on the ground floor and could leave easily on their own. The others responded that their need for assistance depends on the circumstances.

3.5 Workplaces

Participants in this study worked in buildings that were owned and managed by various organizations. These included city, state, and federal government buildings, school facilities, commercial office buildings, health care facilities, and non-profit centers. Some buildings were iconic and others were nondescript, with heights ranging from two stories to well over sixty stories in height. (Vertical locations of participants' offices within these buildings are discussed in Section 3.6). Many participants stated that emergency policies and procedures were set building-wide by the entity that owns the building or by a professional facility management firm that manages the building's day-to-day operation and maintenance. In some cases, participants were unaware of any building emergency evacuation procedures but were only aware of the emergency evacuation procedures set by their own organization within their workplace. A small number of participants did state that they had been consulted on the emergency evacuation procedures for their building; however, this question was not part of the interview protocol.

The method of recruitment used in this study led to many interviews with people who worked for governmental agencies and disability advocacy groups. This influenced the types of buildings that are represented here. As shown in Table 4 and Figure 3, more than half of the participants worked in government buildings. Most of the others worked in commercial buildings, with a few working in buildings owned and run by non-profit agencies. It was not possible to identify the primary building for a couple of participants; these are the two labeled as N/A, for not applicable, in the data.

Table 4. Ownership of buildings in which participants work

Federal	State	City	Commercial	Non-profit	N/A
8	3	18	16	4	2

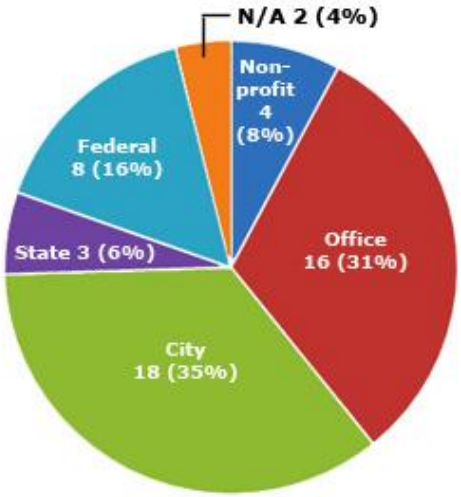

Figure 3. Ownership of building in which participants work

Discussions with participants included current and previous workplaces. Many participants had jobs in which they traveled regularly to other locations within the community, so they were also able to provide us with perspectives from the viewpoint of visitors to an unfamiliar building.

3.6 Locations within the Workplace

Each participant identified the floor on which he or she spent most of their time while in the building. Usually this was where his/her office was located. It should be noted, however, that many participants described an active workday during which they traveled up and down through the building for meetings, discussions, and work breaks. This means that an emergency could occur at a time when they could be located on a floor other than where their office was located (see Figure 5).

Table 5 and Figure 4 show the floors on which participants are primarily assigned to be located during their daily activities. As noted, these locations are widely distributed vertically throughout a multi-story building. For example, Table 5 identifies five participants that work on the ground floor. If the emergency occurs while they are in their office, they are able to exit the building directly without needing to move vertically. However, Table 5 also identifies three participants working on the basement level that would need to ascend at least one flight of stairs during an evacuation. The rest of the participants work above the ground floor and must descend at least one or more flights of stairs to reach safety during an evacuation. The discussions made clear that for many, in the absence of an elevator, traversing a single flight of stairs either in an upward or downward direction provided as much of a barrier to independent movement as traversing a dozen flights of stairs. Almost all of the participants depend on elevators to travel vertically within their workplaces on a daily basis.

Table 5. Floors on which participants work

Floor								
Basement	**Ground**	**2**	**3**	**4-5**	**6-8**	**9-13**	**14-35**	**N/A**
3	5	6	8	9	7	5	6	2

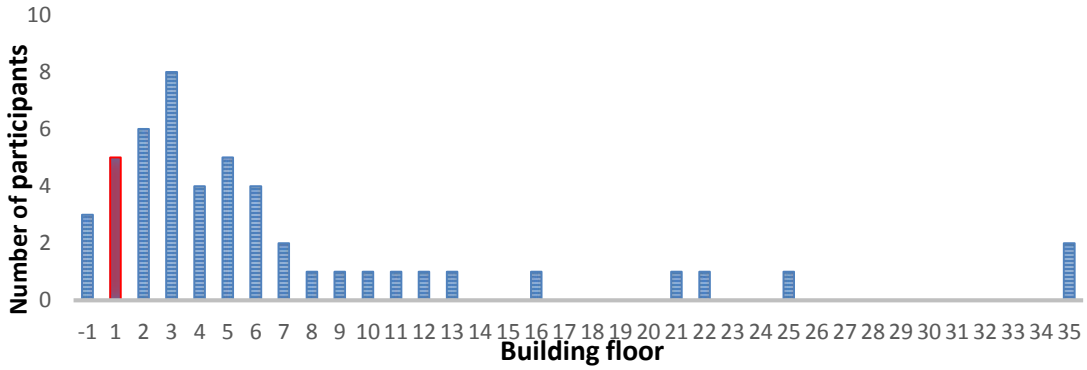

Figure 4. Floor on which each participant works

The location of each participant within their building is shown in Figure 5. In this plot, buildings are arrayed by height given in number of stories. Under each building icon is the number of buildings at that height. Each person is represented by a yellow square located at the appropriate floor within the building icon representing the height of his or her building. People whose primary location is at the basement level are positioned below the base of the plot.

The building heights used in this plot are the number of stories reported by the participants, unless the participant was uncertain of the building height and the guess was inaccurate by more than a few stories.

3.7 Building Accessibility

The ADA Standards for Accessible Design [21] and the Architectural Barriers Act Accessibility Standard (ABAAS), the equivalent of the ADA for federal facilities [22], set minimum requirements for new construction and renovations of government facilities, public accommodations, and commercial buildings. The intent is to allow people with disabilities to readily access and use these facilities. Among the many building features covered by the accessibility standards are entrances, passageways, elevators, exit stairs, and restrooms. When asked about their everyday activities, many study participants expressed satisfaction with their workplaces. However, a considerable number of study participants related difficulties in travelling throughout the workplace. Concerns that may affect their ability to evacuate without delays included doors that were too heavy to open effortlessly and existing elevator call buttons and floor selection buttons that were too high or too hard to press.

Doors in the means of egress continue to be a workplace issue for occupants with mobility impairments. Heavy doors without automatic openers require some participants to call on assistance from security guards, coworkers, or passers-by. When doors are locked outside of normal business hours, access becomes a problem for those whose work or commuting schedules require them to arrive early or stay late. Participants also reported that automatic door openers sometimes break, especially when they are heavily used.

One of the study participants explained his/her situation this way:

> “I'm parked outside. I get in the elevator, go upstairs to the lobby and go right back out to those heavy doors. And, pushing it outward is heavier than on the outside opening it because opening from the outside, the way it swings outward towards me, there's a maneuver that I use that I just throw it open, and it's because of the position that I'm in and the amount of years that I've been doing it. From the inside, I can't position myself that way, I'm pushing out, so it's harder going out than going in.” (Participant (AA)

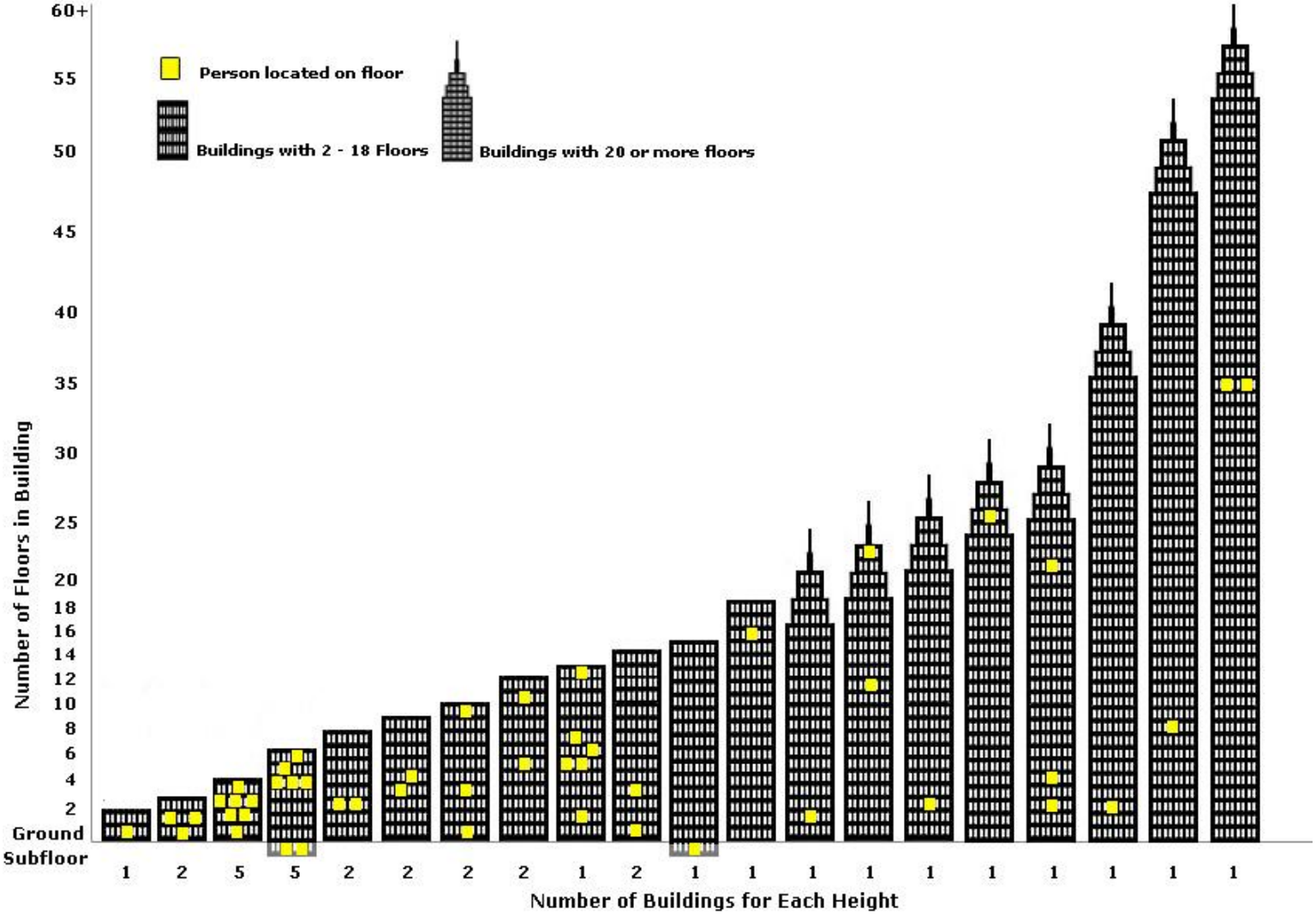

Figure 5 Locations of participants within their buildings

Existing elevator call buttons and floor selection buttons are another area of difficulty for some people. Those with muscle weaknesses or limitations in arm or hand movement may have difficulty in reaching the desired button and pressing it. Some study participants described relying on security guards or on others in the elevator to press the button for their floor. If they are alone, they wait for assistance or maneuver themselves with effort to reach the button.

> "The buttons in the elevator are also hard for me to reach…especially reaching up to four is hard. And if there's a day that I'm feeling more tired, that's an issue, and it's kind of like in the corner, so I often come at a time when there's other people in the elevator and I'll let them push the buttons. But yes, at night I do it. So I just sort of have to get positioned just right and make sure I have my hands free." (Participant AI)

Despite these issues with accessibility in the workplace, most participants were satisfied with how their needs were accommodated. Design features that won extra praise included strike plates for automatic door openers that could be pressed by either a foot or a hand, doors that swing open automatically on approach, elevator buttons positioned low enough for a wheelchair user to reach easily, elevators that open on two sides to allow wheelchairs to drive through rather than turn around, and ramps to get from one level to another. Special parking arrangements make commutes easier, especially in bad weather. Many participants expressed their gratitude that building management had been responsive to their needs and had readily made changes that maintained their health, improved their comfort, and helped them to accomplish their tasks.

4 Evacuation experiences

During the interviews, study participants were asked about their experiences with building evacuations during a fire or other emergency incidents. For every experience that came to mind, they were asked to talk about the fire alarm audible messages and other emergency audible messages, their response to the notification, the evacuation itself, and aspects of the evacuation that did or did not work for them.

Evacuating a building during an emergency situation is always a stressful experience. However, if emergency egress and relocation drills are held with sufficient frequency to familiarize all occupants, including persons with mobility impairments, with the evacuation plan and procedures, an evacuation can become routine in nature and leave a positive impression, strengthening the confidence of occupants that the evacuation plan and emergency procedures will keep them safe. Conversely, not conducting emergency egress and relocation drills can contribute to erosion of trust. Negative experiences and low levels of trust can affect management of occupant actions during future emergencies, as will be discussed later in this report.

Section 4.1 describes some of the evacuation experiences related by the study participants during their interviews. The factors that were associated with a generally positive experience are discussed in Section 4.2, and those that resulted in negative experiences are presented in Section 4.3.

4.1 Experiences

Half (26/51) of the study participants reported that they had experienced a building evacuation during an emergency incident at some point during their lives. An additional eight people had been in emergency situations but had not evacuated – either they had sheltered in place or the all-clear was sounded before they had a chance to evacuate. Almost all participants without these direct experiences were able to describe their participation in an emergency egress and/or relocation drill (e.g., fire drill), during which they at least talked through the procedures to be followed.

Among the experiences described by participants in emergency situations were the following scenarios:

- After the fire alarm sounded, the participant and coworkers quickly secured the area and calmed customers as they had been taught in regular drills, then made their way down the stairs. (Participant CO)
- During a power failure, firefighters rigged a pulley system to evacuate the participant down the stairs in his/her wheelchair. The participant first directed the breakdown of the chair so that items such as the heavy battery could be carried separately. (Participant AN)

- Security personnel directed people with mobility impairments to evacuate via the freight elevator. This was not the standard protocol, but people were happy to obey orders to get out quickly and easily. (Participant BV)
- A grease fire started in the workplace kitchen early in the morning. Members of upper management quickly assembled the few people who were available at that hour, who were not part of the regular team of assistants, to evacuate the participant by emergency stair travel device. (Participant BJ)
- An elevator broke, leaving several people with mobility impairments stranded in a theater basement for up to three hours. Everyone was eventually evacuated with their equipment by police, using methods that were specific to each individual after respectfully asking how each wished to be helped. (Participant CM)
- An earthquake occurred during a training session in an unfamiliar building. The participant was isolated while everyone else left the room. The elevator was still in operation and the person was able to evacuate on his or her own. (Participant CP)
- When a fire alarm sounded on a high floor, people with mobility impairments were told to stay where they were. No information was provided about the emergency, and those in authority gave conflicting directions. They were never evacuated. (Participant CN)
- In an earthquake, the participant went to the designated room. Nobody showed up, and he/she was still in the room when the emergency was called off. (Participant CR)
- In a non-fire emergency in which all elevators were shut down, coworkers assisted the participant in walking down the stairs from the sixth floor, one step at a time, with considerable difficulty and pain. To retrieve the car in the parking garage, the participant descended an additional four flights in a sitting position. It took over a week to recover. (Participant CT)
- A building was evacuated due to damage to a gas pipeline. The participant and an assistant went to the area of refuge, where they learned about the nature of the emergency over the communications phone. After waiting for about twenty minutes to hear some word about rescue, they decided to take action on their own. They walked slowly down the stairs and inadvertently exited the building at the same location as the gas leak. (Participant CX)

4.2 Positive Factors

Evacuations that left study participants with a positive feeling about the experience had some common elements. These include continuing communication about the situation and the efforts that were being made on their behalf; planning that included the input of the participant; regular training on what to do in an emergency, including emergency egress and relocation drills; authoritative leadership during the event; appropriate assistance from a familiar colleague; and orderly efficient and safe evacuation from the building. Assistance from first responders was most appreciated when they asked how

they could best help the person with a disability. Of course, the procedure was easiest for those on the first floor, who could evacuate the same way they always leave the building.

