



The Human Dimensions of Sheltering: Social Science Considerations for Safe Rooms and Shelters During Extreme Wind Events

A White Paper by the Natural Hazards Center

Submitted to the Federal Emergency Management Agency

First Drafted: September 13, 2024 | Last Updated: January 31, 2025



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Funding and Audience: This project was funded by the Federal Emergency Management Agency (FEMA) through an award to the Applied Technology Council (ATC). Researchers at the Natural Hazards Center (NHC) produced this document for internal use by relevant parties within FEMA and at the ATC.

Suggested Citation: MacPherson-Krutsky, C. (2024) The Human Dimensions of Sheltering: Social Science Considerations for Safe Rooms and Shelters During Extreme Wind Events. Natural Hazards Center, University of Colorado Boulder.

ABSTRACT

While significant advancements have been made in engineering safe rooms and storm shelters to withstand extreme wind events, less attention has been given to whether these shelters meet the social and psychological needs of those who use them. This white paper reviews 105 social science articles and 13 federal agency reports published between 1999 and 2024 that explore the human factors influencing shelter use, barriers to sheltering, and shelter occupant experiences. Findings are focused on the U.S., U.S. Territories, and Tribal Nations and organized chronologically: before the storm, during the storm, and between storms (i.e., ongoing issues during non-emergency periods). Key findings include reasons for not sheltering (e.g., lack of awareness of shelter locations, false sense of security at home, having pets, etc.), challenges faced while sheltering (e.g., lack of privacy, unclear signage, issues with lifelines, etc.), and systemic issues (e.g., shelter deficits, issues with long-term maintenance, etc.). Recommendations are offered to address the issues identified in the literature and are organized into four categories: (1) human-centered design, (2) operations, (3) planning and outreach, and (4) policy change. Policy makers, government agencies, and emergency managers can use these findings and recommendations to update shelter planning and policy. Researchers can use the research gaps pinpointed here to guide future research into social and psychological shelter experiences. This thorough review of literature provides novel insights into the human dimensions of sheltering during extreme wind events, with a goal of ensuring those most at risk can find safety.

Keywords: sheltering, human factors, social sciences, engineering, storm shelter, safe room

INTRODUCTION

Significant advancements have been achieved in the design and construction of storm shelters and safe rooms to the impressive extent that **no safe room or storm shelter meeting Federal Emergency Management Agency (FEMA) and International Code Council (ICC) 500 guidelines has experienced a known failure** (P. Scott, personal communication, April 1, 2024). Additionally, as of 2024, **FEMA has invested \$1,455,501,828 on the completion of 46,677 safe room projects** (P. Scott, personal communication, May 9, 2024). In light of these significant investments, it is critical to carefully assess how these shelters are being used by the people they are designed and built to protect. However, gaps remain in FEMA’s understanding of *how* and *why* some people choose to shelter, their experiences while sheltering, and if building designs could be updated to improve shelter conditions and use. Although the engineering and design of safe rooms and storm shelters has progressed dramatically, broad understanding of these critical human dimensions of sheltering is lacking.

This document responds to this gap in knowledge by summarizing and synthesizing relevant social science literature and agency reports that capture the human dimensions of sheltering from tornadoes, hurricanes, and other extreme wind hazards. Here we consider “human dimensions” to include topics related to psychology and sociology, including physical and mental health, human behavior, decision-making, and experiences around sheltering from extreme wind hazards. The intent is to provide social and behavioral science-informed recommendations that account for the human factors that influence shelter use and experiences. Information gaps and further research needs are also identified.

This paper concentrates on research associated with extreme wind hazards, because FEMA guidance—***FEMA P-361: Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms*** (2021) and ***FEMA P-320: Taking Shelter from the Storm - Building or Installing a Safe Room for Your Home*** (2021)—focuses on constructing shelters to withstand tornadoes, hurricanes, and straight-line winds. Research on sheltering from other hazards, such as tsunamis and earthquakes, is not included here due to time and scope considerations.

This report begins with a summary of communities at risk of extreme wind hazards and reviews the state of storm shelter and safe room guidance. It is followed by a brief overview of the process used to identify and review literature focused on the human dimensions of sheltering. Findings and recommendations focus on social factors associated with sheltering and offer novel guidance on future planning, outreach, and design of storm shelters and safe rooms.

A Note on Terminology

“Shelter” is a term with many definitions and protection levels from extreme wind hazards (**Figure 1**). For example, safe rooms and storm shelters must meet certain safety and design criteria and provide almost absolute protection from extreme wind hazards. Mass shelters and recovery shelters may be places people stay during and after storms but are typically constructed buildings that do not provide additional protection. Wherever possible, the type of shelter being referenced is specified. In certain places, the general term “shelter” is used because the source material did not clarify shelter type, or an idea applies across shelter types and uses.

See **Appendix A** for a glossary of other key terms.

Safe Room

Buildings or portions thereof that comply with the criteria described in FEMA P-361, Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms. (FEMA P-320, 2021)

Residential

Serves occupants of a dwelling unit designated for no more than 16 occupants. Can be in residence or stand alone.

Community

A non-residential safe room. It can be open to the public, or a specific set of intended occupants.

Storm Shelter

Buildings or portions thereof that comply with the International Code Council (ICC) and National Storm Shelter Association (NSSA) ICC/NSSA Standard for the Design and Construction of Storm Shelters, also called ICC 500. (FEMA P-320, 2021)

Best Available Refuge Area (BARA)

An area in an existing building that has been deemed by a registered design professional to be likely to protect building occupants during an extreme-wind event better than other areas in the building when a safe room is not available. The BARA should be regarded as an interim measure to be used until a FEMA-compliant safe room or ICC-500 compliant storm shelter can be made available. (FEMA, n.d.)

Typical Construction

Typical building construction complies with minimum building code requirements, which have much lower design parameters. Such buildings are not hardened or designed to protect occupants and provide life-safety protection from extreme-wind events such as hurricanes and tornadoes. Taking refuge in a building of typical construction during an extreme-wind event could result in injury or death. (FEMA PR-RA 3, 2018)



Figure 1. Diagram showing shelter type by protection provided. Mass shelters and recovery shelters typically fall into the BARA and typical construction categories.

EXTREME WIND EVENTS IN THE U.S.

Each year, the U.S. experiences deadly and damaging tornadoes, hurricanes, and straight-line winds, but their impacts are not felt uniformly in terms of warning times as well as the geographies and human populations affected. Tornadoes affect relatively narrow swaths of land and warnings are often issued just minutes or hours before the event—though warning times are increasing with advances in meteorology. Hurricanes typically have longer advance warning times and can affect multiple states and entire regions. Straight-line winds are a phenomenon that creates single direction wind gusts of up to 150 miles per hour and causes tornado-like damage (NWS, n.d.). All types of wind hazards can be dangerous to people and property. People who are socially and economically marginalized are more likely to be injured and to die in these hazard events (Adams et al., 2020; Andrade, 2020; Zahran et al., 2008). In particular, the elderly, low-income populations, populations with limited English proficiency, and people of color are especially at risk. Geographies most at-risk to tornadoes are the Midwest, Southwest, and Southeast regions of the U.S. (**Figure 2**). Tornadoes cost millions of dollars in damage each year, with the costliest events reaching multiple billions. The top three costliest tornadoes occurred since 2011 and ranged in costs from \$2.6 to \$3.8 billion (CPI adjusted to 2023) (NOAA, 2023b). Between 1940 and 2023 tornadoes led to 7,975 deaths in the U.S. (NOAA, 2024). Geographies most at-risk to hurricanes are states along the Gulf Coast and East Coast as well as U.S. Territories such as the U.S. Virgin Islands and Puerto Rico (**Figure 2**). Since 1980, hurricanes in the U.S. have been among the deadliest and costliest disasters, causing 6,890 deaths and costing over \$1.3 trillion—an average of \$22.8 billion per event (NOAA, 2023a).

Wind hazard risks are expected to rise as climate conditions change. Researchers estimate that tornado risks will grow as the locations, timing, and intensity of tornadoes shift (Capucci, 2024) and that almost 30 million people will be at-risk of hurricane-force winds by 2053 (Muyskens et al., 2023). Given population growth in at-risk areas and people's increasing exposure to these hazards, it is critical to understand which actions can be taken to protect those in harm's way. All advancements require careful assessment of current practices and hazard event outcomes.

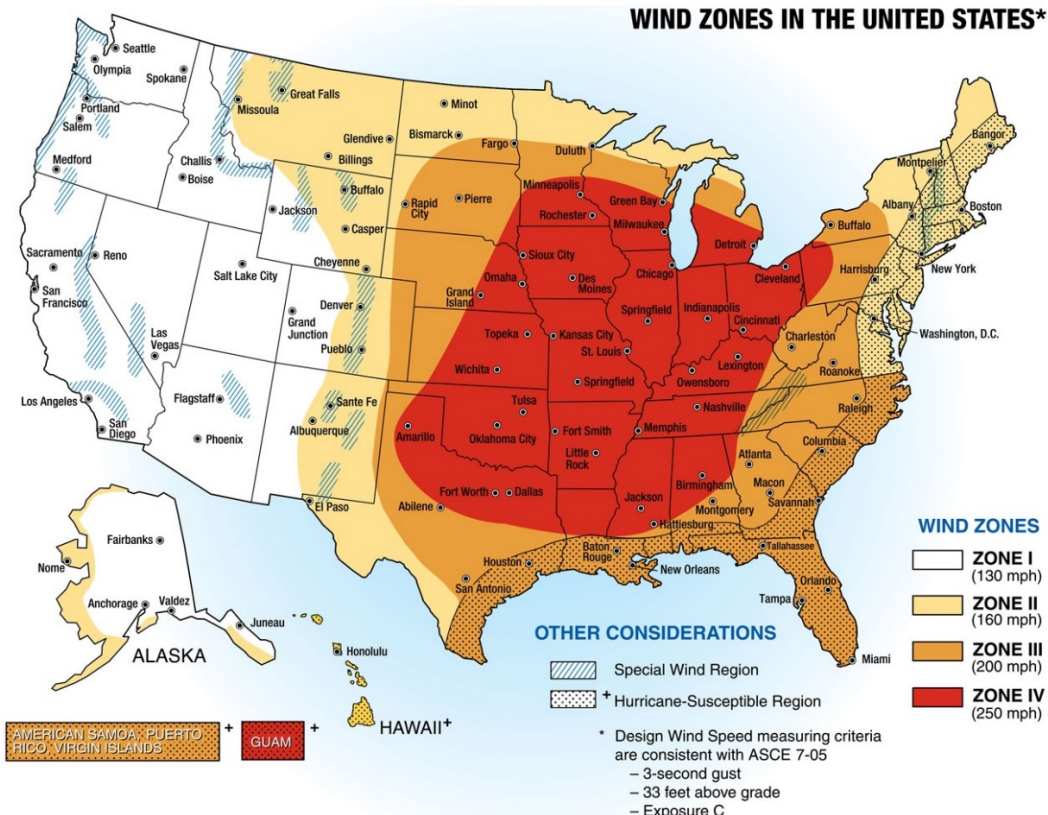


Figure 2. High wind and hurricane zones in the United States (Image source: FEMA P-320, 2021)

DEVELOPMENT OF STANDARDS AND GUIDANCE FOR SAFE ROOMS AND STORM SHELTERS

The development of building standards and guidance for safe rooms and storm shelters was borne out of decades of devastating extreme wind events that exposed a need for structures that could provide safety to people unable to evacuate. Over the past 50 years, engineers and architects have refined and formalized this guidance for residential and community safe rooms and storm shelters to protect people from extreme wind (Table 1).

FEMA P-361 (2021) and FEMA P-320 (2021) are widely used documents that provide shelter design and construction guidance for developing community and residential safe rooms (Figure 3). In fact, “FEMA P-320 is the most requested FEMA document in history, with over a million copies having been printed” (Levitan, 2013, p. 421). Between 2018 and 2024, there were more than 150,000 digital downloads and over 9,000 hard copies requested (D. Zagara, personal communication, June 3, 2024). As mentioned above, FEMA and communities have invested tremendous resources to implement this guidance, which resulted in the construction of thousands of safe rooms. This guidance will continue to evolve to meet community sheltering needs.

The aim of this paper is to contribute to FEMA’s tradition of using research and practical insights to shape guidance. By summarizing and synthesizing research on peoples’ motivations for and experiences with sheltering, these findings can help inform the next generation of shelter guidance and design.