The following quotes illustrate some of the approaches that worked well during evacuation procedures.

Respectful assistance

> "[They] called the fire department and the guys came, and they said, 'Okay, how can we best help you?' And we'd tell them, I told them what to do. And they took us down the stairs…Really, [asking] is critical because different people have different needs, different abilities and different comfort levels, and some people can become very anxious and frightened. And, for people who have speech impairments, it's even more critical because the professionals might not take the time to be patient and listen to the individuals. So, some disability training for the emergency personnel is, I think, very important in what might be needed for different types of disabilities." (Participant AE)

> "So, I worked as a team with [the firefighters] by, basically, instructing them on how to assist. You know macho guys, right? They were like, 'Well it's all about the brawn, and we can just carry everything.' I was like, 'No, no, no, it's not safe for you guys and it's not, particularly, safe for me.' So they took about 100 pounds off my chair by taking all the auxiliary pieces and we had someone follow in the back with all those other pieces of equipment--the batteries, I think they're about 80 pounds." (Participant AN)

Evacuation by trusted individuals

> "We were in a night meeting…Then we have this thing go off...They just didn't even think twice. [A coworker at the meeting], he was a big man. He just scooped me up and then started going down the stairs. Because, you don't know what's going on. This was after hours. …You're not going to have a drill at that time. …So then, [another coworker] said, 'I'll take over from here.'…He took me all the way down like that. …I was gratified that, you know, I didn't even really have to think about my safety." (Participant BV)

4.3 Negative Factors

The negative evacuation experiences related by study participants left them feeling that they were at risk during the emergency event. In many cases they had been left behind, often without communication, and sometimes even after being told that someone would come to get them. Others found themselves in a strange building with no idea what they were supposed to do to evacuate. In some cases, the first responders did not take the individual's needs into consideration.

Participants describe some of their negative evacuation experiences in the following quotes.

Isolated

> "Something happened where something overheated…and the alarms did go off up here. We were told the procedure was that…someone was supposed to come up here to check on us up here. That never happened. My coworkers were here, fortunately, at the time…often they're not because we're out in the field quite a bit. So I am here by myself on occasion. …It wasn't until maybe 20-30 minutes later that…we found out what was going on, and they just told us to stay up here and that it was fine. I wasn't concerned at the time, but if there was a real emergency, I was really nervous about what would actually happen here." (Participant BB)

> "When it was the actual earthquake, on that day, I was worried about taking the elevator so I didn't do that. So on that day, I went to the designated room and…A) at that point they didn't have a chair available to evacuate me, if that was needed, B) there wasn't anyone who showed up. …Eventually someone passed in the hall and I flagged them down so that they could help me use the phone to call the security desk to let them know that I was waiting. We did that twice, the security guard said that they would come around and have someone help me, and that never happened. … I never got out of the building." (Participant CR)

> "The alarms went off. Everyone evacuated, except for me--I stayed up here. We have our little lobby area just to congregate in, for anyone who has disabilities or can't use the stairs. I was the only one at that point. The drill person got the word that things were all clear, but he left so I was up here by myself. I kind of stayed up here for over an hour, all by myself. So, the security people downstairs, they took the elevator up here, actually to try to find me, and they couldn't find me. It was kind of a mistake, they were on the one side of the building floor and I was on the other side of the floor and we were kind of circling around, and we missed each other. …Eventually, yes, they did find me. So they used one of those evacuation chairs to get me down [five] flights of stairs." (Participant CS)

Conflicting instructions

> "[Security personnel] came in and they were just looking, 'What are you doing here? Okay, stay here. Oh, let me find out.' Then, 'Did you try to take the elevator?' So, one guard would tell me to take the elevator, go down, then the other one would say, 'No, don't do it, let's just see what's

going on.' 'Oh, I don't want you to go outside if you don't have to.' So it was just mass confusion." (Participant CN)

Lack of communication

"…There were two people waiting with me and we were actually really almost going to carry me down the stairs. Because everyone had to evacuate the entire building and we didn't know what was going on and … the only thing [our coworkers texting from outside the building] were telling me is that more fire trucks were showing up. And so we were like, 'Uh, that sounds a little sketchy, we don't really want to wait until it's too late to get out. Why don't we just--' … But I think they were just able to get it under control. I think the whole thing took like an hour though. We were in limbo for 30 minutes or something and that's why we were like, 'Well maybe we should just go.'" (Participant AP)

"I was in training…the classroom was on the second floor. And as most people, the earthquake hit, many people did not know what it was at first—thought it was some kind of train derailment, other big accident, bomb—who knows. But, it pretty much, the alarms went out, and then everyone just took off. It was chaotic. And, not having any real instruction, instinct just took over, and I went to the elevator, I pushed the button, waited a second, the elevator arrived. So I decided to get in and take it down to the first floor and exit the building. …I was not confident at all that I would be able to make it out. And if it were a life-threatening situation, I was scared. I was like, 'Well, I may not make it out of here.' That's exactly how I felt. …it's not like I screamed or cried or anything like that. But it was a very palpable sense of fear. …And the fact that it was training in a foreign building, to me, I think that only heightened the experience." (Participant CP)

Evacuee needs

"What hasn't worked is when the first responders come and automatically try to hustle you out without taking into consideration that you might have a need." (Participant AE)

"The last time I was evacuated, I was in a manual chair, which is much lighter, and [the firefighters] did take me down the stairs … I kept telling them, 'Tilt me back, tilt me back.'…and they kept insisting on taking me at a 90-degree [angle]. Well, 90-degrees, with stairs, I have a great possibility of toppling out, and I kept telling them, 'Tilt me back, tilt me back, it'll be easier for me AND for you!' and they just wouldn't listen, they would not listen to me at all. (Participant AG)

5 Existing Evacuation Methods

The participants in this study mentioned a number of methods by which people with mobility impairments could evacuate a building during a fire emergency. Some were methods that they had trained on or used during a fire drill or emergency; others were methods that they had heard of or had thought of using. These included the building's existing elevators, emergency stair travel devices, areas of refuge, walking or crawling down the exit stairs, and being carried by coworkers or fire evacuation personnel. Use of the stairs with minimal assistance from others included walking with or without crutches; crawling using hands, feet, or buttocks; and controlled descent using the wheelchair. Participants described their thoughts about and experiences with these methods, including potential risks to their own safety and the safety of those assisting them. The following sections present each method along with the benefits and concerns identified by the participants.

5.1 Existing Passenger Elevator

This section discusses the elevators that participants use to enter and leave the building every day to go to their office. The conversations on this topic took place before they viewed the video on Occupant Evacuation Elevators described in Section 2.2, which clarified some of the issues with existing elevators and explained how OEEs addressed these issues. Participant viewpoints on OEEs are presented in Section 7 along with their recommendations for improving elevator design and procedures. The possibility of using the freight or service elevators in their buildings is discussed in Section 5.2.

All of the buildings in this study had elevators that participants used to travel vertically during the course of their work day. For those with mobility impairments, having a rapid and safe method to use during fire evacuations is extremely important. However it is well known among the public that elevators should not be used during fire evacuations [23].

> "I certainly don't even think about using an elevator, just because it's always been drilled into you. I mean wherever you go, hotels, anywhere, it's that, 'In an event of an evacuation never use the elevator'." (Participant BB)

Although they were not always aware of the reasons, many study participants understood that during a fire emergency the elevators in their building could be brought to the ground floor and taken out of service, at least until fire personnel arrive. Despite this knowledge, as well as their own concerns about safety, many participants brought up the idea of using the building elevators on their own while discussing their evacuation experiences.

> "I'm concerned…that the elevator being connected to the electricity, to the power supply, is it safe to use it? Would it be safe? So that's a concern. But, all things being equal, if it wouldn't be affected by an electrical problem then, really and truly, because usually when I think

> of a fire I wonder if, 'Lord, could I quickly use the elevator before it's taken out of service?'" (Participant AB)

Some study participants had actually tried the elevators during a fire drill or emergency incident, found them operational, and taken them. These people generally related their concerns about the other evacuation options available to them and expressed relief on being able to take an easier path out. Participants also provided their thoughts about the building elevators at a later point in the interview, when they were specifically asked about using them during evacuation.

5.1.1 Benefits

Although their responses were colored by the understanding that elevators are not supposed to be used during a fire emergency, participants described many benefits that would be gained if this option were available to them. These include familiarity and ease of use, the ability to move many people quickly, and the safety and independence of remaining in their own mobility devices.

Evacuation by elevator would make it easier and faster for occupants and visitors with mobility impairments to evacuate a building. This is the most familiar route – people reach their offices by elevator in the morning, use them all day to carry out business and break for lunch, and enter them to leave in the evening. Using this same method to evacuate during an emergency reduces the stress and anxiety in an unusual situation.

In an emergency situation in which time is of the essence, an elevator can transport people with mobility impairments vertically through the building more quickly than other methods. In the case of one non-profit agency in which many employees and most of their clientele are disabled, a study participant described a procedure for using elevators for evacuation in the time period before first responders arrive at the scene. This was a special building designed and built specifically for this agency. The participant had a strong preference for this option over the areas of refuge in the building where one would wait for rescue.

> "We have this other program that I prefer, and I've used, is that you get to the elevator, you push the help button,[d] someone on the first floor, and they will manually work the elevators to get as many people who cannot use the stairs down before the fire people come. Because when the fire people come, they will turn off the elevators. …So the last time they did a fire drill, I left my spot and I came over. I started hollering at people, especially people in wheelchairs, 'Let's go, let's go, let's go, quick in the elevator.' And I pushed it and everything worked out." (Participant AG)

[d] This is a special designation associated with this building; not necessarily a feature in every building.

Using an elevator during evacuation enables people with mobility impairments to keep their mobility device, and their independence, throughout the procedure. Many of the participants depend on their mobility device to maintain their health, mobility, and independence. Wheelchairs may be highly customized to provide support where musculature is weak and to prevent pressure sores. One participant with a neuromuscular disability explained that the tilting capabilities of the wheelchair allowed him/her to lean back to take a deep breath and to adjust his/her position to help with pain and balance. Some participants described the risk of injury from being picked up in order to transfer to an evacuation device or to be carried. The risk of injury to assistants is also avoided when the elevator is used.

A few participants pointed out that the ability to safely use an elevator in a fire emergency depends on where the fire is within the building. Knowledge and communication are key to making an informed decision. Others commented that the elevator becomes a more important option as the building height increases. For very tall buildings, the number of flights of stairs becomes a challenge for an increasing number of ambulatory people as well as those with disabilities.

5.1.2 Concerns

Although the idea of exiting the building in an emergency the same way they came in was attractive, study participants could think of many reasons why this would not work well for them. The knowledge that they were not supposed to use the elevators in case of a fire was enough to discourage some. Others worried about specific safety issues, including the need to communicate with personnel outside the elevator if something went wrong. Experiences with waiting for the elevator to arrive, trying to enter a crowded elevator in a large wheelchair, and stopping at multiple floors on the way down detracted from the image of the elevator as a rapid means of evacuation. The same issues of elevator button accessibility mentioned in Section 3.7 apply, requiring some participants to seek assistance during evacuation. The elevators for some buildings did not provide a path directly to grade level but instead stopped on a floor level with a need to travel to another bank of elevators or follow some other procedure to reach safety.

Existing passenger elevators designed before the development of OEEs present risks to safety for occupants if used for self-evacuation in a fire emergency. Participants were concerned that the elevator would fill up with smoke and that the elevator would stop working or get stuck between floors. If the elevator breaks down in the middle of the evacuation, participants feared that those inside the elevator could be trapped – a situation many identified as a nightmare scenario.

Also feeding into anxiety is an uncertainty about whether elevator users would be able to communicate with security or first responders from the elevator or elevator lobby. Communication before boarding the elevator is important for obtaining information that supports timely decision-making about whether to take the elevator or not. Communication on the elevator is needed for reassurance in case trouble arises.

> "And, if [the elevator were to get stuck], …who would know I'm in there? Does the emergency phone in the elevator work? Does it connect to a place where there's always someone? Does it connect to a place where the concierge might not be at their desk?" (Participant CP)

Participants expressed concern that elevators are not necessarily a quick route out of the building. People need to wait in the elevator lobby on their floor for them to arrive. On a top floor of the building and during rush periods when many people are using the elevators, this can be a long wait. Under normal operation, the ride to the ground floor is not direct, with the elevator stopping to board passengers from intermediate floors. Wheelchairs take up much more room in an elevator than a person standing, so a crowded elevator often means not being able to enter and having to wait for the next one.

If elevators became a potential option in an emergency, everyone may want to use them. The study participants therefore considered priority use to be a key procedural concern. People who do not have mobility impairments may readily use the stairs. Those for whom the stairs are a slow, difficult, and perhaps impossible choice would hope and expect that they would be given top priority in using the elevators to leave the building. How then can those with limited options be assured of safe evacuation? Other procedural concerns included whether space would be available for a wheelchair in a small or crowded elevator, whether elevators would open at every floor even if they were full, and the order in which the evacuation would proceed.

> "I'd say my number one practical concern is that when I think of elevator usage during an emergency, I'm like, 'Oh awesome it'll be worse than waiting for an elevator in rush hour or any other time when elevators are in demand.' …I just have a feeling that it's going to be hard to enforce [rules that limit those who use elevators in an emergency]. Like, 'Only the people who really need this are going to be in and that'll be half the building.'" (Participant AP)

Even if the elevator could be used for evacuation, many participants agreed on the need for a backup plan. Is there a backup generator in case the electricity fails? If the elevator is damaged, or the path to the elevator is blocked by the fire or other danger, what is the alternative plan? Participants stated clearly that the evacuation plan and procedures must include options that take their individual situations into account.

In Section 7, the ways that Occupant Evacuation Elevators are designed to address some of these concerns raised by study participants are mentioned. Remaining concerns are incorporated into the study guidance in Section 8.

5.2 Freight Elevator and Service Elevator

Participants whose buildings contain freight and service elevators in addition to the passenger elevators they used every day were asked whether they would consider using these elevators during a fire evacuation, although recognizing that this may not an ideal

suggestion. Freight elevators, whose primary purpose is to carry freight and which are reserved for the exclusive use of the operator and freight handlers, are not required to meet ADA or ABAAS guidelines [21]. Service elevators may simply be a larger passenger elevator placed with other passenger elevators or may be in a separate location. They would typically meet appropriate guidelines.

5.2.1 Benefits

The freight and service elevators have similar advantages to the passenger elevators when considering using them during a fire emergency. People can be transported quickly up and down, and they can remain with their mobility devices. In addition, if these elevators are not also used as passenger elevators, the trip to the ground floor is not as likely to be interrupted by stops at intermediate floors.

Some participants perceived the freight and service elevator as safer than the passenger elevator, because it is located in a more out-of-the-way location or because it may be better maintained.

Freight and service elevators are often larger than passenger elevators intended to transport people only.

> "What happens is you have to wait for elevators because sometimes elevator sizes are too small, the way they're designed. The freight elevator is bigger, so I prefer the freight elevator." (Participant CM)

In some buildings, the freight elevator is capable of traveling to every floor in a building, whereas certain passenger elevators may only travel to a designated number of floors in a building.