Figure 3. Covers of the most recent editions of FEMA P-361 (left) and FEMA P-320 (right)

Table 1. Timeline of Key Safe Room and Shelter Advancements and Publications (Modified from FEMA, 2016, p. 10)

Year	Event or Publication
1974	In-residence shelters are first reported (Kiesling and Goolsby, 1974)
1975	<i>Wind-Resistant Design Concepts for Residences</i> published by the Defense Civil Preparedness Agency ¹
1980	<i>TR-83A, Interim Guidelines for Building Occupant Protection from Tornadoes and Extreme Winds</i> published by the Defense Civil Preparedness Agency
1982	<i>TR-83B, Tornado Protection: Selecting and Designing Safe Areas in Buildings</i> published by the Defense Civil Preparedness Agency
1998	<i>FEMA P-320: Taking Shelter from the Storm - Building or Installing a Safe Room for Your Home</i> , first edition was published and included federal guidelines for building residential safe rooms
2000	<i>FEMA P-361: Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms</i> first edition was published with adapted guidance for community and residential safe rooms
2008	<i>ICC-500: Standard Design and Construction of Storm Shelters</i> is published by The National Storm Shelter Association (NSSA) who “develop industry standards and quality assurance procedures.” These guidelines are slightly less strict than FEMA’s and are employed nationally and internationally to guide everything from manufacturing to installation of shelters and their components to protect life.
2012	Buildings must meet ICC 500 criteria to be considered a “storm shelter” ²
2015	Storm shelters are required for certain building types such as schools and critical emergency operations centers within 250 mph wind zones.
2021	5 th and 4 th Editions of FEMA P-361 and P-320 are published, respectively (Figure 3).
2023	4 th edition of ICC-500 is published (ICC/NSSA)
2024	New editions of FEMA P-361 and P-320 that meet ICC 500-2023 were published in Fall of 2024

¹ The Defense Civil Preparedness Agency was dissolved in 1979 via an executive order and its duties were given to FEMA which formed from the consolidation of several singular federal agencies that same year.

² A storm shelter must meet ICC500 criteria while a safe room must meet stricter FEMA-361 guidelines.

METHODS

To assess the state of social science knowledge related to the human factors of sheltering, an in-depth review of 105 peer-reviewed articles and 13 agency reports was conducted. The review included acquisition, examination, and synthesis of literature that met specific inclusion guidelines (See **Appendices B** and **C** for details on process and criteria used).

The literature was divided into documents that focused on tornado sheltering (n=18), hurricane sheltering (n=63), or general sheltering (n=24) (**Figure 4**). Many peer-reviewed papers focused on “sheltering” in a broad sense, but did not distinguish between the type of shelter being assessed (e.g., storm shelter, safe room, recovery shelter, mass shelter, etc.), which made differentiating between shelter type in the findings challenging. The literature largely referenced community-sized shelters (e.g., school gymnasiums or churches) and mass shelters (e.g., stadiums), with some papers discussing residential shelters. For the agency reports, the review focused on those with relevant findings associated with the human factors of sheltering (e.g., reported issues with people finding or using shelters). The findings from the agency reports were added to those from the peer-reviewed literature. A synthesis table was developed that includes a comprehensive list of findings associated with shelter experiences, implications for shelter design, and supporting citations (See **Appendix D**).

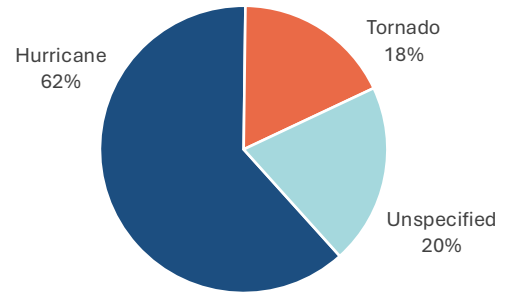


Figure 4. Percent of Documents by Hazard Focus (n=118)

FINDINGS

The findings from the literature review are divided into three sections and summarized in **Table 2**. Section A, *Before the Storm: Barriers to Evacuating and Using Shelters*, focuses on why people evacuate, seek out shelter, or remain at home during extreme wind hazard events like tornadoes and hurricanes. Section B, *During the Storm: Experiences and Issues While Sheltering*, focuses on social or physical issues that arise during the use of shelters such as space, operations, and mental health, which were documented in the sheltering literature. The length of time people occupy shelters strongly influences these issues. As such, this section is subdivided into three time spans: short-duration (<less than 24 hours), extended-duration (> 24 hours), and all-duration sheltering. Short-duration is typically associated with tornadoes while extended-duration is typically associated with hurricanes. Section C, *Between Storms: Systemic Issues with Shelters*, focuses on broad issues identified with sheltering that go beyond individual shelters or specific events.

A. BEFORE THE STORM: BARRIERS TO EVACUATING AND USING SHELTERS

Peoples’ decisions to evacuate, shelter, or stay in place are complex. The actions people take during disasters are shaped by an array of factors that include their physical environment, their social networks, the type of hazard information they receive and when they receive it, their personal experiences, and more (Lindell and Perry, 2012). During hazard events, like tornadoes and hurricanes, these variables converge to influence people’s risk perceptions, and perceptions of which actions will protect them. For example, findings across a series of case studies and simulations suggest that women and minorities perceive tornado and hurricane risks as higher and are more likely to evacuate or go to shelters (Comstock and Mallonee, 2005; DeWinter- Maciag and McPherson, 2023; Jon et al., 2019; Le Greca et al., 2019; Burger et al., 2019). Similarly, Whitehead et al. (2000) found that women are almost twice as likely than men to evacuate when given a mandatory order. However, there are many barriers, as detailed below, that can make it hard for people of all backgrounds—but especially those from socially and economically marginalized backgrounds—to evacuate or take shelter outside of their homes.

Table 2. Summary of Findings

<p>A. Before the Storm: Barriers to Evacuating and Using Shelters Factors that influence which protective actions people take during extreme wind hazard events.</p> <ul style="list-style-type: none">A1. People are unaware of shelters or don't know where to get information.A2. People have negative perceptions of shelters.A3. People believe they are safe at home.A4. People lack the transportation, resources, time, or social support needed to evacuate or shelter.A5. Evacuating with pets and service animals is difficult and shelters often lack accommodations for them.A6. Authorities and agencies fail to plan for people with Access and Functional Needs (AFN).
<p>B. During the Storm: Experiences and Issues While Sheltering Physical and psychological experiences with shelters and sheltering such as emotional responses, perceptions, mental and physical health needs, space needs, functionality, and more.</p> <p>Short-Duration (<24 Hours):</p> <ul style="list-style-type: none">B1. People don't bring important items with them while sheltering.B2. Emergency responders struggle to locate shelters. <p>Extended-Duration (>24 Hours):</p> <ul style="list-style-type: none">B3. Shelters get used beyond their minimum time frames.B4. Lifelines (power, water, sewerage, and communications) are not always reliable.B5. Lack of accommodations for people with AFN.B6. Lack of security and privacy.B7. Shelter conditions can be unsanitary and uncomfortable.B8. Shelters are not always equipped to meet the physical and mental health needs of occupants and staff. <p>All-Duration:</p> <ul style="list-style-type: none">B9. Shelter signage is unhelpful and sometimes dangerously misleading.B10. Shelter space can be insufficient to accommodate occupants.
<p>C. Between Storms: Systemic Issues with Shelters Broad issues related to shelters that go beyond individual shelters or specific events.</p> <ul style="list-style-type: none">C1. There are not enough shelters located in the right places.C2. Resources for long-term shelter maintenance and assessment are limited, especially for schools.C3. Shelter costs and perceptions influence investment in shelters.

A1. People are unaware of shelters or don't know where to get information

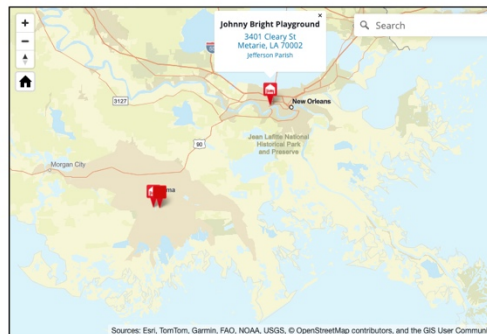
People cannot evacuate to shelters if they don't know where nearby shelters are and what they can expect when they get there. Lack of shelter awareness across stakeholder types and specific population groups—authorities, officials, and diverse members of the public—was pervasive throughout the literature. A lack of shelter awareness from authorities is especially problematic and exacerbates issues with the public awareness. In one situation, emergency officials failed to direct people with disabilities where to go because they were unsure which shelters could accommodate them (Van Willigen et al., 2002). A FEMA report summarizes this issue by saying, “the presence of community safe rooms is unknown to the local populace” (FEMA, 2010, p. 20). This is especially true for populations with limited English proficiency and populations with disabilities (Christensen et al., 2013; Eisenman et al., 2007), who are some of the most vulnerable when disasters strike. Emergency guidance and alerts are rarely translated into other languages and accessible formats (MacPherson-Krutsky et al., 2024) leaving people to make decisions on whether to evacuate and where to shelter based on limited information. This lack of awareness compounds response issues because instead of heading to shelters, people will stay home, go to hospitals, hotels, or other places familiar to them (e.g., department stores), which get overwhelmed or can be unsafe (Whitehead et al., 2000; Eisenman et al., 2007).

Residents, particularly those of low-income areas, need more explicit information on how to find safety or evacuate if they have no car, financial resources, or place to stay outside the city or if someone else in their family is physically disabled (Brodie et al., 2006, p. 1407).

Additionally, information on shelter locations is generally inaccessible to the public. Though FEMA keeps records of funded storm shelters and safe rooms, these are not publicly available (P. Scott, personal communication, July 15, 2024). Municipalities who oversee shelter incentive programs are responsible for managing and maintaining databases of shelter locations and sharing with the public if they choose (FEMA P-361, 2021, p. A4-7.). The American Red Cross website includes a publicly accessible map of open recovery shelters (Figure 5), but it is unclear whether they are rated to withstand extreme wind hazards and can be used during a storm (American Red Cross, n.d.). It was unclear from the literature the extent to which shelter databases are created, maintained, and shared with the public during events. This deficit leaves the public, and often the authorities, with limited information to make decisions.

Find Open Shelters and Disaster Relief Services

If an emergency has forced you to evacuate your home, or disrupted your access to essential services, the Red Cross may be able to help.



Click or tap the red pins for information. Pins with a tent icon show overnight shelters. Plain pins show sites where you can obtain other disaster relief services.

Figure 5. Red Cross map of open shelters as of September 12, 2024 (Red Cross, n.d.).

A2. People have negative perceptions of shelters

Fears about personal safety and property while sheltering or that shelters will not meet personal needs were common, especially for women and children (Farmer et al., 2018; Farmer, 2020; Sullivan and Nagle, 2020), racial or religious minorities (Burger et al., 2019; Mando et al., 2011; Peek, 2020) and those with Access and Functional Needs (AFN, McGuire et al., 2007; Stough, 2021). Mando et al. (2011) found that Muslim religious minorities had concerns about safety, cleanliness, privacy for religious practice, and finding food options consistent with their faith practices in public shelters. Similarly, diabetics (Burger, 2019) and people with small children (LaGreca et al., 2019) also have concerns over finding appropriate food options in shelters. People also worry that shelters are not equipped to mitigate the spread of diseases, which was especially true during the COVID-19 pandemic (Collins et al., 2024). Fear around sheltering for certain communities may be associated with perceptions of entry requirements or prior experiences. For example, during Hurricane Harvey, rumors circulated that immigration agents would be at shelters deporting undocumented people (Melendez, 2017). Instead, people opt to stay with family and friends or at hotels (Schwartz et al., 2018; Smith and McCarty; Taioli et al., 2018); When those options are unavailable, they stay home despite the risks (Brodie et al., 2006).