> "It takes me a good ten minutes to get into my office once I arrive. …When I'm using the freight, in less than five minutes, I can be out of the building." (Participant CM)

5.2.2 Concerns

Perceptions involving the vulnerability of the freight elevator to smoke from a fire and water from fire suppression, along with a question of whether they are operational during a fire emergency, were similar to those expressed for the passenger elevators that participants use every day. Additional concerns had to do with the function of the freight elevator as servicing the building in a different way than the passenger elevator, and with issues of accessibility for people with mobility impairments, who are not the usual or intended users.

Because a freight elevator is normally used for a specific purpose, use of these elevators may be controlled through special keys or keycards. In these cases, either an escort or possession of the key would be needed to gain access.

The design of an enclosed lobby for the freight elevator may make entry difficult for those with mobility impairments. Entrance doors to the lobby may be too heavy for one to open effortlessly. In addition, the enclosed lobby and means of egress leading from the enclosed elevator lobby may be cluttered with supplies or equipment, reducing the means of egress width necessary for access or egress by a wheelchair. Lastly, the freight elevator may discharge onto a loading dock rather than to an accessible exit from the building.

Unlike the passenger elevators people use every day, many of the study participants were uncertain about whether their buildings had freight or service elevators, or where they were located on their office floor. In the absence of regular training, finding and operating a freight or service elevator for self-evacuation during an emergency would be an unfamiliar and potentially stressful task.

5.3 Emergency stair travel devices

Code-compliant exit stairs are well-protected during fire emergencies [10] [24]**.** Emergency stair travel devices provide an option for getting people who cannot navigate stairs on foot out of the building during an emergency [25] [26]. Once individuals transfer to the device by themselves or with assistance, they are strapped into the device to prevent slippage and falls. Emergency stair travel devices provide an evacuation option for some users.

> "[Our emergency manager] just recently came up and showed me that cool chair, these neat chairs that you can sit in them. …I'm not lightweight. And a 100-pound woman could get me down the stairs, a 400-pound male could get me down the stairs. …Because the chair takes the brunt, not you—you're primarily just driving it. And I thought that was wicked cool." (Participant CU)

Some models are motorized, giving them the ability to move both up and down the stairs. More inexpensive versions require assistants to lift and carry the evacuation device and individual.

5.3.1 Benefits

Emergency stair travel devices allow people with even severe mobility impairments to exit the building via the stairs.

> "If everybody was evacuating I personally would prefer that there be somebody who takes the responsibility to get me down with an evacuation chair rather than waiting for the fire people to come. That's just how I feel and I feel really strongly about it. I've heard horror stories." (Participant CF)

Several study participants expressed a desire not to be the last person out of the building. If they are using an emergency stair travel device, they could begin preparation procedures involved in the use of this device. Once the individual is transferred into the device and secured in place, they may enter the stairwell along with their assistants. The appeal of being treated the same as everyone else is described by one participant as follows:

> "It's also a big cultural and ideological shift, I think, to go actually from 'Disabled people are the special people who need to be specially evacuated by rescue personnel' vs. 'Disabled people can be integrated with their co-workers and be evacuated by their office mate or the cubie next to you.' And I think that's one of the final points of integration, right? Because you don't want to be 'special' people who need 'special handling.'" (Participant AN)

5.3.2 Concerns

Although emergency stair travel devices provide the capability to get people with mobility impairments out of the building, they are not a perfect solution. The primary concern raised by study participants, particularly those in power wheelchairs, was that they would be leaving their mobility device behind. Other concerns included physical risk, anxiety, the need for assistance and training, and the fact that an emergency stair travel device can carry only one person per trip.

While manual wheelchairs and crutches may be carried down the stairs by coworkers, power wheelchairs are very heavy--300 pounds or more according to study participants. If power wheelchair users transfer to an emergency stair travel device, they will be able to exit the building but they will have to abandon their mobility devices. For them, loss of their mobility aid is a major concern – one that for some impairs their ability to continue with daily life. The importance of the mobility device is reflected in the following reactions.

> "It's always an issue...letting go of my equipment, because so much of my health, my mobility, and my independence is tied to a very customized piece of equipment. It's not like, 'Oh okay, I'll go pick up an extra one at the grocery store.'…It's more than just we are being stubborn and we don't want to leave our chairs behind. It's a survival issue, quality of life, survival." (Participant AN)

> "I'm not doing it [getting out of my chair]. If I can help it, I'm not doing it. Again, you have to get out of your chair, LEAVE your chair in the burning or exploding building, or whatever, flooded building, whatever is going to happen, and I'm not doing it." (Participant AG)

> "My chair is way too heavy for anyone to carry with me in the chair, so automatically I have to be parted from my chair. That is a tremendously

> nerve wracking thought to have…Once you get down to the outside, what are they going to do with me? Are they going to keep carrying me around? …Will they put me on a park bench? Are they going to put me on the ground? …And what am I going to do without my chair?" (Participant CP)

Many study participants expressed their anxiety on using an emergency stair travel device. Because of the need to transfer from the mobility device into the device, there is some physical risk for both the individual being evacuated and the people assisting him or her. Some participants were able to transfer themselves. But for those who cannot self-transfer, the possibility of being dropped during transfer is a concern. Injuries may also result from conditions such as brittle bones and fragile skin, or from body support that is provided by their mobility device but not the emergency stair travel device. Participants were also concerned that their coworkers could be injured while assisting with the device.

> "It's like the evacuation chair is great but that's… It's stressful, it's a little scary, everybody is nervous about how to use it correctly." (Participant AI)

> "It's an uncomfortable chair for someone with a significant disability with seating challenges, skin concerns. …So, any time, with the exception of when it's critical, I don't want to be in this thing. I don't want to have to transfer into it again. I don't want to have to deal with it. I'm sure it's not good for my skin to be in that thing and so it's certainly not ideal." (Participant AX)

> "I myself haven't transferred over to [the emergency stair travel device during training] because…I'm worried about the risks involved in doing that—either with a fall or with catching…because my skin is more fragile, so I'm worried about skin tears or things like that." (Participant CR)

> "No, those [specific emergency stair travel devices] are horrible. They're what we call lawn chairs, they're low on the floors and you have to transfer. I have no mobility and in order to be able to move from one place to the next, I have to be carried. So, that would require to have two people lifting me out of my chair, putting me all the way down to the floor …, which would be a killer for their backs, unsafe for me, and quite possibly painful in the process." (Participant AN)

It should be noted that some participants stated that undergoing training on the emergency stair travel device reduced their anxiety.

The use of emergency stair travel devices entails dependence on those who transfer the users and operate the chair. Assistants may be coworkers, strangers, or first responders. Participants addressed the issues related to requiring assistance.

> "I guess in the case of an emergency, one shouldn't think of independence so much but just think about the help that you can get. But relying, sometimes, on someone else is somewhat difficult--you're shifting control of your circumstances, your own life, onto somebody else. So, suppose I'm going to need this [emergency stair travel device], I will have to wait for somebody to come to take it out of this box, and I can go and get it and start getting myself together on it rather than waiting." (Participant AB)

> "The issue with the chair is you don't know who is going to be pushing you, you don't know whether or not you're going to be waiting, you don't know … there are too many things you just don't know. And the last thing you want to do is be in a chair and strapped in the chair, and someone leaves you or whatever, then you're stuck. So I don't like that thought at all." (Participant CT)

Knowing that several people are trained on the emergency stair travel device may make a big difference in the comfort level of occupants with mobility impairments, as described by the following participant.

> "When we got the evacuation chair, we trained everybody at the time in using it because we're the kind of organization where people are in and out so much in meetings and things that it's hard to know [who will be around]. So yes, we didn't assign somebody specific to help me. But the understanding is if I do need assistance that whoever is here will help." (Participant AI)

A disadvantage of the emergency stair travel device is that it can carry only one person at a time. If there are more people waiting to be evacuated than there are devices, the device must be returned to the floor in order to help the next person out. This is a slow process for motorized devices that can travel up as well as down; devices that are gravity-driven must be brought back up by the stairs or by elevator. The approach of assigning an emergency stair travel device to every employee who needs one may work well if the building population is fixed and employees generally remain near their offices. However, many participants described dynamic workplaces, in which they moved from floor to floor, clients visited the office, and meetings took place involving multiple wheelchair users. Some participants were aware of the existence of emergency stair travel devices on their floor but did not know if there were enough to deal with everyone who would need one.

> "The thing is though it's possible that we can have consumers visiting on that day who use wheelchairs as well, so we pray that we do not have a fire when there are four or so people in wheelchairs here because it would be kind of difficult to get everybody out." (Participant AB)

5.4 Walking Down Stairs

Stairs are the primary means of vertical travel during fire emergencies. Building codes require exit stairs to provide protection in case of fire, which could include fire-resistant doors and smoke-resistant design [10] [24]. However, exit stairs can become congested during evacuations, especially when firefighters are using the same stairs to move themselves and their equipment toward the fire, producing a counterflow that slows the evacuation [27]. Some study participants were able to evacuate using the exit stairs despite their mobility impairments, either with or without crutches.

5.4.1 Benefits

The biggest benefit for those individuals who are able to negotiate the stairs is being able to evacuate the building and reach safety with other building occupants. They remain independent and in control of their evacuation, able to leave without waiting for someone to come get them.

5.4.2 Concerns

People with mobility impairments who are able to navigate the exit stairs in a fire emergency explain that this presents a significant challenge for them. Concerns include the time it takes to reach safety, the risk of physical injury, and the effort required. Evacuation studies have shown that people with mobility impairments take longer to negotiate the stairs than the general population [28]. Study participants who consider evacuating by walking down the stairs recognize this problem.

> "[Walking down the stairs from a high floor] would be a very slow process for me. …I have myself pretty well trained that when I'm on stairs, that I don't tip forward. If I ever come close to falling, at all, and I've fallen on stairs before, I'd fall backwards rather than forward. And when I'm going upstairs, I fall forward rather than back and suffer a higher fall. But, if I had somebody behind me who was a bigger and stronger guy, because I'm a big guy, myself, I would hope that there would be somebody who might be able to just catch me. Well, it is what it is." (Participant BD)

> "I would think [everyone else would evacuate first] because then we're in the way of everybody. We know everybody's really coming down fast. There's really no way for us to get in the middle of that. …We could lose our balance. We could fall. We would stall the people coming behind us. …It's not feasible to go down when everybody else is going down. So we have to wait. To me, that's a concern because it's like, you know, by the time everyone goes down, and then if it's a real fire, are we really going to get someone to come back up here and say you need to go down? That's a real concern for me." (Participant BW)

Walking down several flights of stairs can exacerbate the physical problems associated with a disability. There is a risk of falling due to balance issues and to the possibility that others may accidentally bump into them. The extra time within the building may expose occupants to smoke and other dangers from the fire. Some participants described pain or incapacitation that lasted for days after they had used stairs to evacuate a building.

> "For me, I think the expectation is I would probably walk down because there's only one person [assigned to accompany multiple people with mobility impairments on their hall]. The only one time I did it, it's just not effective because then my legs hurt a lot for the next two days." (Participant BW)

> "It took me forever to get down the steps. I can do one or two steps, I can make my legs work. But, after a point, my legs decide they don't want to work, especially my left one. And I only go down on my right leg--I cannot bend. I have torn cartilage in the knee, which adds another issue to it. But, saying that, trying to get down, the left leg, it flops like it's a fish out of water--it just spasms. …I can only do one step at a time—I'd have to wait for the spasm to stop." (Participant CT)

5.5 Taking Stairs in Wheelchair

It is possible for some people in lightweight manual wheelchairs to move themselves and their wheelchair down the exit stair. Doing this without assistance requires significant upper body strength.

> "I find, myself, that I can go down backwards, holding on, as long as it's a continuous handrail, I can go down backwards. I've demonstrated it, I don't like to do it a lot because it's hard …When there's a break in the handrail, it's a little more difficult. But it can still be done." (Participant CQ)

Participants often preferred to have people they trusted assist them by spotting or steadying the wheelchair. Some participants also described having friends take them up or down stairs in their wheelchairs.

> "I can just get somebody to pop my chair back on a wheelie and take me down the 15 stairs and get the hell out of the building on a moment's notice. So let's go fast and furious and leave. I have my helpers. Worst case, they grab the front and the back of the chair on either side, they pick it up, and we walk down." (Participant AV)

5.5.1 Benefits

Those study participants who have developed the skill of maneuvering up or down the stairs in their manual wheelchairs expressed satisfaction in having some control over their

fate in an emergency situation. Using a spotter that they had trained to assist enabled them to move with greater speed and confidence.

> "If there's a fire, I'm gonna go down the stairs. Now, if there was a fire and I didn't have a spotter, I would still go down the stairs by myself. I would just hold onto the rail a little bit more, which is actually how you go upstairs." (Participant CB)

For manual wheelchair users, traveling on the exit stairs in their mobility device provides them with independence of movement after the fire evacuation.

5.5.2 Concerns

Concerns of participants who can evacuate with their manual wheelchairs on the exit stairs are similar to those of walking down the stairs. Their progress is generally slower than the flow of other occupants on the stairs. They are at increased risk of injury from losing control of the wheelchair, falling, and fatigue from the effort to maneuver the chairs. Assistance from a friend or coworker helps to ensure their safety.

Going down the stairs in a wheelchair is hard work. Injury can occur if the person in the wheelchair loses control or if someone else on the stairs gets in the way.

> "When I [go down backwards holding onto the handrail], I like to have somebody in front of me, because especially if everybody is evacuating – if you're evacuating a 10-story building, and it's not a timed evacuation, or controlled evacuation – you have four floors ahead of you of people trying to evacuate, too. …And I don't really know how dispersed the traffic would be going down. So I'd like to have someone at least in front of me to divert people around me so I don't end up with people in my lap, because that could happen. And I could hold me but I don't know about holding people in my lap as we go down." (Participant CQ)

Going down the stairs may also damage the wheelchair.

> "I don't like to do it because it's hard on the chair. It's hard on the front wheels. So I don't like to go down but so many [steps] to demonstrate. If I had to, if it's burning, I'm going down. I don't care what the front end looks like when I get down to the bottom." (Participant CQ)

5.6 Crawling or Sliding on Stairs

Many study participants described a preference for getting out of the building quickly rather than waiting in the area of refuge for an indeterminate time. Some are able to get themselves up or down the stairs without assistance if they drop to the ground and crawl or slide on the stairs.

5.6.1 Benefits

No participants wanted to traverse the exit stairs by crawling or sliding. But those who knew that they could do it considered getting out of the building quickly to be preferable to waiting for someone to come evacuate them, or even to using an emergency stair travel device. Some participants also worked late into the evening and knew that coworkers may not be around to assist them with other evacuation methods.

> "If I'm here by myself and I know I'm by myself, and I'm going to go. I'm going to get up those seven or eight stairs. I might get hurt doing it, but I'm going to do it. That's my evacuation plan, even though it shouldn't be that way, but that's my evacuation plan." (Participant AA)

> "I think I would always know that I'm going to be the last person. I've had, in situations; just got out of my chair and crawled down steps and have had somebody take my wheelchair. So that would be what I would do. …We have [an emergency stair travel device] for the second floor. But, to be honest with you, probably what I'm going to do is I would probably prefer to get out of my chair and go down steps. …If I'm in [an emergency stair travel device], they're probably not bringing my chair with me. So, do I want to, when I get to the bottom, be stuck in the [emergency stair travel device]? No, I would much rather have my manual chair there to be able to move myself away to safety." (Participant AZ)

Like the other methods of using the exit stairs without assistance, crawling on the stairs is attractive because they perceive that it keeps control over their lives and safety in their own hands.

> "Actually, I can do stairs. I have stairs at home. But not with the wheelchair, obviously. But I just get down out of the wheelchair and scoot myself down or climb up. So I could do stairs and, in an actual emergency, I'll tell you, I'm doing it because I'm not going to let them leave me behind. …So, after everybody else has gone down, because I don't want to be trampled, …I will have the buddy carry [a manual wheelchair that I keep in the kitchen] down to the ground floor and then walk down the stairs with me as I go down, step by step, as I scoot myself down. And then, there will be the buddy and one other person at the bottom, in the lobby, to lift me into the manual wheelchair." (Participant AO)

5.6.2 Concerns

Participants who intend to crawl or slide down the stairs in a fire evacuation have concerns similar to those of participants who intend to use their wheelchair or walk down the stairs.

The risk for injury is higher for these individuals because they are low to the ground. They may injure themselves in climbing out of the wheelchair, they may slip, and others may trip over them. Some explained that they have arranged with coworkers to walk with them and announce their presence.

> "I've got two people assigned to help me. Okay? We wait for a clear spot at the stairs, we wait for the crowd to let up. And, at that point, I hop out of my chair, onto the floor … and I go down the steps until I get to the ground floor. And one of the two people who is with me is in charge of my wheelchair. …The other one kind of also keeps the crowd from trying to walk around and all of that because it's not fun when someone steps on your hands." (Participant BX)

5.7 Being carried

If the evacuation requires everyone to leave the building, another option for people with mobility impairments is to be carried down the exit stairs. There are a variety of lifts that can be used – each type of lift has associated advantages and disadvantages. Some people may be harmed if carried. The choice of lift therefore depends on the individual needs of the person being carried [29].

5.7.1 Benefits

People carried down the exit stairs by coworkers or emergency personnel are able to leave the building with others. Sometimes they may be evacuated with their mobility device. Participants explained that being carried allowed them to get out of the building quickly, and they were aware that fireman were trained in how to carry them safely.

> "I'm not a heavy individual, you know? I can be carried, safely, if somebody is physically able to do that. So if there wasn't an evacuation chair, that would be an option for me. And I would rather take that option if somebody is able to do it, and willing to do it, than wait for help that may never come." (Participant CF)

Most concerns expressed by study participants were about the risk of physical harm. Injury could result from being dropped or from being carried incorrectly. Certain disabilities, such as brittle bone syndrome, exacerbate the risk. One participant said that being thrown over someone's shoulder could constrict movement of the diaphragm, which prevents correct breathing. Another described the dangers as follows.

> "There's never been a cause for me to evacuate, and I'm glad because had I been evacuated, I would have been injured. If someone tried to lift me, my body is pretty weak, so if you try to put your hand under there, if you didn't know how to lift someone like me properly, you'd hurt me.

> And, generally speaking, that's a big problem…..If you slung me over someone's back, you'd break my back." (Participant BC)

Injury can also occur if the people assisting in the evacuation are inexperienced or do not listen to the needs of the person being transported. In the following case, the person was carried down along with the wheelchair.

> "And what hasn't worked is… and this did happen to me… where they had to carry me, in my chair, down a couple of flights of stairs and they were not securing me properly or… again, this has to do with balance. And, not only balance, but tipping forward or back. So they try to take you down the wrong way, in a wheelchair, you never go down facing up, you have to go down facing because when you tilt, you want to be looking forward…Because you're tilted. Because the weight of the chair and the weight of the body, if you're facing backwards and the guy is behind you, your weight can knock that person over." (Participant AE)

As with other methods, the mobility device is likely to be left behind if the person is carried out of the building, especially if it is a heavy power wheelchair. This results in the temporary loss of independence and mobility.

> "I feel very comfortable with the fact that people here are super willing to carry me out, if necessary. Obviously it's not an ideal situation, for a number of reasons. Like carrying anyone down stairs, especially 18 flights or more, because of the thing is a pain. But, also, where am I going to sit when I get downstairs? I'm leaving my chair; the chair is obviously a key part of my day-to-day mobility. All these things. Getting back up. Just the whole thing, it was an uncomfortable feeling. (Participant AP)

5.8 Area of Refuge

Evacuating all occupants from a high-rise building could require a considerable amount of time. One proposed solution for providing safety for people with mobility limitations is an area of refuge where individuals can safely wait until assistance arrives. Design features for these areas may include sprinkler systems, fire and smoke resistant walls, ceilings and doors, and two-way communication systems [10] [21] [29].

Areas of refuge allow individuals with mobility impairments the opportunity to remain in their mobility devices in a protected area while they await either resolution of the emergency situation (such as determination of an erroneous fire alarm) or evacuation assistance from emergency responders.

Study participants' perceptions of areas of refuge ranged from corridors to fire-rated exit stairs to office lunch rooms where they have been instructed to wait in an emergency.

However, unless the building is fully sprinklered, these areas identified by participants may not meet all code requirements for an area of refuge.

5.8.1 Benefits

Some participants appreciated the ability to find protection if they are unable to readily evacuate in a fire situation.

> "I'm seeing [an area of rescue] in more places in very obvious ways, and that's a little comforting…Because if there is a designated, noted, assigned area of rescue, that perhaps the fire department and emergency teams are going to know to look in those places. It's not a random search." (Participant AT)

An area of refuge can be used for temporary protection until the initial rush subsides.

> "So the fact that there is a shelter-in-place…is good, because it can be confusing and it can be – not a madhouse – but a little bit of panic, people are trying to get out. It's probably a good thing for me to be out of the way for at least the initial sort of minute or two." (Participant CV)

Direct two-way communication with emergency personnel was considered a critical feature of the area of refuge. In the best situations, participants understood that emergency staff would be notified of how many people are waiting for rescue, and that the people in the area of refuge would be informed about what was going on and how long they would need to wait.

> "Well, the shelter-in-place has a phone line that stays open, and so in the evacuation of the earthquake, we were able to use that to communicate with security and make sure that they were, in fact, going to turn on one of the elevators and come up and get me, because the elevators were off and we were unsure what to do. …Having a dedicated phone line that can be used to access security downstairs… and knowing that it's not going to shut off, or at least hopefully it's not going to shut off, has worked in the past." (Participant CV)

> "I think…having the communication is of paramount importance—someone to tell me what to do, or someone to tell me it's going to be okay, or someone who is telling me what's going on, or how long it will be for the firefighters to get me out. All very, very, very important." (Participant CP)

5.8.2 Concerns

Many participants described significant anxiety about using the area of refuge. Among these were being left behind with nobody coming to rescue them and lack of

communication about the nature and severity of the fire. In addition, some areas had problems with accessibility. Since a crucial aspect of the success of the area of refuge is the occupant's acceptance and use during a fire [30], concerns from the potential users should be addressed.

If access to the area of refuge is difficult, or the means for two-way communication is not accessible, this method becomes impossible to use without assistance. Some participants described serious issues with access.

> "I'm supposed to go out into the hallway, open up a door to the stairwell, which I cannot open myself. And it's a heavy door because it's fireproof. And I'm supposed to wait up in the stairwell – there's a designated spot up there – and I'm supposed to grab the phone that's in there, which I can't reach, and someone in security is supposed to pick up and I'm supposed to let them know that I'm up here." (Participant BB)

> "The emergency phone is in there not because it was required by code, but when we plan-checked it, we insisted they put it in there, because when the building went into emergency and the fire doors closed, and they pressurize the floors, now they pressurize the area of refuge. And the problem is, the pressure differential made it very difficult to open the doors." (Participant BC)

> "There's not an automatic door to [the area of refuge], but it's set up in a way that I can get in but I can't get out, which is a problem that hasn't been fixed. I was told they were going to work on an automatic door for it but it hasn't happened. …I only go into the room when I'm with someone, so that way if there's some reason that I need to get out of there very quickly, I have a way to do that." (Participant CR)

When people with mobility impairments retreat to the area of refuge, they know that their ambulatory coworkers are able to exit the building and get to a safe place, while they are left behind. This is a situation that results in anxiety for many. Without regular communication and credible assurances that help is on the way, people are left to wonder when first responders may come, if at all, to assist them with evacuating the building.

> "In the event of an actual emergency, I find it frightening to sit there and be waiting. Here's smoke I smell, people are screaming by, you know, going, 'Are you okay, are you okay?' 'Yes, I'm waiting for someone.' I'm waiting for someone. I'm waiting for someone. I hope someone comes." (Participant BJ)

> "When we wait, we're supposed to wait…in the hallway, in front of the door that has the stairwell. That's where we wait. We normally wait until they come tell us 'Yes, it's real,' or 'No, it's not real.'…Just

> because I'm just not trusting that people will remember we're up here, I'll usually tell two or three of my friends – 'Now remember, us four people are up here in this thing. So that if the firefighters need to know, can you all make sure to tell them?'" (Participant BW)

For some, the anxiety associated with the area of refuge is severe enough that they refuse to consider it as a viable option.

> "No, I'm not using [the area of refuge]. I'm not going to be stuck here hoping that people are going to come save me." (Participant AG)

> "There certainly is a requirement to have areas of refuge or rescue assistance, which they do have. And they do have a communication device in there and that is here I would wait for all the other people to get down the stairs who are above us. But frankly, in a drill that's fine. In a drill, I'm happy to wait there. In an actual emergency, I will get myself out because I don't trust that the fire department – who knows when they're coming. Who knows what could happen before that time. So my feeling is I'm…getting out." (Participant AO)

> "And this area of refuge thing is such a…give me a break. I'm not staying in the building; I'm using every resource I have to get the hell out of the building." (Participant AV)

5.9 Summary

Table 6 provides a summary of the benefits and concerns for each of the emergency evacuation methods discussed by the participants in this study.

Table 6. Summary of benefits and concerns for current evacuation methods

Evacuation Method	Benefits	Concerns
Existing passenger elevator	• Means to evacuate the building quickly and easily • Familiar • Keep mobility device • Safety of others	• Fear and anxiety • Communication • Waiting time • Stopping on other floors • Elevator size • Operation may require assistance • In some buildings, the elevator does not lead directly to an exit • Need for a backup plan
Existing freight or service elevator	• Safety • Elevator size • May go directly to exit	• Not readily available to occupants • Inaccessible for occupants with mobility impairments • Unfamiliar
Emergency stair travel devices	• Ability to evacuate the building • Physical safety • Can evacuate along with coworkers	• Loss of mobility device • Physical risk • Anxiety • Requires assistance • One emergency stair travel device per person per trip
Walking down stairs	• Independence and control	• Slow • Risk of injury or physical harm • Exertion and recovery time
Taking stairs in wheelchair	• Independence and control • Remain in wheelchair	• Risk of injury to self or others • Risk of damage to wheelchair
Crawling or sliding on stairs	• Ability to evacuate the building • Independence and control	• Risk of injury or physical harm
Being carried	• Ability to evacuate the building	• Risk of injury or physical harm • Loss of mobility device
Area of refuge	• Safety in a known location while waiting for rescue • Communication with security and rescue personnel	• May be inaccessible and unusable • Anxiety

6 Evacuation Plans and Training

During the interview, each study participant was asked what they are supposed to do in a fire emergency and whether they had received any type of training on evacuation procedures during a fire incident. After they provided their answers, they were asked if they were satisfied with the training, and why or why not.

A wide range of evacuation plans and training were reported by participants, from none at all to regular discussion and practice. Section 6.1 presents participant comments about the emergency plans in their workplaces, divided into positive and negative aspects. Section 6.2 presents attitudes toward training. An interesting finding from these discussions was the number of participants who admitted to having an alternative evacuation plan in mind – Section 6.3 addresses this phenomenon. In addition to being occupants in buildings where they are employed, participants also visit other buildings in order to perform their job function. Many of the study participants are also responsible for the safety of clients visiting their buildings. Thoughts from study participants about including visitors in emergency planning are provided in Section 6.4.

6.1 Emergency Plans

Many participants described in detail the procedures that the emergency plans in their buildings or agencies expect them to follow. Other participants explained that they actually didn't have any idea what they were supposed to do in an emergency. A few had approached their facility managers to ask how they should respond to an emergency alarm and did not receive a satisfactory answer. The factors that contribute to plans that work are discussed in Section 6.1.1, and those factors that contribute to plans that don't work are in Section 6.1.2.

6.1.1 Satisfaction

Participants were asked if they were satisfied with their evacuation plan and what satisfaction meant to them. Responses for those who said they were satisfied included a detailed, well-organized, and practiced plan, written policies, knowing there were evacuation options such as an emergency stair travel device, trust in the security/emergency personnel, and being included as part of the planning process.

> "People know their roles, people know where they're supposed to be, and people know how to use the equipment that they've been given." (Participant AJ)

Trust requires good leadership, attention to the needs of all building occupants, and a habit of listening, both before and after an emergency event. When an emergency occurs, emergency personnel are present, assessing the situation, directing the action, and making sure that everyone is accounted for. After the event, building and emergency managers ask people with mobility impairments for their opinions on what improvements they could make to the evacuation plan and process.

> "[I feel confidence because of]…my trust in my colleagues, first and foremost – that they'd be concerned for my well-being, as I would be for theirs...I've gotten to know pretty much all [of the security folks] through the years. Head of security…is a great guy – he and I have discussions all the time. So yes, I think trust is at least an element of your sense of exposure and vulnerability or comfort." (Participant AX)

> "Well, at least for myself or for any new employee that has a disability, you know, have that person attend an evacuation class or have the individual that's in charge of evacuating people in the building ...set up an appointment with that person and go over the evacuation process, show them the locations, where to go, and you know, just have a conversation with that person and explain to that person, you know, in case of an emergency, what is expected." (Participant CE)

Several participants stated that having an elevator for evacuation would make them feel both safe and satisfied.

> "[I define satisfaction as] feeling safe with the protocol that has been established. But, I will say that if I had the ability to go down the freight elevator every time that they said…or during a real emergency, that I would feel safer." (Participant BV)

> "Yes, it's been detailed but, in reality, how do we really put it into practice because maybe if we were able to just flash out in the elevator I'd feel a little better." (Participant AB)

6.1.2 Dissatisfaction

If participants responded that they were not satisfied with their plan, they were asked why or what could be changed so that they would be satisfied. Reasons for dissatisfaction included having no plan, not being asked for input during the planning process, not having a designated person to oversee evacuations, and not understanding how the plan would keep them safe.

Participants were unhappy if there was no plan for how to deal with their safety in an emergency.

> "[The fire marshals who are assigned by the building] told us what we needed to do, who they were, and everything that the building had and planned for the people who are able-bodied and could get around and who are mobile. After that, even though our floor has agencies that, at any number of times, have quite a few people with mobility impairments—whether there are walkers, crutches, wheelchairs—asking the fire marshals what was the evacuation plan, they didn't have

> any. They told us that they would have to get in touch with the building who hired them to see what they had. And they never got back to us…" (Participant AA)

> "I think they are relying a lot on the fire department to figure this out, or the building people. Assuming that it's not an emergency. I was hoping they had a little more detailed plan of what they were going to do if one had to do something before the fire department got here. But I think they're counting on the fact that they will advise the building and that they will keep me in the stairwell until that happens." (Participant AC)

People in different areas of the building can have very different experiences on emergency planning and training. One participant described a move from one agency to another in the same building:

> "The whole time I was on the second floor, there was never any discussion about what happens if you have a fire drill. I didn't have any appointed buddies, as it were. It was very striking to me, because the moment I came to work and moved to the fifth floor in a different agency, they had a protocol, they have a process, they made sure that it was documented, they made sure that we knew who the buddies were, and that the floor captains knew I was there and what was going to happen. The agencies are supposed to follow similar processes. But it just struck me that with my prior agency, this had never been addressed. And this one was very on top of things, had things very organized in a good way." (Participant BZ)

This story ends well, as the participant related this discovery to a coworker in the previous agency, who talked with building management and succeeded in having emergency protocols installed throughout the building.