A3. People believe they are safe at home

In both tornado and hurricane events, many believe they can withstand the storm in their residences. This is sometimes due to prior experience or a perception—often influenced by gender, race, social class, and other social factors—that their residence will keep them safe during the storm (Ash et al., 2020; Whitehead et al., 2000). During tornadoes, people tend to follow common advice to shelter in interior rooms that lack windows, such as closets, bathrooms, or basements. However, this advice is not appropriate for all tornado severities and building types, which people may be unaware of (FEMA P-908, 2012; Mason and Senkbeil, 2014). Sheltering at home can be especially problematic for those living in

manufactured homes (Niederkrötenhaller et al., 2013) or in wood frame homes when tornadic winds reach speeds exceeding 166 miles per hour—Enhanced Fujita (EF) Scale 4 or greater (Mason et al., 2014). Many residents perceive their manufactured homes to be relatively safe and take shelter in them (Ash et al., 2020; Schmidlin et al., 2009). Twenty-seven percent of the people who died during a series of EF 5 tornadoes in Oklahoma were in a bathroom or closet of their home (Brown et al., 2002). The EF 5 tornado that hit Joplin, Missouri in May of 2011 was the deadliest since 1947, killing 158 people (NOAA, n.d.). Survivors shared that they were unaware of the tornadoes or had heard sirens but were not able to confirm the threat or understand what to do (NIST NCSTAR 3, 2014). One survivor shared that prior tornado experience created a false sense of security saying, “every spring we hear [tornado sirens] go off at some storm, and people around this area go on their front porch and sit there and wait for something to come. I mean nobody really takes shelter...” (NIST NCSTAR 3, 2013, p. 269). Others cited a lack of transportation or nearby shelters as reasons why they are not able to take shelter (Hammer et al., 2002). Finally, there is a relatively large body of social science research that has shown that women and mothers with children are *more likely* to want to evacuate to shelters or other safe refuges, while men are more likely to eschew official warnings and refuse to evacuate (Fothergill, 2004; Fothergill and Peek, 2015; Trumbo et al., 2014; Villarreal, 2024).

A4. People lack the transportation, resources, time, or social support needed to evacuate or shelter

Despite warning times being different for tornadoes and hurricanes, transportation and other resources influence how people find shelter during both hazards. During tornadoes, warning time, distance to shelter, and prior knowledge of shelters influence how they shelter. Most people report having less than 20 minutes of warning for a tornado (FEMA, 2010; FEMA P-908, 2012) with some reporting less than ten minutes (Balluz et al., 2000; Comstock and Mallonee, 2005). Given the short warning times for tornadoes, people use prior knowledge of shelters and distance to decide whether they will leave their home and by which mode of transportation. Distance to the nearest shelter was a factor for whether people walked or drove. Schmidlin et al. (2009) found that people would drive if a shelter was more than 650 feet away, while Hammer and Schmidlin (2002) reported that the median distance people would run or walk to a shelter was about 98 feet. Post-event reports found that people would sometimes put themselves in greater danger by driving to shelters that they were familiar with located more than ½ mile away (FEMA P-908, 2012; NIST NCSTAR 3, 2014). In a 1999 tornado in Oklahoma City, more than half of those who left their homes for shelter drove a median distance of 3.0 miles (Hammer and Schmidlin, 2002).

For hurricanes, transportation issues become more complex. For example, during Hurricane Katrina, many stayed put because they could not access transportation out of the city, had few resources (e.g., vehicles or cash), or had disabled or elderly relatives who they would not leave (Burger et al., 2019; Eisenman et al., 2007). In a study of long-term care facilities in Florida, 81% of those interviewed sheltered in place during the hurricane because they had limited transportation options and faced issues finding places for residents to go (Hyer et al., 2009). Others stayed in place due to anticipated issues with evacuation or finding shelter, which are likely influenced by past events such as Hurricane Floyd, when “the 2 million Floridians who tried to evacuate, found themselves trapped in traffic and many did not find any available shelters” (Rincon, 2001 p. 279).

A5. Evacuating with pets and service animals is difficult and shelters often lack accommodations for them.

Unclear communication about where to take pets during events and other barriers, leave people with limited options for evacuating and sheltering with pets and service animals. According to the American Veterinary Medical Association (2022), 62 million households in the U.S. own dogs (44.6%), 37 million

own cats (26%), and 3.5 million own birds (2.5%). Many people consider pets to be their family members, which can impact people's ability to evacuate and shelter (Austin, J., 2020; Babcock and Smith, 2020; Douglas et al., 2019; Farmer et al., 2016). Studies across many states and hurricane events show people with pets are significantly less likely to evacuate or go to shelters than those without (Collins et al., 2024; Smith and McCarthy, 2009; Whitehead et al., 2000). Some reasons include difficulties with transporting animals (Burger et al., 2019; Douglas et al., 2019), a real or perceived lack of pet-friendly shelters (Farmer et al., 2016), and preferences for staying at a hotel with a pet (Lagiewski et al., 2023). Those that can evacuate with animals bring cats and dogs, but also reptiles, rodents, fish, and more, which shelters may not be equipped for (Austin, J., 2020; Austin, J. 2013; Condon et al., 2010). Twigg (2020) argues that service animals are also brought to shelters and should be able to stay with their owners. Challenges evacuating and sheltering pets are especially significant for low income (Burger et al., 2019) and elderly (Dostal, 2015) populations. In a survey on evacuation decision-making, one person shared, "[I] have three cats, and they are like my kids, so if I was to stay at a public shelter, I would have to be allowed to bring the cats along." (Farmer et al., 2016, p. 6).

A6. Authorities and agencies fail to plan for people with Access and Functional Needs (AFN)

Lack of planning for those with AFN creates significant barriers to evacuating or sheltering (Brown et al., 2015; Claver et al., 2013; Lach et al., 2005; Laditka et al., 2008; McGuire et al., 2007). Sirens, commonly used for storm warnings, are inaccessible to Deaf and hard-of-hearing populations (Kuligowski et al., 2020). During tornadoes, short warning times and sound-based alerts may hinder those with AFN from reaching shelters. Additionally, many residential shelters are underground which may be particularly challenging or impossible for people with AFN to access (FEMA P908, 2012). During hurricanes with longer lead times, older adults and people with disabilities often require more time and evacuation resources to ensure their medical equipment is brought with them when they evacuate. However, there are many examples of a lack of planning for those with AFN during evacuations. In one example from Hurricane Bonnie,

"[A] disabled resident with quadriplegia contacted the police for assistance in evacuating himself, his wife and two sons in advance of the flooding. The police were unable to evacuate his power wheelchair and other equipment he needs to survive. He would have been unable to evacuate if a local resident with a logging truck had not heard of his situation and volunteered to drive through flood waters to his home to bring him and his equipment out." (VanWilligen et al., 2002, p.103)

In a similar example, a person's wheelchair was left behind because evacuating authorities did not have space for it in their vehicle (Vanwilligen et al., 2002). As a result, the individual spent five days in a shelter unable to move. These examples underscore the grave inequities that exist during hurricane evacuations for populations with AFN. Both examples show that individuals intended to take protective actions, but that infrastructure and planning severely limited their options.

B. DURING THE STORM: EXPERIENCES AND ISSUES WHILE SHELTERING

During extreme wind hazard events, people use shelters for various reasons, times, and durations. People may use shelters for minutes to hours, such as those used during tornadoes. For multi-day events, such as hurricanes, people may head to shelters in advance of the storm, stay during, and remain after. Most of the findings fall into the extended-duration category. This is, in part, because issues are exacerbated with time, but also because more of the documents (>62%) focused on sheltering experiences that exceeded 24 hours.

Short-Duration (<24 Hours)

B1. People don't bring important items with them while sheltering

Residential shelter guidelines recommend people bring a set of tools and communication devices (e.g., cell phone, Ham radio, etc.) with them when they shelter. The intent of this guidance is so people can use tools to help open the shelter if debris has fallen on it or if a latch is stuck and use communication devices to call for help. However, post-event reports show that people did not follow this guidance (FEMA P-908, 2012; FEMA, 2010), which makes it hard for first responders to locate people who need assistance.

B2. Emergency responders struggle to locate shelters

People with residential shelters are often encouraged, but not required, to register their shelters locally (FEMA P-320, 2021, p. 59). Lack of registration by residents is problematic after an event, because responders are not sure where residential shelters are located to rescue people who may be trapped and mitigation assessment teams are sometimes unsure of where to go to assess damage of residential or community shelters (FEMA P-2021, 2018a; FEMA P-2020, 2018b; FEMA P-2342, 2023).

Extended-Duration (>24 Hours)

B3. Shelters get used beyond their minimum time frames

Hurricane shelters are designed for stays up to 24 hours (FEMA P-361, 2021, p. A4-4). However, shelters are often used for days or even weeks beyond this limit (FEMA P-2342, 2023; Nigg et al., 2006; Sanusi et al., 2020; Ridpath et al., 2015). For instance, during Hurricane Ian, people were encouraged to evacuate to shelters two days before landfall and required to remain there for days afterward due to unsafe surrounding conditions (FEMA P-2342, 2023). Following storms, community safe rooms and storm shelters are sometimes the only buildings available with basic utilities and are critical to recovery operations. However, extended use beyond minimum shelter times can compromise their function and safety, increasing the risk of disease transmission. During Hurricane Sandy, New York City opened 73 temporary evacuation shelters intended to be used for less than five days (Ridpath et al., 2015). However, the storm was so strong that 15 of the shelters had to stay open for more than a week. This led to disease transmission and the need for health monitoring and quarantining of occupants. In instances of mass shelters, prolonged shelter use has resulted in violence and drug use among occupants (FEMA P-2342, 2023). In Puerto Rico following Hurricanes Irma and Maria, FEMA acknowledged issues with the use of shelters beyond 24 hours and increased reimbursement amounts to cover upgrades for safe rooms to extend the sheltering duration to 72 hours (FEMA P-2342, 2023, p. 5-45). The 24-hour time frame is not sufficient for how storm shelters and safe rooms are used during hurricanes.

B4. Lifelines (power, water, sewerage, and communications) are not always reliable

The ability of shelters to function depends on consistent access to lifelines such as energy (power and fuel), water (potable and wastewater), and communication (infrastructure and responder communications) systems. When power is compromised, essential systems like wastewater disposal, air conditioning, and refrigeration fail, leading to uncomfortable and unsafe conditions (FEMA 488, 2005a; FEMA 489, 2005b; Holmes et al., 2022). Recovery shelters have had to close or relocate occupants because of power issues (Choi et al., 2020; Sanusi et al., 2020), which can put people and staff in danger. In some cases, backup power was available but insufficient to run shelter air conditioning or laundry machines, which led to health and hygiene issues (Hyer et al., 2009). Without air conditioning, shelters can become uncomfortably hot and humid (Laditka et al. 2009), posing safety risks, especially for older adults and children who are more vulnerable to heat-related illnesses. When energy systems fail, those

who use power-dependent medical devices are especially vulnerable (Behr and Diaz, 2013). Communications are also essential for staff and occupants. Shelter staff shared issues communicating things like shelter status and capacity with local officials during events and reported that after the event, communications and coordinating with volunteers was a challenge (Jiang and Tedeschi, 2020; Sanusi et al., 2020). Without access to the outside world and family, occupants may become stressed or bored (Beaudoin, 2007).

B5. Lack of accommodations for people with AFN

Older adults and those with AFN experience higher morbidity and mortality during disasters compared to other groups (McGuire et al., 2007), making it essential that shelters are available and accessible for these populations. However, evidence suggests that public shelters of all types fail to meet the needs of people with disabilities and AFN during emergencies. In particular, most emergency response systems, including shelters, “are designed for people who can walk, run, see, drive, read, hear, speak and quickly understand and respond to instructions and alerts” (Kailes, 2008, p. 10).

Specific sheltering issues for those with AFN include physical access, admission, facilities, meals, medications, communications, and personal support (Table 3; Twigg et al., 2011). During Hurricane Irma in Florida, access was a particular issue when an evacuation shelter for people with special needs was located on the building’s second floor and became inaccessible when elevators malfunctioned (Holmes et al., 2022). As a result, those with AFN had to co-locate at the general population shelter, where a lack of accessible restrooms and overcrowding made conditions difficult. Researchers share that barriers for those with AFN while sheltering are not novel, but that despite repeated evidence of inequities, agencies do not appear to update practices (Twigg et al., 2011). Information and lessons are not shared across agency lines, which limits issue awareness and the development of accessible plans and systems.