It was important to participants for members of security or facility managers to ask them for their input on the evacuation plan.

> "I think it's, like I said, if the building manager takes that and owns it as their responsibility and I think really is clear about communication and roles, and follows up every six months and checks in with people, staff changes and times. Making sure that there are assigned roles and that those roles have been filled by somebody else, taking a more active role in that and taking it seriously. I just felt like the previous building management felt it was something that was mandatory that she had to do but didn't really take it seriously." (Participant BB)

A lack of understanding of the plan and how it will transport everyone to safety contributes to anxiety.

> "[You have to] have faith that you're not going to be forgotten about and that everyone is going to know what to do. And you have a stairwell that people are going to be walking down, as well. So now, do you wait until everyone has evacuated the building that can do so by foot and then carry chairs down? Or, are you trying to navigate the pedestrians along with the chairs down a crowded stairwell? So those are the questions I have. And I don't have answers to. And…I know there are some other wheelchair users who work in this building who are on other floors. So, what does a sweep look like? Do you take people from the higher floors first, and then the lower floors? ... Because I don't know—fire departments, I imagine they deal with hospitals and they deal with nursing homes, and places like that. But I don't know what their plan is when you have a multitude of people using mobility devices in a large building and where you have people, potentially, on many floors that need assistance evacuating." (Participant AT)

6.2 Training

Preparedness for an emergency evacuation requires not only a plan but regular practice. The benefits of fire drills include making the emergency response second nature, reducing the stress of the situation. They also illuminate any weaknesses in the emergency plan, which can be addressed before an actual incident occurs. Training can include education on the plan itself, combined with an actual emergency egress and relocation drill and/or discussion of what each individual is expected to do.

It should be noted that many study participants admitted that they would rather avoid emergency egress and relocation drills (e.g., fire drills) because of added stress or physical discomfort.

6.2.1 Emergency Egress and Relocation Drills

Participants who said they were satisfied with their training often contributed this to regular drills, which made them fully aware of the plan and well-prepared. The drills conducted by their organizations were routine and well-organized.

> "So our staff actually, we have a very robust safety training program here, I think. And so there are people on each floor who are trained to really walk through the whole floor and tell people where to find the exits that they can use and they know to push people who would need assistance to those two floors where the chairs are. And then staff who are trained are there watching." (Participant AK)

> "Yes, relatively satisfied. I mean I have done two or three practice drills. I do know they were organized; they did get everybody out there. I mean

> they didn't put me in the stairwell at that point but there was a fire marshal who came and talked to all of us at that time." (Participant AC)

Many participants spoke about the importance of gathering feedback after an evacuation drill had occurred.

> "All the fire inspectors, they're in this building. So I know most of the fire inspectors, the captains. So usually, like when they come up for procedures, they'll come talk to us. "So what do you think?"…"What's your opinion on it?"...[It gives you] a higher comfort level." (Participant BY)

As mentioned in the section on emergency stair travel devices, the drills were especially important for this evacuation method – not only to familiarize those with mobility impairments with the procedure, but also to train the coworkers who would take responsibility for their safety.

> "It's scary but I didn't realize, at first I didn't want to get on it (emergency stair travel device) when they did the training in the beginning. But, after seeing it being put into use, and you see how it really is simple to use. Because all you have to do is hold on to the grips." (Participant AA)

Some participants mentioned that they may be informed about a fire drill in advance so that they could avoid the drill. The warning is often appreciated because of the dread of evacuation and the potential of injury.

> "There is a fire drill tomorrow and I am going to go get coffee because I am not going down the steps." (Participant AS)

> "I shouldn't say it but if I know that's there's going to be a fire drill, I'll go get a cup of coffee. They're pretty good at not giving heads up warning and, as a supervisor, I wouldn't give it. But, if I was coming toward the building and I saw people evacuation, I'll just go back and drink more coffee. …And if they're going to have a fire drill, they're not going to give anybody a heads up because it's pointless because everybody would be out of there." (Participant BC)

> "They are having a fire drill at my work this afternoon and several different people made a point to let me know that I might want to avoid the area. (Participant CI)

> "If I know there's going to be a drill, I try to work from home, truthfully. It just saves so much headache. …You don't want to be forced to go down steps and stuff when you know that you're going to pay for it for days afterwards. …If someone has bad knees or…a bad back and neck, when you go down the steps, yes, you might make it down the steps, but

> you're probably going to pay for it anywhere from the next two days to two weeks." (Participant CT)

> Well, normally what happens when I see the fire trucks pulling up as I run to the elevator and go to the ground floor before they hit the alarm, because the elevators go to the ground floor and won't go anywhere. So, basically, I just kind of beat the alarm and head out." (Participant BX)

6.2.2 Inadequate Training

Participants who said they were dissatisfied with emergency evacuation training complained that it was lacking, infrequent, or cursory.

> "Sadly, my first thought is, 'I'm satisfied because I'm in denial that it's going to be an issue.' It's a funny question, too, because I'm the one responsible for figuring it and so it's hard to say, 'No, I'm not satisfied.' But, no, I think we could and should do a better job of going over it regularly and really thinking through all the 'what-ifs' and making sure people have practiced doing what we need to do." (Participant AI)

> "I don't fault anybody, so I don't know why people are assigned to do something that they're really not trained to do. And one training is not enough. Two trainings is not enough. If this is the only system they can come up they have to be trained twice a year, three times a year, or whatever to understand all this." (Participant AG)

Participants who were informed about a fire drill in advance and chose to skip them were aware that there was a definite downside for not being involved in the practice.

> "[In response to 'What has worked for you in fire evacuations in the past, including these drills?'] It's going to sound flippant, it's not meant to be, but being at home on tele-work on the days they do those. Which is not particularly a help with when the question is, how do you get out of the building?" (Participant CU)

> "And I'll be frank with you, I do avoid… I will say that I kind of avoid like, Okay, this means a day when I won't be down. I studiously avoid being down…. I mean, I understand the irony in that. You are a person with a disability and you would think you would want to prioritize your safety in the event. But I've experienced it once and I just don't want…[to go down in the chair]" (Participant AX)

6.3 Personal Evacuation Plan vs. Official Evacuation Plan

A surprising response from a number of study participants was that they had little intention of following the official evacuation plan in an actual emergency, even if they

understood it well and had practiced it in drills. These individuals had their own plan to evacuate the building to safety.

Many of the participants in this category said that they were willing to wait in an area of refuge during a drill, but in an actual emergency their own personal evacuation plan was to get themselves out of the building.

> "So, in this building, I am supposed to come with everybody to the fire stairs, which are located in the center of the building by the freight elevators. …Everybody else would be instructed to proceed down to two floors beneath, which is considered the next safety floor. And I am instructed to wait by the freight [elevator]. And we all know that's not what's going to happen. Everybody is going to go down to the lobby and exit the building, and I'm going to rush to these elevators and take the first one that comes for me. …I have a separate system with [a colleague]. …I have direct cell phone contact for [him], and he has made a promise to take me on his back, and we're going to run for it." (Participant CL)

> "And, if they take *me*, carry me out of here, put me on the curb across the street, then what? My chair is here, how do I go home? I mean, you know, and the building is devastated, let's say? Then what? …My life is saved, which is wonderful, however, now what do I do? So, I thought this through and, like I said, people better get out of my way because I'm going to that elevator and I'm going down." (Participant AG)

> "[The people who have volunteered to assist me and I are] getting out as fast and as furiously as we can, as close to the main or any alternate exit as we can, as quickly as we can, and the most efficient way that we can. … And I'm not sitting waiting for anybody, and I don't care what their procedures are, or what they say prior to." (Participant AV)

> "I told the folks that were with me, that were assigned to be with me, 'Okay, this is how I'm going to do this. I'm not going to hang around on this floor and wait. I'm going to get out. There is a way to do it. I'm going to explain it to you and you're going to help me do this.' And they all went, 'Okay.' And so we did." (Participant BX)

Despite the pervasive warnings that everyday elevators are not to be used during a fire, some participants plan to take that risk, if they can get to the elevator before it is taken down to the ground floor and taken out of operation.

> "So yes, the elevators were pretty unsafe. But, frankly, if I had a choice between using the elevators vs. staying there and waiting, I would probably use the elevators, and pray the whole time. It would be 20-30 seconds of emotional hell, but, you know." (Participant AN)

6.4 Including Visitors in Evacuation Plan

Many participants talked about the need for an emergency evacuation plan that includes visitors to the building. Several work for agencies that are responsible for the welfare of clients or meeting attendees with disabilities that visit their offices every day. Others are frequent visitors themselves to multi-story buildings.

> "It was always on the drills that you get that 'aha' moment, like maybe something is wrong. It's that when the drills come, it's good to have them, because you never know who we have and we are an agency that we work with people with all disabilities. We have people who are blind, people who are deaf, people with mobility [problems], people [who are] blind AND deaf. We have people who are neurological, like our coworker who goes into seizures. And so when those drills, it allows us to see how unprepared we are and the importance of becoming prepared because we never know who we are seeing that particular day and what obstacle or barrier they may have if we have to evacuate. …I think we feel a responsibility that if they're here on our invitation, that if something was to happen, we're not just going to leave them alone. …We have a responsibility to try and get our clients out, and we can't just flee." (Participant AA)

Study participants were less worried about visitors with mobility impairments in their building when they knew that the emergency plan took them into account. Some buildings had extra emergency stair travel devices to handle visitors, and some planned to accommodate visitors in areas of refuge. Including visitors in fire drills provided useful practice.

As visitors to other buildings, participants did not know how they were expected to respond in an emergency. Sometimes this came as a sudden realization when they experienced a fire alarm in an unfamiliar building. They were uncomfortable with the idea of relying on strangers to help them.

> "If something happens in another building, I'm not familiar with their emergency protocols. …My colleagues here, we have all worked together for a number of years, we know each other and I would trust them. But, how can you make yourself available to be helped by folks who maybe you've been to meetings with but you don't necessarily know. Especially with something so personal where I would require hands-on help." (Participant AN)

7 Occupant Evacuation Elevators

This study demonstrates a need for better evacuation options for building occupants with mobility impairments. One participant described feelings of vulnerability after experiencing a fire alarm during an after-hours meeting in an unfamiliar building:

> "Up to that point, I had kind of known, intellectually, that the building codes require access but they don't guarantee safe egress for people with disabilities. The systems just aren't there. …If it starts to get really uncomfortable, just starts to be a lot of smoke on this floor, what are my options? And hoofing it down seven flights of stairs was my only other option. And it's like, 'Well, I may have a heart attack before I get to the bottom of it, but if I hang around on the fire floor, I'm going to be a roasty-toasty critter." (Participant BX)

Improvements in design, procedures, and education can make it possible to evacuate people from tall buildings using elevators [31]. A history of this effort includes a 1993 NIST workshop on elevator use during fires [32] [33].

Near the end of each interview, participants were shown a video about the design features of OEEs, as described in Section 2.2. Following the video, participants were asked their opinions about using an OEE for evacuation, including benefits, concerns, and recommendations for improving the design. In particular, they were asked to contrast the OEEs against the elevators they use every day, to find out whether and by how much the video had resolved their concerns. This section presents the perspectives of the study participants on these questions.

7.1 Benefits

> "I trust this elevator. It's fast, it's less work for everybody, myself included. Let's get the hell out of here and give it a shot." (Participant AV)

The video on OEEs presented several features that address the safety and anxiety issues associated with waiting for and using existing elevators for fire evacuation, including protection against heat, smoke, and water, communication, and direct transport to the main exit discharge floor. In addition, people with mobility impairments can evacuate at the same time as everybody else, using the same elevator they use to enter and exit the building during their normal workday (which is now an OEE) while remaining in their mobility device. The following benefits are listed in order of the number of participants who named them, from most to least frequent.

Safety

Above all, the study participants appreciated the intent of OEEs to provide a safe way of evacuating the building by elevator. The design of OEE addresses the risks from electrical failure and smoke and water penetration in traditional elevators. OEEs were particularly attractive to participants in comparison with the risks of injury experienced by occupants with mobility impairments in moving down the stairs by foot, in their manual wheelchairs, by crawling or by being carried. For those with sensitive skin tissue or fragile bones, OEEs also appear to be a safer option than transferring into and being transported in emergency stair travel devices.

Feelings of comfort or relief

The psychological benefits of the OEE appear to be numerous. People with mobility impairments don't have to wait in an area of refuge wondering if anyone is going to come to evacuate them. They can leave with the mobility device and do not have to worry about what they are going to do when they get to the street level. They also do not have to be concerned about who is going to assist them or if anyone will be in the office at that time to assist them. They can maintain their independence throughout the evacuation.

Most participants stated that the OEE as presented in the video made them feel more secure, relieving their anxiety about fire evacuations.

Communication

Study participants were enthusiastic about two-way communication with emergency personnel that would be present both in the elevator lobby and in the elevator itself. They found it reassuring to have a message board displaying information about the status of the elevator, including the fact that other floors were being evacuated. This feature would allow both them and their coworkers to make informed decisions on whether to wait for the elevator or to take the stairs.

Speed

Many participants saw the OEE as a way of getting out of the building quickly, alongside their coworkers and without waiting for assistance.

Independence

Participants again brought up the importance of being able to stay with their mobility aid.

> "[The benefits include] the ability to, essentially, evacuate immediately without any separation from your wheelchair. So you leave with what you came with, you leave whole." (Participant BC)

Straight from danger zone to exit point

Running the elevator in an emergency mode that brings the elevator straight from the floor being evacuated to the ground floor was very appealing. Participants appreciated both that this system prioritized the people on the floors with the greatest danger and that

the trip would be much faster without stopping on intermediate floors (especially if the elevator is already full).

Consideration of others

Several participants pointed out that using the OEE would spare their coworkers from risking injury from lifting them, and that firefighters would be able to put their full attention on extinguishing the fire.

> "It gives me the ability to be…responsible for my own safety rather than having to wait on the good graces of others. I don't want someone to be in danger to get me out if they don't have to. I don't care if it's a coworker, fireman, or whoever." (Participant CU)

Efficiency

Participants appreciated that the OEEs could carry large numbers of people quickly out of the building. In addition, the communication encourages those who can to use the stairs, thus spreading the evacuation over more pathways.

> "That kind of elevator would be very useful in getting a building quickly evacuated because it takes time to go down those stairs and the more people you can get out quickly, especially from the higher levels, the less likely there is to be a real disaster." (Participant CX)

Adds an option

Participants who were comfortable with the evacuation methods currently available to them appreciated that the OEE would provide an alternative option for responding to a fire.

Getting out

For some participants, the simple fact that the OEE allows them to get out of the building in a fire was important. This again reflects a discomfort with the idea of the area of refuge, which confines people who are unable to evacuate by the stairs within the building while their coworkers escape to safety.

Everyone can use it

Finally, a small number of participants expressed their enthusiasm about the elevator as a universal option that everyone could use to evacuate the building in case of emergency. These people saw the OEE as an inclusive method that erases the differences between those with and without mobility impairments, enforcing the view of each other simply as coworkers.

7.2 Concerns

Although the concept of OEEs was generally well-received, participants still voiced concerns about their use. These concerns could generally be classified as continuing anxiety about physical danger, policy issues such as priority evacuation for those with disabilities, and aspects of elevator design that were not addressed in the video.