Table 3. Widespread issues with public shelters during emergencies for people with disabilities

Shelter Attribute	Issues (content adapted from Twigg et al., 2011)
Physical Access	Access routes to shelters, locations, and entrances are physically inaccessible for disabled people.
Admission	People with AFN are refused admission to shelters on the grounds that the shelters cannot manage their disability and directed to seek specialist facilities.
Facilities	Lack of accessible restrooms, cots, toilets, bathrooms, showers.
Meals	Difficulty in getting access to meals that are provided; lack of options for specific dietary needs (e.g. people unable to chew, diabetics).
Medication	Problems with refrigerating medication; problems accessing medication, medical equipment, and medical supplies.
Communications	Lack of or inadequate signage, captioning, and translation in communicating messages; inaccessible telephone and other communications equipment.
Personal Support	Caretakers with skills in supporting people with AFN discouraged or denied access; no provision made for service animals, leading to their exclusion from shelters; marginalization and discrimination by other shelter users, particularly in crowded shelters.

B6. Lack of security and privacy

Shelters are often set up as large open areas, but people want and need private or separate spaces. Privacy becomes especially important in shelters that are used for multiple days, and because many perceive shelters to be unsafe spaces with inadequate privacy, people avoid using them. Lack of privacy can also create issues with shelter experiences and health. For example, sleep is often compromised as noises carry throughout the shelter room (Deal et al., 2010; Missildine et al., 2009; Taioli et al., 2018). People often arrive at shelters with chronic or acute mental and physical health needs, but do not have private places to be cared for. In mass shelters where healthcare is available, Shah et al. (2018), found that people are less likely to access counseling for stress or anxiety because they are not able to share their worries privately. In a special needs shelter in Texas, there was no privacy for bedridden occupants for toileting and hygiene (Deal et al., 2006). DeYoung (2020) suggests that having separate rooms in shelters would be helpful for nursing mothers to nurse, bathe, and diaper infants in private. Disease transmission is a prevalent issue in shelters (Murray et al., 2009; Ridpath et al., 2015; Shipp et al., 2016) with people in shelters having a higher risk of infections and disease (Page-Tan and Fraser, 2022). Without separate space within shelters to quarantine, the risk of disease transmission is high (Behr et al., 2021; Veenema and Casey-Lockyer, 2021). Security in shelters is also an issue. During Hurricane Katrina, 12% of survey participants in one study experienced theft while in a mass shelter without safe places to put their possessions (Beaudoin, 2007).

B7. Shelter conditions can be unsanitary and uncomfortable

People's ability to maintain personal hygiene becomes a critical aspect of sheltering longer than 24 hours that affects both mental and physical health of occupants (Rincon et al., 2001). "Because [emergency shelters] are expected to be used for such a brief time, they are often uncomfortable spaces with few amenities and are sparsely provisioned" (Nigg et al., 2006, p. 119). Issues with sanitation were common in a survey across many shelters (Cruz et al., 2017). During Hurricane Katrina, mass sheltering facilities had major issues with waste management and hygiene facilities not working properly (Hamilton et al., 2009). There were also instances where the number of wash areas, toileting facilities, and waste disposal areas were insufficient to meet demand (Holmes et al., 2022). Additionally, certain populations have specific needs for hygiene that are not always met in shelters such as wheelchair users who need accessible toilets and sinks (Deal et al., 2006) or women who need trash bins with lids and running water to clean reusable hygiene products and underwear while menstruating (Sullivan and Nagle, 2020) and places to diaper babies (DeYoung, 2020).

B8. Shelters are not always equipped to meet the physical and mental health needs of occupants and staff

People arrive at shelters already experiencing various forms of mental health challenges, distress, addiction, and more (Shah et al. 2018; King and North, 2021; North et al., 2015), which may have contributed to issues evacuating in advance. Others have chronic health issues that require medications, like diabetes or seizures (Deal et al., 2010; Shah et al., 2018). On top of pre-existing issues, the emotional toll of experiencing a hurricane is significant. Certain demographics, such as women, minorities, and children feel higher stress levels around hazards and sheltering than others (La Greca et al., 2019; Pfefferbaum et al., 2020). Children may be especially impacted during disasters and need additional emotional support, with one study finding that "the shelter experience itself can increase the risk for maladaptive psychological outcomes, especially in children from socially disadvantaged backgrounds" (Pfefferbaum et al., 2020). Shelter staff and occupants report feeling acute stress, anxiety, isolation, and boredom while sheltering (FEMA P-2342; Hyer et al., 2009; La Greca et al., 2019; Ladička et al., 2009; Merlo et al., 2021; Missildine et al., 2009; Pfefferbaum et al., 2020; Saunders, 2007). People who have lost or had to leave pets during a storm to shelter also show elevated levels of psychological distress and can

be more likely to get Post Traumatic Stress Disorder (PTSD) (Austin, 2020). Shelter environments can contribute to anxiety or distress as they can feel foreign and unsettling, with one person sharing, “it’s so crowded and there are strangers all around.” (Shah et al., 2018, p. 13).

All-Duration

B9. Shelter signage is unhelpful and sometimes dangerously misleading

Shelter signage is often inaccessible, missing, or misleading and lacking relevant information. Such issues with signage prevent people from understanding sheltering options and can ultimately put people—and especially already vulnerable populations—in further danger. For example, information is often not translated into other languages for people with limited English proficiency (Peek, 2020; Burger et al., 2019), lacks visuals, is technical, and can be inaccessible for people with disabilities, such as people who are blind (Twigg et al., 2011). Additionally, post-event reports indicate that few community or residential shelters had labels indicating their safety ratings, which made it hard for residents and assessment teams to determine what level of protection they provided (FEMA P-908, 2012; FEMA, 2010). After a tornado outbreak in Mississippi in 2010, investigators learned that people “were afraid to use the [community] safe room” (FEMA, 2010, p. 17) because it was uninviting and was missing signage conveying its purpose or safety rating; instead, they sheltered in a pre-engineered fire department building. In other instances, information did not include helpful information such as if a shelter was accessible for people with disabilities (FEMA P-908, 2012), whether pets were allowed (Babcock and Smith, 2020; Farmer et al., 2016; Collins et al., 2024; Hunt et al., 2012), and if documentation was required to enter (Burger et al., 2019). Without information about shelter requirements, people were unsure of where to go.

Assessment teams observed misleading signage where “areas labeled ‘tornado shelter’ were used as refuge areas but had not been designed or constructed to provide life-safety” (FEMA P-908, 2012, p. iv). During the Joplin tornadoes in 2011, over 200 Walmart staff and shoppers took shelter in a designated “safe area” (NIST NCSTAR 3, 2014; FEMA P-908, 2012). This store was in the direct path of the tornado and suffered major damage which resulted in three fatalities and many injuries (**Figure 6**). After reviewing building design drawings, assessors found that the so-called “safe area” provided no more safety than other areas of the building, suggesting that the safety signage was misleading (NIST NCSTAR 3, 2014). In another report, findings suggest that fatalities would have been higher had more people fled to so called

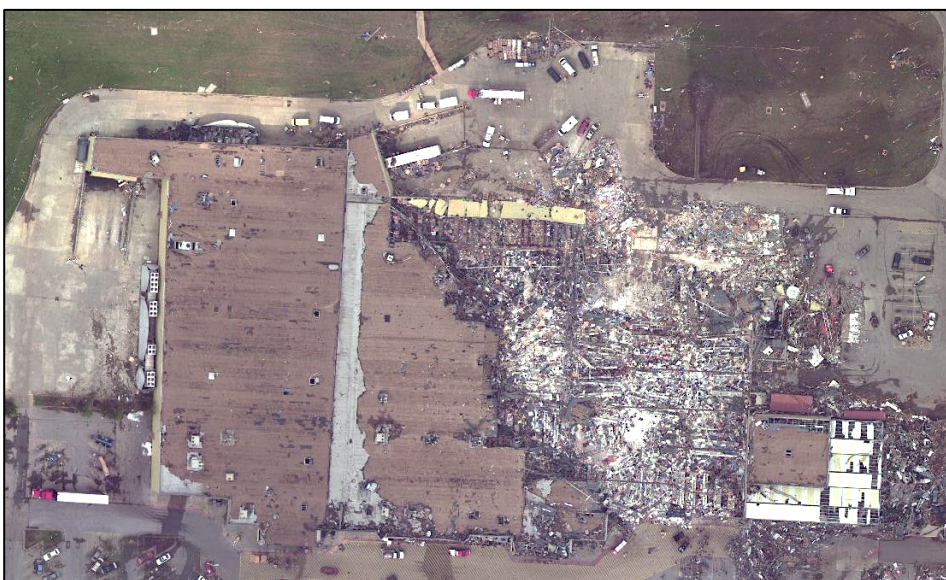


Figure 6. An aerial view of the partially destroyed Walmart where people took shelter during a tornado (image source: FEMA P-908, 2012).

“tornado refuge areas” when the tornadoes struck, as many of these buildings had collapsed and were unsafe (FEMA P-908, 2012, p. 9-7). In another example, missing signage led building administrators to usher people to vulnerable areas of a building instead of ones that had been previously evaluated as places to shelter by Florida’s Department of Community Affairs (FEMA 488, 2005a).

B10. Shelter space can be insufficient to accommodate occupants

The appropriate amount of shelter space depends on the number of expected occupants, occupant type, and the duration of stay, which are influenced by the severity of the hazard event. Safe rooms and storm shelters are built to be used for up to two hours during tornadoes and up to 24 hours during hurricanes, which impacts floor area allocations (Table 4; FEMA P-361, 2021). There are instances across shelter types where space was insufficient for those who needed it. For example, during a tornado outbreak in Mississippi, people filled up the community safe room until it was “standing room only” for a large portion of the day (FEMA P-908, 2012, p. 9-34). During Hurricane Irma, families who headed to evacuation shelters experienced overcrowding, with some having to sleep on the floor (La Greca et al., 2019). During hurricanes in 2005, the Texas Department of Health Services Special Needs Shelter was in a college gym and as evacuees continued to arrive, lack of space and hygiene facilities became major issues (Deal et al., 2006). These issues with space appear at all shelter scales with those staying in mass shelters, such as stadiums, also sharing that they felt crowded (Truong et al., 2020) and uncomfortable (Taioli et al., 2018).

Table 4. Occupant Density for Community Safe Rooms (modified from Tables B5-1 and B5-2, FEMA P-361, 2021)

Occupant type	Minimum Floor Area Per Occupant (in square feet)	
	Tornado ^a	Hurricane ^b
Standing or seated	5	20
Using a wheelchair	10	20
Using a bed or stretcher	30	40

^a Guidance recommends at least one wheelchair space per 200 occupants.
^b Guidance recommends that the designer and authority having jurisdiction determine the number of occupant type spaces based on potential safe room user needs.

Shelter space is especially an issue for older adults and those with AFN who require additional space for equipment and caregivers who they must shelter with. In a survey on shelter experiences, “one respondent recalled having to leave his wheelchair in the lobby of a public-school shelter because the hallways were too crowded for him to pass through in his chair. As a result, he was restricted to his cot for the duration of the evacuation.” (Van Willigen et al., 2002, p. 103). In other situations, caregivers and service animals were denied or discouraged from accompanying the people they supported into shelters (Twigg et al., 2011; Twigg, 2020). Assessing the right amount of space for shelters is a challenge and one that should depend on the demographics of the nearby community. However, using census data to make these assessments may underrepresent the percentage of people with special needs arriving at shelters and should be considered in planning (Springer and Casey-Lockyer, 2016). Studies suggest that including spaces for people to exercise and for kids to play can improve shelter conditions and occupant’s mental health (Hyer et al., 2009; Missildine et al., 2009; Saunders, 2007). In Florida, a private shelter used circulation corridors as places to exercise and socialize to reduce stress (FEMA P-2342, 2023). The functionality of shelter space depends on occupancy duration and has major implications for the experiences of occupants. See section B5 for more on extended sheltering duration.

C. BETWEEN STORMS: SYSTEMIC ISSUES WITH SHELTERS

Most shelter planning, development, and design occurs in the time between hazard events. As was the case in Joplin, Missouri, many communities without prior protection realize the need for shelters after devastating events have occurred. Systemic issues that exist with shelters need to be considered and addressed outside of hazard events. The issues described below are those that may require national policy change to address.

C1. There are not enough shelters located in the right places

Shelters are sparsely and unevenly distributed throughout wind-prone regions of the U.S., Territories, and Tribal Nations, leading to inequitable access during and after events. This is in part because safe rooms and storm shelters are developed based on requests from local authorities and individuals and not based on regional needs (FEMA, 2024). This leaves some populations without nearby shelters and limited options. During Hurricane Floyd, over 550,000 of the 2 million Florida evacuees lacked shelter access (Rincon, 2001). In 2011, Joplin, Missouri had no community safe rooms or storm shelters, leaving residents unprotected (NIST NCSTAR 3, 2014). Similarly, after Hurricanes Maria and Irma in 2017, the assessment teams could not identify a single building or room in the U.S. Virgin Islands that met FEMA P-361 safe room guidance (FEMA P-2021, 2018a).