Physical danger

> "If I know that it was tested in a fire, I would feel more comfortable. I would love to be able to take the elevator down." (Participant AR)

> "I guess, because it's so against what we've been trained and taught, you have that build-in hesitance. …It's almost like you're trained, "Go and wait here,' versus, 'Go and get in that elevator.' You're almost trained that you're safer to wait for assistance than to get into that elevator." (Participant CH)

For OEEs to be successful, occupants need to consider them a safe option. A major educational effort would be required to counter decades of the message that elevators must never be used for evacuation in a fire. Some participants would be satisfied with a simple declaration that the elevator in their building is now safe to use in a fire emergency. For others, reassurances that OEE design had taken care of problems with electricity, heat, smoke, and water would not be convincing enough. These participants wanted additional proof of these claims before they could let go of concerns that the elevator could fill up with smoke, the elevator could stop working, or they could be trapped. They will need to be convinced with technical explanations of how the system works, test data and other evidence. Ideally, a knowledgeable expert would provide this information in a setting that allows the occupants to ask questions.

Priority use of elevators

Many of the study participants expressed concern over priority use for OEEs. Since using the elevator would be the quickest way out of the building, especially on high floors, people with mobility impairments may be competing for space with those who are capable of evacuating using the stairs.

> "I think it doesn't address the crowding issue at all. In fact, I think my vision of having the elevator doors open, it'd be like a packed car already. And it wouldn't just be five people waiting for the elevator, it'd be like the whole floor or whatever. So I just don't think there's a way to manage that because I think most people are going to perceive that to be the fastest, easiest way to get out. So whether they need to do it that way or not, they will do it that way." (Participant AP)

Of particular concern to users of large wheelchairs is the amount of space they require, which makes it difficult to squeeze in after the elevator starts to fill. One participant (AI)

referred to this as the “Tetris of fitting people in an elevator,” the solution to which is to let wheelchair users enter first and have those who walk squeeze in among them.

Some participants were concerned about whether others in the building would give them priority without some kind of enforcement. They provided a range of suggestions for doing this, including posted signs, announcements during evacuation, a first responder or other person with authority riding in the elevator to oversee its use, and the distribution of special keys for operating the elevator during evacuation mode.

Participants mentioned that some occupants in their building may have hidden disabilities that they have not shared with coworkers or human resource staff, but that would make it difficult to walk all the way down from a high floor. These could include heart or respiratory conditions, fatigue, illness, or temporary injuries. This makes setting the priorities for OEE use during emergencies a task that requires careful thought.

Another concern was how the decision would be made as to which floor would be evacuated first and in what order the floors would proceed. This concern highlights the need to educate building occupants on the codes and standards developed for OEEs, which include the order of evacuation based on the floor or floors that are compromised by fire and/or smoke.

Design issues

Although participants found much to like about the OEE design, they also pointed out some design issues that were not addressed in the video. These included the accessibility of the elevator lobby as well as the elevators, along the lines of the problems with reaching and pressing the elevator buttons that have already been discussed in this report.

Accessible communication requires Braille to accompany signage and audio messages in addition to written ones.

Also mentioned was the need for the OEE doors to remain open long enough to allow people to maneuver their wheelchairs inside, or for people who move slowly with walkers or canes to enter.

8 Fire Evacuation Guidance Regarding Elevators for People with Mobility Impairments

The disability community has adopted the saying, "Nothing about us without us" [34]. In the case of fire evacuation planning, this expression is particularly applicable. People with mobility impairments are aware that their evacuation options are limited. They have a unique perspective on evacuation issues due to their daily experiences as well as their enhanced vulnerability. The development of new procedures, technologies, and designs for response to fire emergencies, including the use of elevators for evacuation, will benefit from their voices.

The participants in this study raised a number of ways to reduce their anxiety about fire evacuation and increase their trust that they would be able to safety evacuate. These include education and consultation in preparation for the evacuation, information and attention to their needs while the evacuation is taking place, and two-way feedback and discussions afterwards. Improving the evacuation procedures for occupants with mobility impairments will make everyone safer.

This study identifies a wide range of issues surrounding the evacuation of occupants with mobility impairments. The following key points resulting from this study provide insight and understanding that are intended to assist designers, facility managers, and fire emergency personnel to improve designs, technologies, and emergency procedures for safer evacuation of occupants with mobility impairments.

Key to all of these issues is the need to include those with mobility impairments in the planning and execution of fire evacuations and to facilitate their ability for self-evacuation as much as is practicable.

8.1 Evacuation Planning and Procedures

This study highlights the need for facility managers of multi-story buildings to establish an emergency plan that addresses fire evacuation for people with mobility impairments, to communicate with these occupants during and after plan development, and to carry out appropriate training consistent with the plan. Practices that would improve the evacuation experiences of occupants with mobility impairments are also included in this section.

Planning

- An emergency evacuation plan is essential. It must include provisions for those with mobility impairments. If they are not included, they may find it necessary to develop their own plan.
- Include building occupants with mobility impairments in the emergency planning process from the beginning.
- Involve building occupants with mobility impairments as essential partners in developing the plan.

- Ask building occupants with mobility impairments how their concerns about being isolated and forgotten in the building can be reduced.
- Ask building occupants with mobility impairments if they want or require assistance during evacuation.
    - If a person needs one or more coworkers to assist them during evacuation, they will also need backups for those assistants.
- Provide multiple options for evacuation. Building occupants with mobility impairments should be informed about these options and allowed to provide input on them.
- Include after-hours evacuation procedures for building occupants and visitors with mobility impairments in the emergency evacuation plan.

Training

- Provide periodic refresher training courses for all building occupants on the building's evacuation plan.
- Encourage building occupants with mobility impairments to take part in emergency egress and relocation drills. Their participation and feedback is important.
    - Make training a comfortable experience for building occupants with mobility impairments, so that they feel comfortable participating and practicing
    - Work out solutions to training concerns with building occupants with mobility impairments (e.g. allow them to witness a willing participant first before engaging in the training activity, talk through and simulate the evacuation).
- Consult with building occupants with mobility impairments before and after each training session.
- Prepare an information sheet (e.g., a laminated card) that contains emergency instructions and a map, and make it available for all building visitors.
- Use a trusted source to provide the fire evacuation training courses. This credible source may differ by population type within the building.

Execution

- Understand the needs of building occupants with mobility impairments and act accordingly. This includes asking these individuals for their preference of evacuation options that may be available within the building. This builds the trust in this process.
- To the extent practical, ensure that the mobility device used by the building occupant with a mobility impairment is with them during the evacuation.

- To the extent practical, minimize the time that a building occupant with a mobility impairment is awaiting assistance to evacuate the building,
- Understand that building occupants with mobility impairments are going to leave the building if they can, and it is important to facilitate that as much as possible.

Communication

- Provide the ability for building occupants with mobility impairments to communicate with emergency personnel while they are waiting for evacuation.
- Allow building occupants with mobility impairments to wait for assistance only in a comfortable and safe area that is known to their management, building security, and fire safety personnel. Within the safe area, there should be a way (e.g. video cameras, two-way communication system) to let management, building security, and fire safety personnel know that they are awaiting assistance.
- To the extent practical, use messages and signage that clearly state what occupants should do during the evacuation and who should do it (e.g., which elevators are available for evacuation and where they are located). Follow best practices for warning guidance [35].
    - Provide message updates as the situation changes.

8.2 Existing Elevators

ASME A17.1 Safety Code for Elevators and Escalators defines elevator operation in existing buildings during a fire emergency [17]. In Phase I, activation of smoke detectors or other automatic fire detectors in a lobby or machine room associated with an elevator automatically recalls the elevator to a designated level. In Phase II, elevators are under the control of firefighters. Firefighters may use elevators to evacuate building occupants with mobility impairments.

A decision to expand the use of elevators in existing buildings for evacuation of building occupants with mobility impairments in a fire emergency requires careful consideration of the elevator's design and controls. The criteria for deciding whether and when to use the elevators for fire evacuation are outside of the scope of this project and document. Current national codes (e.g., International Code Council (ICC), International Building Code, NFPA 101, Life Safety Code, and NFPA 5000, Building Construction and Safety Code) have introduced new requirements that are options for architects to consider when designing tall buildings. These requirements permit the use of passenger elevators for building occupants to be designated as occupant evacuation elevators. The use of these elevators is intended for all building occupants prior to Phase 1 recall activation of all building elevators. These requirements provide a resource for one to review for consideration when developing building-specific procedures for elevator use during fire emergencies.

If, after reviewing the building-specific elevator design, the facility management decides that existing passenger, freight, or service elevators may be used as part of fire evacuations, multiple fire evacuation options may be considered. These options include:

1. Designate specific elevators to be used during fire emergencies by responding fire department personnel during Phase II emergency in-car operation for the purpose of evacuating persons with mobility impairments. Building occupants with mobility impairments are to wait at designated elevator landings or designated staging areas and await further instructions and assistance from the responding fire department. It should be noted that under a non-fire emergency, the fire department may not respond. This issue should be addressed in the building emergency plan. This option is the most common and may be the only option if facility managers decide that existing elevators are not suitable for options 2 and 3.

2. Designate elevators to be used during fire emergencies by a trained elevator operator in the normal elevator operating mode prior to Phase I emergency recall operation for the purpose of evacuating persons with mobility impairments.

3. Designate elevators to be used during fire emergencies for self-evacuation by persons with mobility impairments or with the assistance of designated personnel in the normal elevator operating mode prior to Phase I emergency recall operation.

Evacuation strategies and procedures should also address fire emergencies occurring after normal business hours. In addition, the emergency plan should address visitors to the building.

Note that the intent of this section is to provide insight on use of existing elevators for fire evacuation of people with mobility impairments in the event that facility management has decided that this is a viable option. The criteria for deciding whether and when to use the elevators for fire evacuation are outside of the scope of this project.

Design Considerations

- Elevators should be large enough to hold more than one wheelchair, or to enable wheelchairs to turn around within the car.
- Consider augmenting signage in the elevator lobby with voice communication to allow communication with those waiting for an elevator during evacuation.
- Consider using Braille to accompany the call button in the elevator lobby.
- Call buttons associated with the elevator and communication system should be accessible, both in both location and the pressure required to press them.

Education

- If the existing elevator is an evacuation option during a fire emergency, educate building occupants with mobility impairments on their use. Counter concerns that the elevator would not be safe to use in a fire emergency by allowing occupants to meet and talk with fire safety experts regarding the safety of the elevators.
- During education sessions,
    - Discuss the reliability of the elevator system and the back-up systems in place to make sure they run safely in case of power loss or other operational challenge.
    - Provide information on preventative maintenance.

Communication

- To the extent practical, provide the ability for people with mobility impairments to communicate with emergency personnel while they are waiting for evacuation.
- To the extent possible, provide the ability for people with mobility impairments to communicate with emergency personnel while evacuating by elevator.
- Consider messages and signage to clearly state what people should do and who should do it, including which elevators are available for evacuation. Follow best practices for warning guidance, where possible [35].
- Make sure the information and signage is clear during the evacuation. Ensure that building occupants are aware when the elevators are out of service.

Procedures

- Give preference for elevator use during a fire emergency to wheelchair users and others with mobility impairments. Building occupants able to negotiate the exit stairs should use the stairs until all those with mobility impairments have been evacuated. Possibilities for promoting this preference include:
    - Use training to establish a building culture that encourages preserving priority use of elevators to those with mobility impairments
    - Post and repeat statements such as: “Thank you for keeping the elevators accessible to everyone” or “Reminder: During building evacuations the elevators are to be used primarily for people with disabilities.”
    - Place someone with authority, such as a floor warden, in the lobby to enforce priority use by those with mobility impairments and to help with overcrowding issues.
- If using Option 2 (i.e., a trained elevator operator), provide specific procedures and training to the person with authority who will operate the elevator and accompany the occupants in the elevator.

Options

- Provide alternative evacuation options for building occupants with mobility impairments. Possible options include emergency stair travel devices, areas of refuge, and assistance moving down the stairs. Building occupants with mobility impairments should be informed about these alternative evacuation options and allowed to provide input on them. Options should be developed in consultation with building occupants with mobility impairments.
- Make clear that elevators are one option – not the only option.

8.3 Occupant Evacuation Elevators

New high-rise buildings may include occupant evacuation elevators (OEEs) as part of the design of the building. The guidance in this section is intended to improve the ability of building occupants with mobility impairments to safely and comfortably use this option.

Design Considerations

Design codes for OEEs include design provisions that address accessibility requirements for use in emergency evacuation, such as voice communication and accessible call buttons. Additional guidance includes:

- Elevators should be large enough to hold multiple wheelchairs, or to enable wheelchairs to turn around within the car.
- Consider using Braille to accompany the call button in the elevator lobby.
- As technology advances, consider coordinating emergency communication, elevator signage, lobby signage, and elevator operations. For example, when the call button is pressed, lobby signage could indicate the availability of the elevators for evacuation and the estimated time duration in minutes for the next elevator to arrive.

Education

- Provide multiple means for education on OEEs for building occupants with mobility impairments. For example, allow them to meet and talk with fire safety experts regarding the safety of these elevators.
- During the education/training –
    - If available, provide examples of successes, including how and where OEEs have been used to safely evacuate the building population.
    - If available, provide information on where and how OEEs have been used or practiced in fire emergencies.
    - Provide information on preventative maintenance.

- During education sessions, discuss the reliability of the elevator system and the back-up systems in place to make sure they run safely in case of power loss or other operational challenge.

Communication

- Provide the ability, where possible, for people with mobility impairments to communicate with emergency personnel while they are waiting for evacuation.
- Provide the ability, where possible, for people with mobility impairments to communicate with emergency personnel while evacuating by elevator.
- Provide timely information to support decision-making on evacuation and sheltering options, for example by following the guidelines set forth in [36]. Information should include type of emergency, status of evacuation, location of fire, and if possible where they are in the queue to be evacuated.
- To the extent practical, in addition to a telephone inside the car allowing for communication with the command center, provide a mechanism allowing the people inside the car to see that someone is there at the command center (available to answer if there is a problem).
- Use messages and signage to clearly state what building occupants should do and who should do it, including which elevators are available for evacuation and where they are. Follow best practices for warning guidance [35]. Provide message updates and feedback as the situation changes.
- Make sure the information and signage is clear during the evacuation, while elevators are functioning as OEEs. Ensure building occupants are aware when the elevators are out of service.

Procedures

- Give preference for OEE use to wheelchair users and others with mobility impairments. Building occupants able to negotiate the exit stairs should use the stairs until all those with mobility impairments have been evacuated. Possibilities for promoting this preference include:
    - Use training to establish a building culture that encourages use of OEEs during evacuations while preserving priority use to those with mobility impairments
    - Post and repeat statements such as: “Thank you for keeping the evacuation elevators accessible to everyone” or “Reminder: During building evacuations the elevators are to be used primarily for people with disabilities.”
    - Place someone with authority, such as a floor warden, in the lobby to enforce priority use by those with mobility impairments and to help with overcrowding issues.
    - Consider reserving a time period in the beginning of the evacuation for people with mobility impairments only. During this designated time

period, appropriate signage could state: “Elevators are in priority mode. If you can, please use the stairs.”

Options

- Provide alternative evacuation options for occupants with mobility impairments. Possible options include emergency stair travel devices, areas of refuge, and assistance moving down the stairs. Building occupants with mobility impairments should be informed about these alternative evacuation options and allowed to provide input on them. Options should be developed in consultation with building occupants with mobility impairments.
- Make clear that elevators are one option – not the only option.