While the prevalence of residential and community safe rooms and storm shelters has increased, shelter deficits persist and are significant (Balluz et al., 2000; FEMA 488; FEMA P-2342; Niederkrotenthaler et al., 2013). In the Houston-Galveston, Texas area, Karaye et al. (2020) estimate an evacuation shelter deficit of 352,713 persons and suggest that existing shelters are poorly located. In Lee County, Florida, emergency hurricane shelters are inland and far from population centers, conflicting with the need to have shelters close to where people live (Figure 7, FEMA P-2342, 2023). Most of the community safe rooms in Mississippi concentrate in the northern and southern parts, leaving the central areas with few places to shelter (FEMA, 2010). In places without safe rooms and storm shelters, communities often rely on main buildings in town that may not provide additional protection, like hospitals or long-term care facilities (FEMA 489, 2005b; FEMA P-757, 2009; FEMA P-942, 2013). Deficits for vulnerable populations, such as those with special needs, are a major issue (FEMA P-2342, 2023) with Horner et al. (2018) estimating a shortage of 720 special need shelters in Florida. These deficits force people to seek shelter in unsafe places that may lack supplies or sanitation and are often unable to serve populations with special needs.

C2. Resources for long-term shelter maintenance and assessment are limited, especially for schools

Starting in 2015, the International Building Code began requiring that new construction of certain buildings like schools and critical facilities (e.g., 911 call stations, emergency operation centers, etc.) include storm shelters (ICC, 2023, Sec. 423.4.4-5). Schools are unique in terms of their primary function and how they operate as shelters. They are defacto shelters since school policy dictates that children remain with school officials during emergencies until parents can pick them up (FEMA P-1000, 2017a), but they also may be used by the general population during emergencies. This can create issues in determining how schools will operate as shelters and return to their primary function following disasters. Additionally, schools are typically resource-limited which can create long-term issues with funding and maintaining shelters over time. As of 2002, estimates suggest that Oklahoma would need an additional 1,750 shelters to provide school children

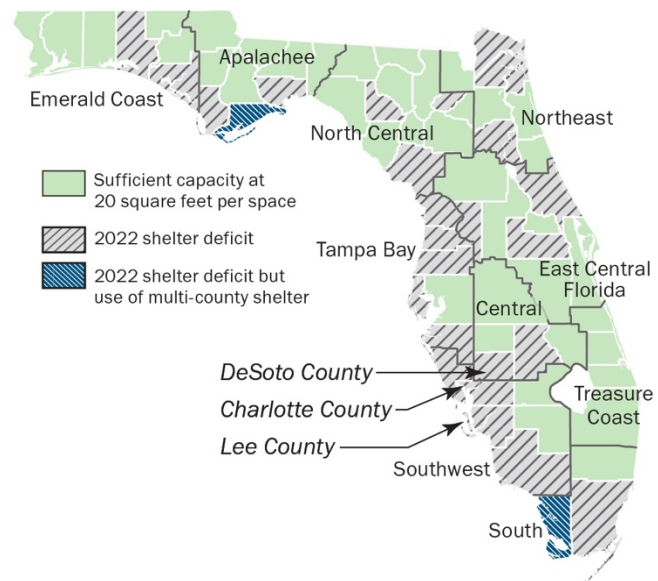


Figure 7. Florida counties with shelter deficits as of 2022
(Image source: FEMA P-2342, 2023).

with adequate storm protection (Buckley, 2002); however, costs to build this infrastructure would exceed \$1.3 billion. Additional concerns include determining who can use school shelters, who will manage them, and how long they will remain operational delaying schools from resuming normal activities (FEMA P-1000, 2017a).

C3. Shelter costs and perceptions influence investment in shelters

People who have residential shelters report feelings of safety and comfort having them (FEMA P-908, 2012). Yet, the costs to install storm shelters and safe rooms are prohibitive for many. Adjusting for inflation, residential shelter costs can range from \$6,000 to \$33,000, not including installation costs (FEMA P-320, 2020, p.47-48). These amounts represent between 8% and 44% of the median U.S. income in 2023 (U.S. Census Bureau, 2023), respectively. Community shelter costs are harder to estimate as they depend on size, if they are new constructions or retrofits, and if they are single- or multi-use, among other factors (FEMA P-361, 2021, p. A3-1-A3-5). Many individuals and communities may not be able to afford storm shelters and safe rooms, and they may perceive the costs outweigh the benefits (Levitan, 2013; Merrell et al., 2002a). State incentive programs, funded by FEMA, provide some relief by covering portions of the total shelter costs (FEMA, 2024). One such program in Oklahoma received 14,000 applications from homeowners in its first year (Merrell et al., 2002b); most of the applications came from White residents suggesting that people of color may be less likely or able to apply. Despite being more vulnerable, renters and those living in mobile homes have limited access to safe rooms (Schmidlin et al., 2009) and do not qualify for these incentive programs. There is public support for legislation to build more shelters generally, especially in places like mobile home parks and apartment buildings (Brown et al., 2002). Incentive programs are helpful at increasing the number of residential and community shelters but currently fall short in terms of providing equitable access to shelters for those who are most at risk.

Post-tornado reports from Missouri and Mississippi found that people are more aware of below ground shelters and perceive above ground ones to be less safe (FEMA, 2010; FEMA P-908, 2012). People also consider below ground shelters to be easier to install, faster to construct, cheaper, and more available. People preferred prefabricated shelters to those built onsite. One homeowner planned to install a concrete safe room, but the construction equipment could not access the location, so he installed a lighter below ground shelter instead (FEMA, 2010, p. 15). Most homeowners shared that the installation times for their below ground shelters were between one and two days as opposed to longer for above ground storm shelters (FEMA, 2010, p. 19).

RECOMMENDATIONS

The recommendations were developed in direct response to the findings above and were summarized and synthesized to ensure that each recommendation addresses at least two or more findings (**Table 5; Appendix D**). These can be applied specifically to storm shelters and safe rooms but may also be relevant for other shelter types. The recommendations are divided into four categories—human-centered design, operations, planning and outreach, and policy change. The scale at which they should be carried out varies. Some may be more appropriate for local governments to address while others may require federal action. The recommendations focus on addressing the issues identified in the literature, but how they are pursued and applied will depend on many factors, such as agency purview and funding, which is beyond the scope of this study.

Table 5. Recommendations Mapped to Findings

Human-Centered Design	Findings Addressed
a. Employ universal design principles to ensure shelters are accessible for all.	A2, A6, B5, B7, B8, B9, B10
b. Design shelter spaces to feel safe, welcoming, and comfortable with options for privacy and provisions for those with special needs.	A2, B6, B7, B8, B10
c. Develop accessible, clear and standardized shelter signage.	A1, A2, B2, B9
d. Increase the number and density of shelters, especially in places with high levels of physical and social vulnerability.	A4, A5, A6, B7, B10, C1
Operations	
e. Bolster shelter lifelines (power, water, sewer, and communications).	B1, B4
f. For hurricane shelters, extend minimum sheltering time frames to at least 72 hours.	B3, B4, B7, B10
Planning and Outreach	
g. Improve evacuation and shelter planning to meet the needs of a diverse public by involving individuals or groups with lived experience.	A4, A5, A6, B5
h. Expand education on evacuation plans and storm shelters and safe rooms before and during events, especially to vulnerable populations.	A1, A2, A3, B1, B2, C1
i. Develop a national resource website that provides information about shelter options before and during extreme wind events.	A1, A2, A3, B1, B2
Policy Change	
j. Expand cost-sharing, incentive, and funding programs for storm shelters and safe rooms with special considerations for vulnerable populations and schools.	C2, C3
k. Update post-event assessments to include data on human experiences during sheltering to assess occupancy levels, duration and other issues with sheltering beyond structure performance.	B3, see also research gaps

HUMAN-CENTERED DESIGN

a. *Employ universal design principles to ensure shelters are accessible for all.*

“Universal design is a concept in which products and environments are designed to be *usable by all* people, to the greatest extent possible, without the need for adaption or specialized design” (U.S. GSA, 2023). This type of design moves away from the idea of accessibility where the goal is to prevent discrimination and instead promotes creating spaces and practices that don’t create barriers for people to begin with. “By considering the diverse needs and abilities of all throughout the design process, universal design creates digital and built environments, services and systems that meet peoples' needs. Simply put, universal design is good design.” (CEUD, n.d.). Universal design includes seven principles that, when applied to shelters, will help ensure that those with and without AFN can use shelters equitably (**Table 6**). These design principles can be used across shelter types and scales.

Table 6. Universal Design Principles, Definitions, and Shelter Examples

Principle	Definition (adapted from CEUD, n.d.)	Examples in Shelters
1. Equitable Use	The design is useful to people with diverse abilities.	Accessible paths, entrances and hygiene facilities; accommodations for service animals.
2. Flexibility in Use	The design accommodates a wide range of individual preferences and abilities.	Adjustable spaces (places for prayer or breastfeeding) and privacy options (e.g., walls or screens); designated and separate places for pets.
3. Simple and Intuitive Use	Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.	Clear signage (includes occupancy, allotted time, safety provided), easy to navigate layouts.
4. Perceptible Information	The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.	Signage that uses high-contrast, large-font text and is translated into other languages.
5. Tolerance for Error	The design minimizes hazards and the adverse consequences of accidental or unintended actions.	Slip-resistant flooring, rounded corners on furniture, and backup power.
6. Low Physical Effort	The design can be used efficiently and comfortably and with a minimum of fatigue.	Lever style door handles, touchless faucets.
7. Size and Space for Approach and Use	Appropriate size and space are provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.	Entrances, hallways, and main areas that are spacious enough for wheelchairs or other medical devices to occupy and pass through.

b. Design shelter spaces to feel safe, welcoming, and comfortable with options for privacy and provisions for those with special needs.

Finding opportunities to reduce stress and promote mental and physical health while sheltering is critical to improve occupant experiences and increase shelter use. Features such as physically separate spaces for safety, privacy, or quarantine; lockers for valuables to enhance feelings of security; and areas for movement, like hallways or open spaces for children to play and adults to exercise, can all contribute to a more welcoming and pleasant shelter environment. These spaces also help ensure those who use wheelchairs or who have other medical devices can move comfortably through the space. Examples from other shelter types illustrate the power of design. For example, a study on shelter design for unhoused populations found that upgraded rooms offered some individual control and privacy, which reduced stress and empowered occupants (Pable, 2012). Another shelter housed in a church, was updated by adding natural materials and calming colors to create a comfortable place for families to stay (Figure 8; Uherbelau, 2021).

c. Develop accessible, clear and standardized shelter signage.

Current signage practices for tornado and hurricane shelters are inconsistent and confusing. This can create situations where people don't know where to go or travel to places that they think are safe, but are not (e.g., a Walmart). Spaces that do not meet FEMA guidelines or ICC500 Standards for wind protection



Figure 8. An example of a welcoming shelter space designs in Portland, Oregon for unhoused families (image source: Uherbelau, 2021).

should not be labelled as “tornado or hurricane shelters,” and should clearly state the level of protection they provide. Mileti et al. (2004) summarize an extensive list of hazard and risk education best practices that can be applied to shelter signage. Some recommendations include developing communications that are clear, tell people what to do, use words and graphics, are placed around the community, are available in other languages, and are tailored to different groups (e.g., renters, manufactured homeowners, people with AFN, etc.). Applying these best practices to shelter signage, can improve shelter awareness and help people identify where to go during hazard events.

d. *Increase the number and density of shelters, especially in places with high levels of physical and social vulnerability.*

Physical vulnerability refers to aspects of the built environment—homes, power plants, roads, etc.—that are exposed to hazards, making a community more vulnerable (CDC/ATSDR, 2024, p.18). Social vulnerability refers to “the sociodemographic characteristics of a population and the physical, social, economic, and environmental factors that increase their susceptibility to adverse disaster outcomes and capacity to anticipate, cope with, resist, and recover from disaster events” (Adams et al., 2019). Local, state, and federal governments should identify places to build more shelters where physical vulnerability intersects with social vulnerability. By including both types of vulnerability, shelters can be built in locations where they are most urgently needed. This analysis could also provide opportunities to promote shelter construction in high vulnerability areas by increasing grant funding and cost share amounts in those areas. Social vulnerability indices (SVIs) are tools that could be used for initial assessments, but local investigation and input is also critical to ensure local characteristics and data are accurately represented, especially because the national dataset that often underpin SVIs can underrepresent populations who are most vulnerable, such as minorities (Wines and Cramer, 2022).

OPERATIONS

e. Bolster shelter lifelines (power, water, sewer, and communications).

Lifelines are critical to shelter function during and after a wind hazard event. Though guidance on constructing storm shelters and safe rooms already includes specifications for ensuring certain lifelines are maintained, additional considerations can help support shelter occupant and staff needs. Some include:

- Ensuring that main and back-up power are available to run lighting, but also air conditioning, refrigeration, and medical devices.
- Increasing the number of hygiene facilities available and ensuring facilities are accessible.
- Ensuring that communication systems are available at shelters and considering options for occupants to charge and use their communications devices while sheltering.
- For shelters occupied for days, having places to charge cellphones and having options for occupants to use WI-FI and access news and entertainment (FEMA 2342, 2023).

f. For hurricane shelters, extend minimum sheltering time frames to at least 72 hours.

Hurricane storm shelters and safe rooms get used beyond their intended time frames regularly, which creates issues for shelter operations and occupants. To reduce these issues, timeframes for hurricane safe rooms and storm shelters should be updated from 24 to 72 hours, as was already done following Hurricane Maria in Puerto Rico (FEMA P-2342, 2023, p. 5-45). This extended time frame will help ensure that people sheltering can weather the storm and potential impacts and reduce some of the issues that arise with extended stays. Having storm shelters and safe rooms be designed for longer use also allows people to shelter safely while recovery shelters mobilize following a disaster.

PLANNING AND OUTREACH

g. Improve evacuation and shelter planning to meet the needs of a diverse public by involving individuals or groups with lived experience.

Populations who have challenges evacuating and sheltering due to lack of planning for their specific needs include, but are not limited to:

- People with AFN
- Children and older adults
- Populations with limited English proficiency
- People with pets and service animals
- Low-income populations
- Transportation-limited populations
- Residents of manufactured homes
- People with mental health challenges

Local and federal governments should consult with groups who serve these populations to aid in evacuation planning and shelter design. Community-based organizations or advocacy groups that serve the populations above have vital perspectives on the needs of those populations and can help provide critical guidance. In one example focused on evacuating pets and their owners, the City of New Orleans collaborated with the Louisiana Society for the Prevention of Cruelty to Animals to develop an effective model for evacuating and sheltering pets (Babcock and Smith, 2020). The plan included transportation and tracking procedures, co-location options, and regular training for staff and responders, and was successfully implemented during Hurricane Gustav. Similarly, during Hurricane Florence in North Carolina, the Wake County Animal Center deployed “PET PODS”—shipping containers filled with animal supplies—to evacuation shelters (Federico and Banks, 2020).

These examples demonstrate how advanced planning and collaboration between emergency response agencies and local groups who understand the needs of a specific population, such as pets and their owners, reduces barriers to evacuation and improves sheltering experiences.

h. Expand education on evacuation plans and storm shelters and safe rooms before and during events, especially to vulnerable populations.

Audiences include local officials, news agencies, emergency responders, safe room designers/companies and the public with specific attention to vulnerable populations such as renters, manufactured home residents, people with AFN, and populations with limited English proficiency. Education efforts should aim to improve awareness of:

- What local evacuation plans are and how they are carried out
- What shelter options are available
- When to use different sheltering options
- Where shelters are located
- The protection ability provided by different shelter types (e.g., safe room or storm shelter, BARA, etc.)
- Where to find information about evacuations and shelter facilities before and during events
- What to expect at shelters (e.g., who can use them, if pets are allowed, what to bring, length of use, etc.)
- Costs, benefits, incentives and grant programs, etc. for storm shelters and safe rooms

Principles of risk communication for socially vulnerable groups, which can also be applied to storm shelter and safe room education, include (1) communicating through familiar and trusted messengers, (2) providing clear, actionable information; and (3) tailoring messages and information pathways for target audiences (Campbell, N. et al., 2020). These can be combined with the hazard education best practices outlined by Mileti et al. (2004), to ensure communications are as effective as possible for all audiences.

i. Develop a national resource website that provides information about shelter options before and during extreme wind events.

Even though shelter programs and data are often managed locally, having a national resource website focused on sheltering during extreme wind hazards would help to provide standardization and a single place where people could go to learn about sheltering, addressing several of the information gaps listed above. This website could include a map of where federally funded public-use storm shelters and safe-rooms are located, the protections they provide, and a list of local resources. The U.S. Department of Housing and Urban Development has a website like this, but for unhoused and resource insecure populations looking for information on where to find shelter, food, health clinics, and clothing: [hud.gov/findshelter](https://www.hud.gov/findshelter). When visitors enter their address and topic of interest and a map showing nearby shelters and resources is displayed. The Red Cross's shelter map is another simple but effective way to communicate shelter locations (Red Cross, n.d.).

Municipalities are best positioned to have comprehensive lists of shelters in their communities and how they operate during an event, but having a national website and map that consolidates and standardizes this information would be useful. This website could also help direct people to credible local resource pages to reduce the onus on individuals having to find that information. This national resource page could be an opportunity for federal and local governments to work together to standardize and maintain shelter information.

POLICY CHANGE

j. Expand cost-sharing, incentive, and funding programs for storm shelters and safe rooms with special considerations for vulnerable populations and schools.

Finding opportunities to make shelters more affordable for communities and individuals will improve their development and use. The expense of building and maintaining storm shelters and safe rooms is prohibitive for many but cost sharing and incentive programs are one avenue to reduce costs. Expanding these programs to new structure types—apartment buildings and manufactured home parks—as well considering need-based adjustments to cost-sharing amounts can ensure that safe shelter options are more available to populations who are most at risk. Additionally, creating shelters that are multi-use spaces can help justify their cost. For example, schools can have gymnasiums or cafeterias that double as shelters to optimize costs and space (Buckley, 2002; FEMA P-908, 2012). This same idea can be implemented elsewhere such as community centers, libraries, senior living common spaces and other areas where people go regularly. Providing funding for maintenance can assist individuals and communities, particularly those in rural or under-resourced areas, in keeping shelters compliant and effective during extreme wind events.

k. Update post-event assessments to include data on human experiences during sheltering to assess occupancy levels, duration and other issues with sheltering beyond structure performance.

FEMA's mitigation assessment teams visit locations that have recently experienced extreme wind events to assess building performance and observe impacts. Included in these reports are often summaries of safe room and shelter performance. Some reports detail how people used the safe rooms and shelters, but few discuss issues experienced by shelter occupants, occupancy numbers, or how long people used the shelters for. This information is critical to better identify what is working well and how safe room and storm shelter designs could be improved. Much of the research literature fails to distinguish between safe rooms, storm shelters and typically constructed buildings being used as shelter, so it is challenging to uncover the differences in people's experiences and how structures can be improved. Leveraging existing efforts to gather information and interview survivors after events can provide opportunities to study the social aspects of sheltering while reducing the need for additional post-event resources.

SHELTERING RESEARCH GAPS

The literature review uncovered a series of research areas that should be explored further. These gaps are posed as questions below:

- To what extent are communities aware of different types of shelters (e.g., do they know the difference between safe room and sheltering at home in terms of protection)?
- What perceptions do people have about levels of protection provided by different shelter construction types?
- What shelter information is most critical to people during an extreme wind event?
- What signage would be most useful to include on or nearby shelters?
- What are people's experiences like in shelters that meet FEMA and ICC500 standards compared to those that do not or are unspecified? During tornadoes? During hurricanes?

- How many people occupied safe rooms and storm shelters during extreme wind events and for what duration?
- How often are shelters used for longer than the durations they were built for? By what duration are they exceeded?
- Where are residential and community shelters located across wind-prone states? How does this compare to where populations are most vulnerable?
- What are the cost/benefits of shelters and safe rooms for high-risk communities? What incentive programs would be most appealing for these communities?
- How can advocacy groups that represent vulnerable populations (e.g., children, people with AFN, elderly, people with companion animals) be included in shelter planning to ensure shelters meet their needs?
- How do findings related to sheltering from wind-based hazards compare to sheltering from other hazards, such as tsunamis and earthquakes? What are commonalities to sheltering barriers? What are the differences?

CONCLUSIONS

This paper consolidates key insights from more than 100 peer-reviewed articles and agency reports on the social dimensions of sheltering during extreme wind events. This analysis highlights the social and psychological factors that shape shelter decision-making and influence people's experiences while sheltering. These insights inform key recommendations across policy and practice to improve the use of and experience with extreme wind shelters. Applying these research-based recommendations will enhance the safety and accessibility of shelters for the communities that rely on them. As the threat of extreme wind events continue to grow for communities across the U.S., its Territories, and Tribal Nations, it is crucial for federal agencies, local governments, and planners to prioritize systematic improvements in shelter design and management. Proactive measures taken now can save lives and better protect vulnerable populations before the next storm strikes.

ACKNOWLEDGEMENTS

This work was made possible through a partnership between FEMA, the Applied Technology Council (ATC), and the Natural Hazards Center. FEMA provided funding for this effort through the Earthquake and Wind Programs Branch Architectural & Engineering support contract. ATC provided project contracting support and oversight. Special thanks go to Pataya Scott and Daniel Bass with FEMA for prompting this work and providing expertise, insights, and guidance throughout as well as paper review, Jon Heintz with ATC for project facilitation, contract oversight and paper review and Bernadette Hadnagy with ATC for contract administration, and Lori Peek with the Natural Hazards Center for project guidance, paper review, and unwavering support.

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APPENDICES

APPENDIX A. GLOSSARY OF KEY TERMS

The language around sheltering and building types can be confusing as shelter has a multitude of definitions and is used in many contexts. Key terms are defined below to clarify how they are used in this document. These definitions were gathered from federal agency sources where possible as well as peer-reviewed articles and other reputable sources.

Access and Functional Needs (AFN): individuals who need assistance due to any condition (temporary or permanent) that limits their ability to act. To have access and functional needs does not require that the individual have any kind of diagnosis or specific evaluation. Individuals having access and functional needs may include, but are not limited to, individuals with disabilities, seniors, and populations having limited English proficiency, limited access to transportation, and/or limited access to financial resources to prepare for, respond to, and recover from the emergency (FEMA, 2021).

Best Available Refuge Area (BARA): An area in an existing building that has been deemed by a registered design professional to be likely to protect building occupants during an extreme-wind event better than other areas in the building when a safe room is not available. The BARA should be regarded as an interim measure to be used until a FEMA-compliant safe room or ICC-500 compliant storm shelter can be made available (FEMA, 2017b).

Evacuation Shelter: Provides initial and immediate safety and refuge from or during a threatened or actual incident. The primary function of these shelters is to keep people out of harm's way. After the incident occurs, this type of shelter may evolve into other types of sheltering (IAVM, 2010, p. 14).

Human-Centered Design: is a problem-solving technique that puts real people at the center of the development process, enabling you to create products and services that resonate and are tailored to your audience's needs (Landry, 2020).

Life Safety: the design and operating features of a building that provide its occupants a reasonable level of safety during fires and other emergencies (ENSAFE, 2022).

Mass or Mega Shelter: A large shelter (e.g., stadium, convention center, etc.) that is generally necessary when the number of people requiring shelter support is large and extensive damage to structures and community infrastructure limits sheltering options and results in longer shelter operational periods (IAVM, 2010, p. 14).

Physical Vulnerability: The aspects of the built environment (including homes, power plants, roads) that are exposed to hazards making a community more vulnerable (CDC/ATSDR, 2024 p.18).

Protective Actions: Actions that people take to reduce risk from extreme events in the natural environment before or during an event (Lindell and Perry, 2012).

Recovery Shelter: Shelters that are available to people following a disaster. These are often occupied for days, weeks, and in some case months after a disaster and offer food, places to sleep, health services, emergency supplies and more (Red Cross, n.d.).

Social Vulnerability: the sociodemographic characteristics of a population and the physical, social, economic, and environmental factors that increase their susceptibility to adverse disaster outcomes and capacity to anticipate, cope with, resist, and recover from disaster events. (Adams et al., 2019)

Safe Room: a building or portions thereof that comply with the criteria described in FEMA P-361, Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms (FEMA P-320, 2021).