Acknowledgments

The authors would like to thank Dave Frable, Senior Fire Protection Engineer at the General Services Administration, Public Buildings Service (GSA/PBS), and Edwina Juillet, Director of the National Task Force on Fire and Life Safety for People with Disabilities, for their help with developing the instruments used during the interviews. The study could not have taken place without the dedicated disability advocates in each city who helped us to recruit participants, starting with Marsha Mazz, Director of the Office of Technical and Information Services at the U.S. Access Board. Many thanks to the courageous, thoughtful, witty, capable, and determined individuals who shared their experiences and their thoughts with us. We learned so much from each of you.

This work was partially funded by the U.S. General Services Administration under Agreement PX0013773.

References

[1] U.S. Access Board, "Americans with Disabilities Act and Architectural Barriers Accessibility Guidelines," U.S. Access Board, Washington, D.C., 2004.

[2] J. L. Bryan, "A selected historical view of human behavior in fire," *Fire Protection Engineering,* vol. 16, pp. 6-13, 2002.

[3] B. M. Levin, "Fire and life safety for the handicapped: Reports of the Conference on Fire Safety for the Handicapped," in *Workshops on Life Safety for the Handicapped, held in Washington, DC and Sacramento, CA. August and September 1979. NBS Special Publication 585,* Washington, DC, 1980.

[4] National Institute of Standards and Technology, "World Trade Center Disaster Study," [Online]. Available: http://www.nist.gov/el/disasterstudies/wtc/index.cfm.

[5] J. D. Averill, D. S. Mileti, R. D. Peacock, E. D. Kuligowski, N. Groner, G. Proulx, P. A. Reneke and H. E. Nelson, "Federal Building and Fire Safety Investigation of the World Trade Center Disaster: Occupant behavior, egress, and emergency communications," National Institute of Standards and Technology, Gaithersburg, MD, 2005.

[6] R. R. Gershon, M. S. Rubin, K. A. Qureshi, A. N. Canton and F. J. Matzner, "Participatory action research methodology in disaster research: Results from the World Trade Center evacuation study," *Disaster Medicine and Public Health Preparedness,* vol. 2, no. 03, pp. 142-149, 2008.

[7] T. J. Shields, K. E. Boyce and N. McConnell, "The behavior and evacuation experiences of WTC 9/11 evacuees with self-designated mobility impairments," *Fire Safety Journal,* vol. 44, no. 6, pp. 881-893, 2009.

[8] R. R. Gershon, K. A. Qureshi, M. S. Rubin and V. H. Raveis, "Factors associated with high-rise evacuation: Qualitative results from the World Trade Center evacuation study," *Prehospital and Disaster Medicine,* vol. 22, no. 03, pp. 165-173, 2007.

[9] M. T. Kinateder, H. Omori and E. D. Kuligowski, "The use of elevators for evacuation in fire emergencies in international buildings, NIST Technical Note 1825," National Institute of Standards and Technology, Gaithersburg, MD, 2014.

[10] National Fire Protection Association, "NFPA 101: Life Safety Code, 2015 Edition," National Fire Protection Association, Quincy, MA, 2015.

[11] N. C. McConnell and K. E. Boyce, "Refuge areas and vertical evacuation of multistory buildings: The end users' perspectives," *Fire and Materials,* vol. 39, pp. 396-406, 2015.

[12] J. Koo, Y. S. Kim, B.-I. Kim and K. M. Christensen, "A comparative study of evacuation strategies for people with disabilities in high-rise building evacuation," *Expert Systems with Applications,* vol. 40, no. 2, pp. 408-417, 2013.

[13] B. M. Levin and N. E. Groner, "Human factors considerations for the potential use of elevators for fire evacuation of FAA air traffic control towers, NIST GCR 94-656," National Institute of Standards and Technology, Gaithersburg, MD, 1994.

[14] M. J. Kinsey, E. R. Galea and P. J. Lawrence, "Human factors associated with the selection of lifts/elevators or stairs in emergency and normal usage conditions," *Fire Technology*, vol. 48, no. 1, pp. 3-26, 2012.

[15] International Code Council, "Section 3007 Fire Service Access Elevators and Section 3008 Occupant Evacuation Elevators, International Building Code 2015," International Code Council, Washington, DC, 2015.

[16] National Fire Protection Association, "Section 21.5 Fire Service Access Elevators and Section 21.6 Occupant Evacuation Elevators, NFPA 72-2016," National Fire Protection Association, Quincy, MA, 2016.

[17] American Society of Mechanical Engineers, "ASME A17.1 - 2013 Safety Code for Elevators and Escalators," American Society of Mechanical Engineers, New York, NY, 2013.

[18] Qualitative Research Consultants Association, "What is Qualitative Research?," [Online]. Available: http://www.qrca.org/?page-whatisqualresearch. [Accessed 21 July 2015].

[19] H. R. Bernard and G. W. Ryan, Analyzing Qualitative Data, Thousand Oaks, CA: SAGE Publications, Inc., 2010.

[20] E. D. Kuligowski and R. W. Bukowski, "Design of occupant egress systems for tall buildings," *CIB World Building Congress*, vol. 2004, 2004.

[21] Department of Justice, "2010 ADA Guidelines for Accessible Design," Department of Justice, Washington, DC, 2010.

[22] United States Access Board, "Architectural Barriers Act Accessibility Standard," 2005. [Online]. Available: https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-aba-standards/aba-standards.

[23] J.H. Klote, B.M. Levin, & N.E. Groner, "Emergency Elevator Evacuation Systems Proceedings," in *2nd Symposium, American Society of Mechanical Engineers*, Baltimore, MD, 1995.

[24] International Code Council, "Chapter 10 - Means of Egress, Section 1009 Accessible Means of Egress, International Building Code 2015," International Code Council, Washington, DC, 2015.

[25] G. E. Hedman, "Stair descent devices: An overview of current devices and proposed framework for standards and testing," in *Proceedings of Human Behavior in Fire, 4th International Symposium*, Cambridge, UK, 2009.

[26] G. E. Hedman, "Travel along stairs by individuals with disabilities: A summary of devices used during routine travel and travel during emergencies," in *Proceedings from the 5th International Pedestrian and Evacuation Dynamics Conference*, National Institute of Standards and Technology, Gaithersburg, MD, 2010.

[27] R. W. Bukowski, "Emergency egress strategies for buldings.," NIST, Gaithersburg, MD, 2009.

[28] E. Kuligowski, R. Peacock, E. Wiess and B. Hoskins, "Stair evacuation of older adults and people with mobility impairments," *Fire Safety Journal*, vol. 62, pp. 230-237, 2013.

[29] G. Proulx, "Evacuation planning for occupants with disability.," National Research Council, Canada, 2002.

[30] J. H. Klote, H. E. Nelson, S. Deal and B. M. Levin, "Staging Areas for Persons with Mobility Limitations," NISTIR 4770, National Institute of Standards and Technology, Gaithersburg, MD, 1992.

[31] G. Proulx, "Evacuation by elevators: Who goes first?," in *Workshop on the Use of Elevators in Fires and Other Emergencies*, Atlanta, 2004.

[32] J. Pauls, A. J. Gatfield and E. Juillet, "Elevator use for egress: The human-factors problems and prospects.," in *Symposium on Elevators and Fire*, Baltimore, MD, 1991.

[33] J. H. Klote, S. P. Deal, B. M. Levin, N. E. Groner and E. A. Donoghue, "NISTIR 4993: Workshop on Elevator Use During Fires," National Institute of Standards and Technology, Gaithersburg, MD, 1993.

[34] J. I. Charlton, Nothing About Us Without Us: Disability, Oppression and Empowerment, Berkeley, CA: University of California Press, 1998.

[35] E. D. Kuligowski, S. M. Gwynne, K. M. Butler, B. L. Hoskins and C. R. Sandler, "NIST Technical Note 1733: Developing Emergency Communication Strategies for Buildings," National Institute of Standards and Technology, Gaithersburg, MD, 2012.

[36] E. D. Kuligowski and B. L. Hoskins, "Recommendations for Elevator Messaging Strategies," NIST Technical Note, National Institute of Standards and Technology, Gaithersburg, MD, 2012.

Appendix A Questionnaire

Research on Evacuating Persons with Mobility Impairments: Questionnaire for Occupants with Mobility Impairments

Purpose
This questionnaire is being conducted by the National Institute of Standards and Technology (NIST), an agency of the U.S. Department of Commerce. *The efficient evacuation of people from fire in a high-rise building is a critical concern both for existing buildings and for the design of new buildings. It is particularly important to address the needs of people who have difficulties evacuating quickly during a fire emergency. Elevators may assist in solving this problem, if their safety is trusted. The focus of this research is to gain an understanding of the knowledge, views, and experiences of people with mobility difficulties regarding fire evacuation using elevators. The outcome will be guidance to designers and building managers on aspects of fire evacuation that concern occupants with mobility impairments and on how to improve elevator design and usage during fire emergencies.* *This questionnaire will ask you for basic information on your mobility with regard to evacuation, your previous evacuation experiences, and your preferences on how to evacuate during a fire emergency.* *Completing this questionnaire is voluntary, and you may choose not to answer any specific question. Your assistance will be greatly appreciated to help improve the safety of high-rise building occupants.*

Background

1) How many floors are in the building you work in? ____
2) What floor do you work on? ____
3) How long have you worked in the building? ____ (years)
4) During a normal workday, how do you move vertically from the main floor to your workplace?
   - ☐ Stairs
   - ☐ Elevator
   - ☐ I work on the main/ground floor
5) Please tell us about your everyday mobility on stairs, inside or outside of the workplace. Without assistance from another person but with the use of any mobility aid you normally use (crutches, cane, etc.), how many stairs can you go up or down?
   (Please choose the appropriate response for each item)

	Yes, easily	Yes, but with some difficulty	Yes, but with great difficulty	Not at all
A few steps?				
One flight of stairs?				
2 to 3 flights of stairs?				
4 or more flights of stairs?				

(For this research, a flight of stairs is defined as the stairs that lead from one floor to the next, even if they are in two sets.)

6) Please indicate which of the following mobility aids you use daily in your workplace:

- ☐ Crutches
- ☐ Cane/walking stick
- ☐ Wheelchair
- ☐ Other Please specify _____
- ☐ None of the above

7) How long have you been using one or more mobility aids? (Please select one.)

- ☐ Days
- ☐ Weeks
- ☐ Months
- ☐ Years

8) Do you require assistance during fire evacuations? (Please select one.)

- ☐ Always
- ☐ Often
- ☐ Sometimes
- ☐ Never
- ☐ It depends Please explain _____

Demographic Information

9) What is your age? (Please select one.)

- ☐ 0-25
- ☐ 26-35
- ☐ 36-45
- ☐ 46-55
- ☐ 56+

10) Are you? Male ___ Female ___

NOTE: This collection of information contains Paperwork Reduction Act (PRA) requirements approved by the Office of Management and Budget (OMB). Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA unless that collection of information displays a currently valid OMB control number. Public reporting burden for this collection is estimated to be 15 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed and completing and reviewing the collection of information. Send comments regarding this burden estimate or any aspect of this collection of information, including suggestions for reducing this burden, to the National Institute of Standards and Technology, Attn: Kathryn Butler, kathryn.butler@nist.gov, 301-975-6673.

OMB Control No. 0693-0066
Expiration Date: 8/31/2015

Appendix B Open-ended Interview Questions

Research on Evacuating Persons with Mobility Impairments
One-on-one Interviews with Occupants

Purpose
This interview is being conducted by the National Institute of Standards and Technology (NIST), an agency of the U.S. Department of Commerce. *The efficient evacuation of people from fire in a high-rise building is a critical concern both for existing buildings and for the design of new buildings. It is particularly important to address the needs of people who are less physically able to evacuate quickly during a fire emergency. Elevators may assist in solving this problem, if their safety is trusted. The focus of this research is to gain an understanding of the knowledge, views, and experiences of people with mobility difficulties regarding fire evacuation using elevators. The outcome will be guidance to designers and building managers on aspects of fire evacuation that concern occupants with mobility impairments and on how to improve elevator design and usage during fire emergencies.* *The interview is a follow-on to the questionnaire you previously completed for this study. It will ask you for more detailed information on your previous evacuation experiences, your awareness of emergency procedures, and your views and preferences on using an elevator to evacuate during a fire emergency. The interview will be one-on-one with a member of the research team, either in person or by phone.* *Participating in this interview is voluntary; however, your assistance would be greatly appreciated to help improve the safety of high-rise building occupants.*

Everyday activities

1) What is your normal pattern of movement at work, starting with your arrival at the work site? Take me through a normal day, noting how you travel around the building carrying out your everyday duties. Let's start with how you enter the building…then how you get to your office…etc. You can draw a map if you'd prefer.

   - Questions to probe the response, if needed:

     While carrying out your everyday duties, how do you get where you need to go?

     a) From the building entrance to the elevator or stairs
     b) Up to the floor where you work
     c) To carry out activities on the same floor
     d) To carry out activities on other floors
     e) To go to lunch
     f) To visit the restroom
     g) Down to the ground floor at the end of the workday
     h) To the building exit

Fire Evacuation Experience

2) Can you remember the last time the fire alarm sounded in your building?

3) Please tell me what you did, step-by-step.

   - Probing questions include:
     a) How did you feel when the alarm went off?
     b) Where (on what floor) were you located?
     c) How did you respond to the alarm (stairs, elevators, chair, area of refuge, etc.)?
     d) Where did you go to reach safety?
     e) Were you assisted by anyone?
     f) When did you evacuate – with everyone else or at some other time?

4) Can you remember anything about the fire alarm?

   - Probing questions include:
     a) Can you describe the alarm sound or intercom message?
     b) What did the message say?

5) What has worked during fire evacuations in the past, including drills? What has not worked?

   - Probing questions include:
     a) Have you had any concerns, problems or issues during your evacuation? If so, please describe what these were and why.
     b) Have you had any difficulties in reaching safety?

6) Are there any other fire evacuation incidents that come to mind? *Answer questions (3) through (5) for every experience.*

Fire Evacuation Procedures and Training

7) Please explain what you are supposed to do in a fire emergency. (It's OK if you don't know. In that case, please tell me what you would do.)

   - Probing questions, if needed:
     a) Where are you supposed to go?
     b) Are you provided with assistance (and if so, who provides assistance)?
     c) How will you get there?
     d) When are you supposed to respond – with everyone else or at some other time?
     e) Do you know if the building has emergency stair travel devices?

8) Have you received any type of training on evacuation procedures during fires? If so, what types of training have you received, both initially and periodically?

   - By training, we mean the following: reading pamphlets, watching a video, online classes, in-person class, participating in a practice drill.

9) Are you satisfied with the training for fire evacuation that you have received?
    a) How so?
    b) How do you define "satisfied"?
    c) Do you feel prepared enough to know what to do?

Fire Evacuation by Elevator

10) We would like to have your opinion on using elevators to leave the building during a fire emergency. First, we would like you to consider the entire process, including:
    a) Getting to the elevator lobby
    b) Waiting in the lobby
    c) Getting into the elevator
    d) Taking the elevator down
    e) Getting out of the elevator and into the ground floor lobby
11) Now let's talk about the elevator itself.
    a) First, how many elevators are in this building? Are there freight elevators?
    b) **[If the interviewee has not already mentioned using an elevator during previous experiences]** Is using an elevator to get out of the building during a fire an option that you have considered? If not, why not? If so, when would you consider using an elevator?
    c) Would you consider using the elevator you came in on in the morning? Would you consider a freight elevator?
    d) What benefits do you see in using an elevator to leave the building during a fire?
    e) What concerns do you have about using an elevator for fire evacuation?
    f) Can you think of any changes in procedures or design that would reduce your concerns about using an existing elevator during fire emergencies? What features added to an existing elevator system would make you feel safer? Are there any improvements that would reduce your concerns?
    g) What changes would make you most comfortable in the use of these systems?
12) **[After showing a video or explaining Occupant Evacuation Elevators (OEEs)]** So what do you think?