Shelter: A place of refuge that provides life-sustaining services in a congregate facility for individuals who have been displaced by an emergency or a disaster (FEMA, n.d.)

Special Needs or Medical Needs Shelter: Shelters that support individuals who have medical issues requiring care beyond the capability of a general population shelter. They are established by local, State, or tribal governments in coordination with public health and social services agencies (IAVM, 2010).

Storm Shelter: A building or portions thereof that complies with the International Code Council (ICC) and National Storm Shelter Association (NSSA) ICC/NSSA Standard for the Design and Construction of Storm Shelters, also called ICC 500 (FEMA P-320, 2021).

Typical Construction: Buildings that are not hardened or designed to protect occupants and provide life-safety protection from extreme-wind events such as hurricanes and tornadoes. Taking refuge in a building of typical construction during an extreme-wind event could result in injury or death. (FEMA, 2018c, p. 2)

Universal Design: a concept in which products and environments are designed to be *usable by all* people, to the greatest extent possible, without the need for adaption or specialized design (U.S. GSA, 2023).

APPENDIX B. DETAILED LITERATURE REVIEW METHODS

To gather literature, a list of criteria for inclusion was developed. The criteria included documents that were (1) peer-reviewed articles, dissertations, theses, agency reports, (2) published after 1999³, and (3) focused on or pertained to:

- a. The United States, U.S. Territories and Tribal Nations;
- b. The human dimensions of sheltering during a hurricane, tornado, and extreme wind hazard events including, for example, psychology of shelter use, shelter decision-making, experiences in shelters, mental health impacts of disasters/sheltering, specific population needs for sheltering;
- c. Topics that are relevant or have implications for shelter architecture, layout, or design;
- d. Shelters of all sizes, but with specific preference for those that are intended for short durations (<72 hours);
- e. Time periods that include, before, during or after a hazard event.

Though materials on other types of hazard shelters, such as earthquake or tsunami shelters, may be relevant, they were beyond the scope of this paper and are not included. The criteria were used to develop and refine search terms such that a database query narrowed the articles returned to less than 500. See **Appendix C** for the refined search query. This query was used across three different well known article databases—Web of Science EBSCOHost, and PubMed—which, after removing papers from fields outside of the topic area, returned 135, 231 and 144 publications, respectively. Twenty-two articles from a Natural Hazards Center Research Counts Special Collection on Mass Sheltering and Disasters (Breedon et al., 2021) were then added to bring the total to 532.

The literature screening software called Rayyan AI (rayyan.ai) was used to import all documents into one database and eliminate duplicates. This reduced the number of articles to 465. Each article title and abstract were reviewed in Rayyan AI to decide if the inclusion criteria were met. One hundred and five articles met the inclusion criteria and were then divided into six sociological themes (**Figure B1**). Articles within a theme were reviewed together to help ensure consistent ideas were noted. Notes for each article were recorded in a review table with columns to collect relevant information regarding human factors associated with sheltering (**Table B1**).

To gather insights outside of peer-reviewed literature, 12 FEMA and 1 NIST reports were reviewed that focused on the building impacts of hurricane and tornado events and were published after 1999²; These reports reviewed the hurricanes Charley (2005), Ivan (2005), Ike (2009), Sandy (2013), Irma (2018), Maria (2018), Harvey (2019), Michael (2020), and Ian (2022). The reports on tornadoes focused on an outbreak in Mississippi in April of 2010 and in Missouri in May of 2011.

³ FEMA partners and the research team selected 1999 as this was the year after the first FEMA guidance on storm shelter design, P-320, was available. The goal was to narrow the literature search to be publications about shelters that followed these guidelines.

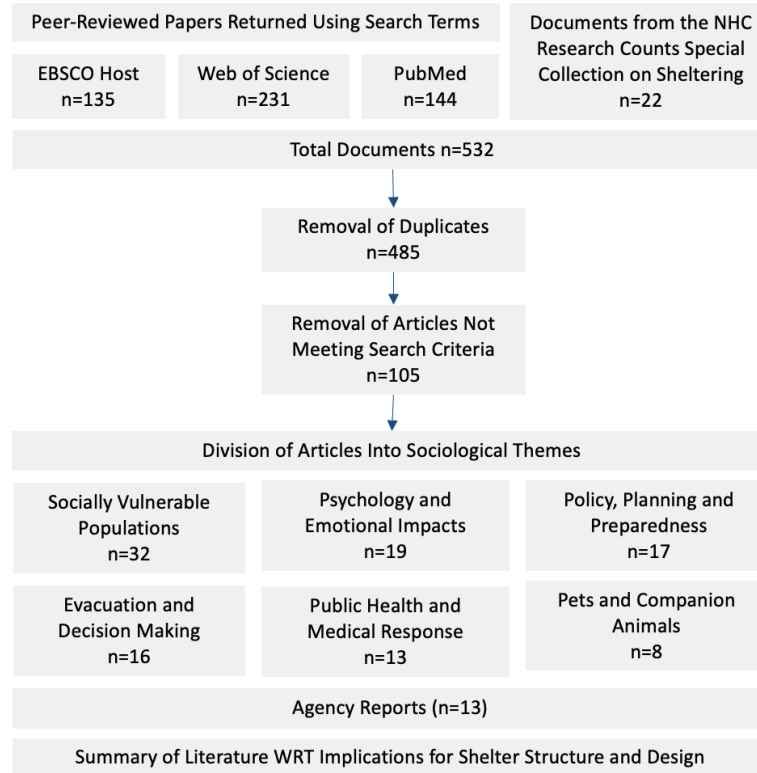


Figure B1. Flow chart of literature collection methods.

Table B1. Literature Review Table Columns

Column Header	Description
Theme	The theme that best matched each article’s topic.
Secondary Theme	A secondary theme for articles that had topics spanning more than one theme.
Case Study	Event name and location for papers that specifically focus on a hazard event (e.g., 2005 Hurricane Katrina or 1999 May Tornadoes)
Disaster Stage	A focus on planning and preparedness, response, or recovery.
Hazard Type	Hazard of focus in the article—hurricane, tornado, or other.
Issues	Issues brought up in articles that relate to the human dimensions of sheltering (e.g., lack of hygiene facilities or fears of safety). Specific focus is paid to social issues associated with shelter design.
Implications for Sheltering	Suggestions, recommendations, and next steps called for by paper authors in terms of shelter considerations, planning, policies, and practices.
Other Relevant Findings	Findings that go beyond issues with sheltering and space but are relevant for human experience of sheltering.

APPENDIX C. SEARCH QUERY

The query below was entered into the literature search function of Web of Science EBSCOHost, and PubMed literature databases to gather relevant literature on white paper topic.

—

[(tornado*) OR (hurricane*) OR (storm*) OR (extreme wind*) OR (wind) OR (straight-line wind*) OR (windstorm*) OR (temporary) OR (short-term) AND

(shelter*) OR (safe room*) OR (best available refuge area) OR (BARA) OR (community shelter) OR (residential shelter)

AND

(human) OR (social) OR (mental health) OR (psychology) OR (panic) OR (claustrophob*) OR (fear) OR (social determinants) OR (planning) OR (pets) OR (capacity) OR (hygiene) OR (resilien*) OR (prepared*) OR (crime) OR (safety) OR (health) OR (socially vulnerable) OR (at-risk) OR (public health) OR (populations) OR (women) OR (minorities) OR (elderly) OR (child*) OR (low income) OR (unhoused) OR (homeless) OR (welfare) OR (faith) OR (vulnerab*) OR (volunteer) OR (community-based organizations)

AND

(united states)

NOT

((homeless shelter*) OR (women's shelter) OR (clinical))]

APPENDIX D. LITERATURE REVIEW DETAILED FINDINGS

Recurring findings and observations from the literature that were relevant to shelter structure and design were compiled and organized in the tables below. These are divided into two sections, findings specific to short-term sheltering, and findings associated with extended-duration sheltering. Each section is then divided into theme areas. Column one indicates a human experience documented in the literature; column two indicates the implications of that finding for shelter structure and design; and column three lists the citations of articles that shared that finding. These were condensed and distilled to develop the white paper findings and recommendations. They are included here as there may be additional nuance that is relevant for shelter design and education.

Short-Duration Sheltering Themes (e.g., tornadoes)

1. Shelter Awareness and Sheltering Behavior		
Human Experience	Implications for Shelter Structure and Design	Citations
<p>Most people shelter in their own due to:</p> <ul style="list-style-type: none"> • Lack of warning time. • Lack of alternate shelter options. • Lack of awareness of nearby shelters. • Perceptions that they will be safe in their homes. 	<ul style="list-style-type: none"> • Need more communications about when safe rooms or storm shelters should be used and what sheltering options are. • Need clearer communications about shelter locations with communities before an event and clear protocols and public education on when staying in homes is appropriate and when a storm shelter is needed to protect life. 	<p>Ash et al., 2020; Balluz et al., 2000; FEMA P-908, 2012; Hammer et al., 2002; Kuligowski 2020; Mason et al., 2014; NIST NCSTAR 3, 2014; Schmidlin et al., 2009; Wang et al., 2023</p>
<p>People living in manufactured homes are at greater risk to death and injury from tornadoes, but residents do not always perceive the heightened risk.</p>	<ul style="list-style-type: none"> • New shelters could be prioritized in or near mobile home parks. It's important to consider how this will be done equitably as some costs may be borne by future residents, such as higher rents. 	<p>Ash et al., 2020; Brown et al., 2002; Merrel et al., 2002a; Niederkrotenthaler et al., 2013; Schmidlin et al., 2009; Simmons et al., 2007; Walters et al., 2020</p>
<p>People avoid using safe rooms that are empty, dark, and uninviting. Additionally, without proper signage, people are skeptical of safety rating and use other spaces to shelter.</p>	<ul style="list-style-type: none"> • Ensure that safe rooms are built to meet safety needs, but also are places people feel comfortable spending time in. Additional outreach to those involved in construction on the design and installation of safe rooms, would be beneficial. 	<p>FEMA, 2010</p>
<p>Most people reported having less than 10 min—some less than 5 min— to respond to a warning. Schmidlin et al. (2009) found that if a shelter was greater than 200 meters away, people will drive.</p>	<ul style="list-style-type: none"> • Build shelters such that they are accessible within less than 10 minutes—Ideally less than 5 minutes—for the target population. 	<p>Balluz et al., 2000; Comstock and Mallonee, 2005; FEMA, 2010; FEMA P-908, 2012; Schmidlin et al., 2009</p>

People report travelling longer distances (>1/2 mi) to reach known shelters. In Joplin, Missouri over 10% of fatalities were reported outside/in cars.	<ul style="list-style-type: none"> Increase public awareness of shelters that are close by. 	FEMA P-908, 2012; NIST NCSTAR 3, 2014
People do not keep tools in their safe rooms to help them exit if locks get damaged by debris.	<ul style="list-style-type: none"> Encourage safe room developers to equip safe rooms with tools and educate owners on the need for tools in their shelters. 	FEMA P-908, 2012
People in safe rooms do not always bring communications devices with them making them unable to contact anyone for help	<ul style="list-style-type: none"> Additional outreach to safe room owners is needed, especially for below ground rooms (e.g., letting neighbors and local EMS know, and having a communications device in the safe room in case people get trapped). 	FEMA, 2010; FEMA P-908, 2012

2. Shelter Design Issues

Human Experience	Implications for Shelter Structure and Design	Citations
Many community shelters did not have toilets and there were issues with how vents were installed (not protected).	<ul style="list-style-type: none"> Code adoption and enforcement could be improved. 	FEMA P-908, 2012
A community safe room was “standing room only” for periods of time.	<ul style="list-style-type: none"> Consider allocation of space for safe rooms and whether it is enough. 	FEMA P-908, 2012