    List of features from the video:

    - *New elevator lobby signage*
    - *Direct access to stairwells from elevator lobby*
    - *Elevator lobbies and shafts that are protected from heat and smoke*
    - *Priority elevator service from the fire floor to the main lobby*
    - *Water kept away from elevator components*
    - *Two-way communication between lobby and fire command center*

    a) Would you be willing to use an OEE to leave the building during a fire emergency?
    b) What benefits do you see in using an OEE to leave the building during a fire?
    c) What concerns do you have about using an OEE for fire evacuation?

d) Can you think of any changes in procedures or design that would reduce your concerns about using an OEE during a fire emergency?

e) What changes would make you most comfortable in the use of these systems?

13) Do you have any other comments? Questions for us?

NOTE: This collection of information contains Paperwork Reduction Act (PRA) requirements approved by the Office of Management and Budget (OMB). Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA unless that collection of information displays a currently valid OMB control number. Public reporting burden for this collection is estimated to be two (2) hours per interview response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed and completing and reviewing the collection of information. Send comments regarding this burden estimate or any aspect of this collection of information, including suggestions for reducing this burden, to the National Institute of Standards and Technology, Attn: Kathryn Butler, kathryn.butler@nist.gov, 301-975-6673.

OMB Control No. 0693-0066
Expiration Date: 8/31/2015

Appendix C Project Code List with Operationalized Definitions and Examples

Overarching	
Emergency philosophy	When someone discusses their thoughts, beliefs, concepts, or attitudes toward fire evacuations *Examples: I trust that someone will get me out in an emergency; or this is part of the risk that I accept in having this career; or I think it is typical for this area, we are in denial that anything will ever happen.*
External accessibility	When someone discusses mobility problems or the inability to move around in a non-workplace area when it is not related to a fire or to a fire evacuation *Examples: I went to a sporting event and the elevator broke and we had to stay in the building for hours. We waited but no one came to help us so my friends carried me out; or the venue where my relative's wedding was held did not have an elevator so the servers carried me up the stairs and someone else brought my wheelchair.*
Everyday workplace mobility	
Disability status	When someone talks about the cause of their mobility impairment, its progression, and/or the impact it has on mobility *Example: Five years ago I could take care of myself and I had full range of motion in my arms so I could open doors in the building. My disease has progressed so that I can no longer open a door to the building.*
Mobility aid	When someone talks about a device designed to assist walking or otherwise improve their mobility *Examples: cane, crutches, wheelchair, or oxygen tank.*
Mobility issues	When someone expresses difficulty with or the inability to move around their workspace or building *Example: The doors are too heavy for me to open myself and there are no accessibility buttons to press, so I have to wait until either the guard or someone else opens the door for me.*
Occupant benefits	When a person states that the building management has been helpful with assisting occupants or visitors with mobility impairments in some way, or that the building design offers some benefit to those with mobility impairments *Examples: The building management made improvements to the entrance by adding an accessible button to automatically open the heavy doors; or after the last fire drill the building manager asked me for feedback to improve the evacuation process.*

Fire evacuation experiences	
Non work related fire experiences	When someone discusses their experiences with a fire evacuation outside of their workplace *Examples*: *There was a fire in our building a couple of months ago and we were told to stay in our apartment until the fire department came to help get us out; or we were at the opera and there was a fire and everyone left so my friends finally carried me out of the building.*
Fire alarm / Information / Communication	When a person talks about how they learned about the fire evacuation; this includes any aspect of the fire alarm – i.e., when it is activated, including the accompanying sound and any other information that is provided during the activation *Examples: When the fire alarm goes off it makes this loud beeping noise and then a message follows that a fire has been detected in the building. There is also a strobe light; or my coworker down the hall always comes to my office to let me know that the fire alarm has gone off.*
Response	When a person talks about the actions they took in response to notification about the fire evacuation *Examples: Management usually tells me that a fire evacuation drill is going to occur on Monday at 8 AM so I either stay home or just go to Starbucks until the drill is completed; or I went out of my office and down the hall to the staging area and then the firemen came and got me and took me down in the elevator. (*Note: this could be exactly what they also said the plan was)*
Response: Assistance	When a person discusses that they need someone to help, assist, aid, or provide support during a fire evacuation *Examples: My 'buddy' is assigned to help me during a fire evacuation. He helps me get into the emergency stair travel device; or the firemen come up on the elevator and help me to get down.*
Response: Evacuation method	When a person discusses the different method(s) that they can use to evacuate the building during a fire emergency *Example: During a fire evacuation, I will go to the stairs with the people who help me to get out of my chair and into the emergency stair travel device. I can also take the stairs if I have to. Sometimes the firemen come and get me and take me down in the elevator.*
Concerns / Problems / Difficulties	When a person expresses trouble, worry, unease, or anxiety about any part of a fire evacuation *Example: I really get concerned about my coworkers putting me in the emergency stair travel device and what will happen to me when I get to the street.*
Continued communication	When a person talks about the fire safety officials and other knowledgeable/responsible individuals continuing to inform them of the status of the fire and their evacuation

	Example: The telephone in the area of refuge is connected to the fire officials in the building. They call us to update us on the status of the fire and we can call them to check up on the fire evacuation.
Building visitors	When a person talks about individuals with mobility impairments who are not part of the building workforce but are visiting the building on any particular day, or about their own experiences as a visitor in a building that is not their own during an evacuation *Example: We have a lot of mobility impaired individuals who regularly access our building. I don't think there are enough emergency stair travel devices if we had to evacuate.*
Risk	When a person describes a situation of an uncertain event or condition, that if it occurs, someone may be physically harmed or may suffer loss or other negative consequence *Example: I know that the firemen are trained to carry people out of the building. But my bones are very fragile and if they try to carry me out they could break one of my bones.*
Fire evacuation training	
Plan	When someone describes what they are supposed to do in a fire evacuation – either related to a formal plan or not. Additionally, this code is used if statements are made about plan awareness. *Example: the plan is for me to go to the area of refuge with my 'buddy' and wait for further instructions; or they keep telling us that they will give us a plan but we never receive a plan.*
Training	When a person talks about education, practice (e.g. evacuation drills or number of drills), or instruction about evacuation of the building during a fire, or states that they have not received this instruction or training *Examples: Every 6 months the fire safety official in the building reviews the evacuation plan with us and we get retrained on using the emergency stair travel device; or I have been here for about 6 months and never received any evacuation training. You would think that would be part of new hire orientation.*
Satisfaction / Dissatisfaction	When a person expresses that they confidently accept something as adequate or pleasing, or that they feel content; or that they disapprove, are unhappy, or displeased; this includes their answer to how they define satisfaction. *Examples: I am satisfied with the fire evacuation plan here in the building because my coworkers know how to use the emergency stair travel device and we practice; or I am not satisfied with the fire evacuation plan here in the building, because quite frankly they don't have one for mobility impaired occupants.*
Planning vs. reality	When someone expresses that they plan to take an action during an evacuation that is different from the action that they are trained to take or that is described in the fire evacuation plan

	Example: I don't care what they tell us the plan is because they expect me to go to an area of refuge. I am going to get in the elevator and get the h__ out of the building.
Elevator use daily and during a fire evacuation	
Building elevator	When someone describes the elevator(s) in their building and talks about their daily use in general terms *Example: I come in on the elevator from the parking level and then cross over to the set of elevators on the first floor. There are four elevator banks in the building. We also have a freight elevator in the corner of the building but I believe it requires a key.*
Existing elevator	When someone talks about the use of the existing building elevator(s) during a fire evacuation *Example: I know that they tell us not to get in the elevator but I am going to get into it and see if I can take it down before they shut it down.*
Freight elevator	When someone talks about the freight elevator in the building and its use during a fire evacuation *Example: I know there is a freight elevator in the building and I would take it during a fire if it was working because they are bigger than the regular elevators.*
Occupant evacuation elevators (OEEs)	When someone comments about OEEs and their use during a fire evacuation *Example: If the OEEs really work that would be really great. To know that I can get out of the building quickly is very reassuring.*
Elevator benefits	When someone states an advantage of an elevator or how an elevator is of help *Example: Using an elevator to get out of a building would be super. I would be able to stay in my wheelchair and not risk injury getting into an emergency stair travel device.*
Elevator concerns	When someone states that they are worried or expresses anxiety or unease about using an elevator during a fire evacuation *Example: I won't use an elevator because it could turn into a box that I get trapped in and it could get filled with smoke.*
Elevator recommendations	When someone expresses a suggestion, advice, or proposal as a course of action for improvements to an elevator or set of elevators *Example: I think that there should be some indication that the elevator is safe to use when there is a fire in the building.*
Video comments	When someone makes a remark, observation, or criticism about the OEE video shown to them *Examples: I think they should find someone with a real disability. Clearly the person in the wheelchair is not disabled; or the window in the safe area is too high so a disabled person in a wheelchair wouldn't be able to see out the window.*

Appendix D Subcodes with Operationalized Definitions

Fire evacuation experiences: Response: Evacuation method	
Emergency stair travel devices	People can be evacuated down the stairs using an emergency stair travel device of some kind, including devices that sit on the stairs and ride down and litter-style devices that are carried. Includes attitudes about this option.
Elevator	People are allowed to use the elevator to evacuate under some circumstances. Includes attitudes about having this option.
Area of refuge	Occupants can evacuate by waiting for assistance in a specified area, which may be protected against fire. Includes attitudes about this option.
Carried bodily	An option for evacuation is for somebody (first responder, strong coworker) to toss the occupant over a shoulder and carry the occupant up or down the stairs, or carry the occupant in his or her wheelchair.
Walking on stairs with or without crutches	Occupant can make their way up or down the stairs using crutches.
Wheelchair on stairs	The occupant is evacuated up or down the stairs in their own chair, either on their own or with help.
Crawling up or down stairs	Occupant can use their own bodies (hands, knees, rump) to navigate up or down the stairs.
Options	There are multiple options for evacuation.
Ramp	Occupants can evacuate the building using a ramp. Also includes attitudes toward using a ramp for evacuation.
No option if elevator is shut down	There is no option for the occupant to evacuate if the elevator is shut down.
Ground floor	Evacuation from the ground floor is the same way that one would always exit the building.
Wayfinding	Signage, emergency lights, and other means are in place to help the occupants find their way.

Elevator use daily and during a fire evacuation: Elevator benefits	
Feelings of comfort or relief	Using the elevator is familiar and easy.
Safety	The elevator is a safer means of evacuation - less chance for injury, reduces recovery time, protected from fire and water (OEEs).
Speed	Elevators are a fast way out of the building.
Keep mobility aid - Independence	With elevators, you can keep your mobility aid with you as you evacuate.
Communication	While waiting for and riding an elevator, there is a way to communicate with first responders or others in charge.
Consideration of others	Those using the elevators would not need the same level of assistance as other methods, reducing responsiblity of coworkers and allowing firefighters to concentrate on putting out the fire.
Straight from danger zone to exit point	The OEE does not stop on intermediate floors but goes straight to the lobby or ground floor. It focuses first on the floors where people are in the most jeopardy.
Getting out	The elevator provides assurances of being able to get out of the building.
Efficient	When the elevator arrives, the person and others are able to board. Large numbers can be evacuated quickly and systematically, and the person with mobility impairments is not the last out of the building.
Adds an option	The elevator becomes one option to evacuate in addition to others.
Everyone can use it	The elevator is an evacuation method that everyone can use.
Depends on building height	An elevator option would be more important for higher buildings.
Depends on where fire is	Being able to use a particular elevator depends on whether it is affected by the fire.

Elevator use daily and during a fire evacuation: Elevator concerns	
Physical danger (PD)	Includes concerns about being injured or dying, being trapped, the elevator not functioning, inappropriate help, the safety of others, and fear and anxiety.
PD: Injury or death	People in elevators are vulnerable to fire, smoke, and heat.
PD: Not functioning	The elevator is shut down during evacuation, perhaps because it goes into emergency mode or because it is broken.
PD: Fear and anxiety	The thought of waiting for and/or using the elevator triggers negative emotions such as anxiety and fear.
PD: Being trapped	Elevators may stop in a position between floors or the doors may fail to open.
PD: Waiting time	The elevator takes a long time to arrive after being called, or the time of its arrival is uncertain, with no indication of how long the wait will be.
PD: Concerns about safety of others	Other people also need to be safely evacuated. Excludes crowding issues.
PD: Inappropriate help	People may break something when they are trying to help. They may not know how to help, and they don't ask for permission or instruction before touching the person or the mobility aid.
Elevator policy (EP)	Concerns that the policy for using the elevator is not clearly laid out, or the policy has flaws.
EP: Priority issues – No room to board	There may not be room for the person with mobility impairments inside of the elevator, whether due to lack of priority, to the elevator arriving full, or due to the size of the elevator cab. The person would have to fight to get on.
EP: Don’t use elevator in a fire	Everybody knows that an elevator must never be used in a fire. (The educational campaign was very successful.)
EP: No information	Knowledge is lacking about key factors that affect decision-making, such as where the fire is, whether the elevators will work.
EP: Stopping on other floors	The elevator does not operate in a manner that facilitates evacuation, including stopping at multiple floors, stopping at intermediate floors even when full, and doors closing too fast.

EP: Backup plan	There needs to be another evacuation option in case the elevator can't be used.
EP: Control of the elevator	Who is controlling the elevator during an evacuation? Can its operation be trusted?
EP: Timely decision-making	People need to make the decision to evacuate at the right time.
EP: Need assistance	Even with an elevator, assistance is still necessary.
EP: After hours	The concerns are different after regular work hours.
Design issues (DI)	Concerns about how the elevator is designed.
DI: Design elements	The elevator needs to be well designed for those with disabilities, including button placement, communication, and force needed to operate them. People with mobility impairments can’t move as fast as others - if the doors close too fast they won't be able to board.
DI: Location of elevators	The elevator doesn't lead directly to an exit. Occupants may need to take multiple elevators, or the path from the bottom floor to an exit is circuitous; or the elevators are all in one space.
DI: Communication out of the elevator	When inside the elevator, people are out of contact with the outside world.
Not in the budget	Developers will find excuses for not spending the money or the building space on elevators to be used during fire evacuations
Need proof	How do we know the elevator is safe unless we have evidence that it will perform well in an emergency?

Elevator use daily and during a fire evacuation: Elevator recommendations	
Design improvements	Changes that should be made to the physical design of the elevator.
Procedural improvements	Changes that should be made to how the elevator is operated during an evacuation.
Communication improvements	Need to make sure that the elevator occupants can communicate with first responders and vice versa. Need to make sure that those waiting for the elevators are informed so they can make a good decision, and that first responders know where people are waiting.
Educational improvements	Changes that should be made to how people are educated about using the elevator during an emergency.
Response improvements	Changes that are suggested for first responder response involving elevator evacuation.
Options	Even with an OEE, there need to be options for evacuating occupants by other means.
Inspection and testing	Need to make sure that the elevators are operating during the emergency as designed.
Planning improvements	The use of OEEs in a fire emergency is improved by organization of the office spaces or other changes in the building environment.
Organizational improvements	Federal agencies and other organizations involved with evacuation planning and design should talk with each other.