3. Costs and Benefits for New Shelters

Human Experience	Implications for Shelter Structure and Design	Citations
People may not perceive the costs of residential shelters outweigh the benefits for these low probability events. However, incentives can help. For example, in OK in 1999, the Safe Room Initiative provided \$2000 rebates for installation of saferooms in homes). It was very popular with more than 14,000 homeowners applying for the program that year. People who tend to apply are more likely to be white.	<ul style="list-style-type: none"> Incentives are a good way to get people to purchase safe rooms but may need to consider demographics if the goal is to reach the most vulnerable. Develop cheaper options for storm shelters or provide additional subsidies. 	Levitan, 2013; Merrel et al., 2002a; Merrel et al., 2002b
People with safe rooms in their homes reported feeling safety and comfort having them		FEMA P-908, 2012
For residential SR, people prefer and are more aware of below ground safe rooms and perceive above ground safe rooms to be less safe. Some reasons may be	<ul style="list-style-type: none"> Need more public outreach about safe room types, costs, and benefits. Opportunities to 	FEMA, 2010; FEMA P-908, 2012

because below ground take less time to construct, cheaper, more available and logistically easier to install. Prefabricated were preferred.	<p>reduce costs are also helpful to consider. Cost and time to install are factors people consider.</p> <ul style="list-style-type: none"> • Need more outreach and education for homeowners and local officials on the benefits of above ground and in-home safe rooms 	
Schools – issues with schools paying for long-term maintenance of shelters. Shelters must be multi-use for it to be cost effective for schools to have a shelter.	<ul style="list-style-type: none"> • Ensure safe rooms in school buildings are multi-purpose rooms 	Buckley, 2002; FEMA P-908, 2012

Extended-Duration Sheltering (e.g., hurricanes)

1. Safety and Operations		
Human Experience	Implications for Shelter Structure and Design	Citations
Some people avoid using shelters because of fears of safety. This is especially true for women. People cite having to guard their belongings while in shelters and not feeling safe.	<ul style="list-style-type: none"> • Ensure toileting facilities have doors, latches and proper lighting; create separate spaces for specific populations (e.g., women and children); have places where people can store valuables. • Include signage on safety features available in the shelter and include communications about safety measures that are taken and available. 	Burger et al., 2019; Beaudoin, 2007; Farmer, 2020; Farmer, 2018; La Greca et al., 2019; Sullivan and Nagel, 2020; Taioli et al., 2018
Religious minorities feel unsafe going to shelters due to fears of discrimination, lack of privacy, and perceived uncleanliness, and lack of food consistent with faith practices.	<ul style="list-style-type: none"> • Provide separate spaces for religious observance. 	Mando et al., 2011; Peek, 2020
When people see poor performance of shelters (whether they met standards or not) it reduces confidence in shelters and makes people less likely to use them	<ul style="list-style-type: none"> • Clearly communicate about shelter designs and criteria to help the public know which shelters are intended to withstand the strong winds and which are not. 	FEMA 488, 2005a
<p>Loss of power severely impacts shelter operations (especially for those who rely on medical devices requiring power and because lack of a/c results in high heat and humidity making spaces uncomfortable)</p> <p>If available, generators are often only used for basics (e.g., lighting and some convenience), but shelter occupants also want outlets for technology (e.g., cell</p>	<ul style="list-style-type: none"> • Ensure there is enough power and back-up power to keep critical shelter functions operational (e.g., hygiene, wastewater, functional needs, refrigeration, cooling). • Ensure there is enough fuel for generators. • Consider adding additional power for technology and communications for occupants by adding extra outlets for charging or medical equipment that can be supplied by the emergency generator. 	Behr and Diaz, 2013; Choi et al., 2020; Claver et al., 2013; FEMA P-942, 2013; FEMA P-2342, 2023; Hyer et al., 2009; Jiang and Tedeschi, 2020; Laditka et al., 2009; Rincon et al., 2001; Sanusi et al., 2020; Schnall et al., 2019; Shipp et al., 2016

phones charging, WIFI, and entertainment) to connect with family and reduce boredom.	<ul style="list-style-type: none"> Ensure utilities for shelters are not in places where storm surge or flooding can damage them. 	
Shelters experienced water intrusion leading to uncomfortable experiences for shelter residents	<ul style="list-style-type: none"> Prioritize reducing water intrusion in shelter design. 	FEMA 488, 2005a; FEMA 489, 2005b
Some shelters lost sewage and potable water had to bring in portable toilets which took time	<ul style="list-style-type: none"> Consider having secondary toileting options for shelters. 	FEMA 489, 2005b; FEMA P-2342, 2023
Emergency shelters become places that people stay much longer than intended (days to weeks with people arriving before landfall and being required to stay due to safety issues). This can cause issues such as occupant discomfort, drug use or violence. There is a continuum of sheltering needs (Emergency shelter, temporary shelter, temporary housing, permanent housing) during and after a major event especially when many homes were destroyed. Sheltering needs are dynamic.	<ul style="list-style-type: none"> Shelters should be multi-length use (e.g., be able to support immediate and post-disaster needs). May need to expand timeline designations for short-term shelters. Consider how security and safety will be factored into shelter designs. 	FEMA P-2342, 2023; Nigg et al., 2006; Ridpath et al., 2015; Sanusi et al., 2020
Issues with maintenance or modifications to safe rooms (example in Puerto Rico where residential safe rooms had been modified for other used by adding ventilation, air flow, or place for sleeping and cooking). Updates made structures vulnerable and could no longer be used for intended storm protection.	<ul style="list-style-type: none"> Need checkups on safe rooms to see if they are still in compliance or if they have been modified over time. Also, in places like PR where all spaces are needed, consider building safe rooms such that they can be used for multiple purposes. Need to require that FEMA 361 criteria be met if grant funding is used to build safe rooms. 	FEMA P-2020, 2018b

2. Health and Hygiene		
Human Experience	Implications for Shelter Structure and Design	Citations
People arrive at shelters with chronic and acute mental and physical health needs. They will need mental and physical healthcare while in shelters.	<ul style="list-style-type: none"> Designate spaces for privacy for provision of health care. Portable screens will work for some situations and not others (e.g., counseling sessions). 	Condon et al., 2010; Deal et al., 2010; Deal et al., 2006; Gavagan et al., 2006; King et al 2021; North et al., 2015; Saunders, 2007; Schnall, 2021; Shah et al., 2018; Taioli et al., 2018; Truong et al., 2020; Vest and Valadez, 2006
Nursing mothers lack privacy or places to bathe and diaper infants in shelters.	<ul style="list-style-type: none"> Provide places to bathe and diaper small infants and private spaces for breastfeeding. 	DeYoung, 2020
Disease can spread more easily in shelters as it is crowded with many people. Pandemics co-occurring reduce the shelter capacity.	<ul style="list-style-type: none"> Have a separate physical place for people to quarantine or isolate in the shelter. Consider shelter capacity reduction when diseases (like COVID-19) compound disaster. 	Behr et al., 2021; Collins et al., 2024; Marshall et al., 2021; Murray et al., 2009; Ridpath et la., 2015; Shipp et al., 2016; Vest and Valadez, 2006; Veenema and Casey-Lockyer, 2021

Occupants have issues getting good sleep in shelters which impacts their experiences and health.	<ul style="list-style-type: none"> Have a separate space for people who can't sleep or want to watch TV, use their phones during sleeping hours to avoid disturbing others and reduce stress 	Missildine et al., 2009; Taioli et al., 2018
Shelter staff and occupants feel acute stress, isolation, and boredom while sheltering.	<ul style="list-style-type: none"> Have designated spaces for exercise and play for adults and children. This helps to reduce stress and keep people occupied. 	FEMA P-2342, 2023; Hyer et al., 2009; La Greca et al., 2019; Laditka et al., 2009; Merlo et al., 2021; Missildine et al., 2009; Pfefferbaum et al., 2020; Saunders, 2007
Anxiety, stress, and depression while in shelters can be lessened by being able to communicate with loved ones and having access to news to understand what is happening during the event	<ul style="list-style-type: none"> Have TVs, computers with internet in shelters. 	Beaudoin, 2007
Shelters report issues with having proper hygiene facilities and that impacts the physical and emotional experience of people sheltering.	<ul style="list-style-type: none"> Ensure hygiene facilities are available and meet the needs of those being sheltered (e.g., toileting facilities have trash bins for women to dispose of sanitary products as well as water for washing) 	Cruz et al., 2017; Deal et al., 2010; Hamilton et al., 2009; Hyer et al., 2009; Rincon et al., 2001; Sullivan and Nagel, 2020
Overcrowding and unpleasant conditions led to physical discomfort in shelters	<ul style="list-style-type: none"> Expand the size of shelters to better accommodate needs and consider other ways to make them more comfortable for people. 	La Greca et al., 2019; Rincon et al., 2001; Shah et al., 2018 ; Taioli et al., 2018

3. Access and Functional Needs (AFN)		
Human Experience	Implications for Shelter Structure and Design	Citations
Shelter facilities are not always accessible (e.g., routes to entrances and entrances are hard to access and restrooms, cots, toilets, and bathrooms are not accessible)	<ul style="list-style-type: none"> Create shelters that are ADA compliant and use universal design principles to ensure they are accessible for people in wheelchairs and others with physical disabilities. Allot space for medical equipment and have adequate power in place to supply them. Have accessible cots, hygiene facilities and restrooms. Involve people with disabilities in shelter design and planning processes can help ensure designs meet user needs. 	Arrieta et al., 2008; Behr and Diaz, 2013; Hamilton et al., 2009; Holmes et al., 2022; Jiange and Tedeschi, 2020; McGuire et al., 2007; Stough, 2021; Twigg et al., 2011
A shelter serving people with AFN was located on the 2 nd floor and required an elevator to access it. The elevator stopped working due to power outages	<ul style="list-style-type: none"> Locate shelters that service people with AFN on the first level of a building and do not install power-dependent lifts or elevators. 	Holmes et al., 2022

Elderly populations and those with AFN tend to shelter in place for because of difficulties associated with disrupting routines, limited transportation options and reliance on medical equipment, etc.	<ul style="list-style-type: none"> • Have space, power, and back-up options for electricity-dependent medical equipment. 	Behr and Diaz, 2013; Dostal, 2015; Hyer et al., 2009; Jiange and Tedeschi, 2020; Rincon et al., 2001
Nursing homes, assisted living, and long-term care facilities have major challenges evacuating the populations they serve.	<ul style="list-style-type: none"> • Prioritize nursing homes, assisted living and long-term care facilities as places to create storm shelters/safe rooms. 	Brown et al., 2015; Claver et al., 2013; Lach et al., 2005; Laditka et al., 2008
Caregivers for people with disabilities will travel with the people they support.	<ul style="list-style-type: none"> • Include space requirements for caregivers in calculations for shelter space. 	Dostal, 2015; Patton-Levine, 2007; Twigg, 2020
Census data likely underrepresents the percentage of people with special needs who will arrive at a shelter.	<ul style="list-style-type: none"> • Estimate how many people with special needs may need to use a shelter. • Avoid using only census data to assess local need and determine shelter capacity. 	Holmes et al., 2022; Springer and Casey-Lockyer, 2016; Yang et al., 2023
Co-locating an AFN shelter with the general public posed problems with overcrowding.	<ul style="list-style-type: none"> • Consider having separate shelters designated and designed for AFN and general population, which must be clearly communicated in advance. 	Holmes et al., 2022

4. Animal Accommodations		
Human Experience	Implications for Shelter Structure and Design	Citations
<p>People are less likely to shelter if they can't bring their pets. This is especially true for populations who are transportation-limited such as older adults or people with disabilities.</p> <ul style="list-style-type: none"> • Losing a pet or having to leave them during disaster produces high levels of psychological stress, PTSD, and anxiety. • If they can afford it, people with pets will avoid shelters and instead stay in hotels or other places that will allow pets. 	<ul style="list-style-type: none"> • Shelter designs and plans should include options for co-housing pets and their supplies. • See New Orleans pet sheltering plans (Babcock and Smith, 2020) and PET PODS program (Federico and Banks, 2020) for existing plans and policies for sheltering pets. 	Austin, J., 2020; Austin, J. 2013; Babcock and Smith, 2020; Burger et al., 2019; Collins et al., 2024; Condon et al., 2010; Dostal, 2015; Douglas et al., 2019; Farmer et al., 2016; Federico, 2020; Federico and Banks, 2020; Hyer et al., 2009; Lagiewski et al., 2023; Smith and McCarthy, 2009; Whitehead et al., 2000
People with pets are not sure if shelters will take them and stay home	<ul style="list-style-type: none"> • Shelters should have clear signage indicating if pets are allowed and which ones 	Babcock and Smith, 2020; Collins et al., 2024; Farmer et al., 2016; Hunt et al., 2012
Pets that people bring to shelters typically include cats and dogs, but can also include reptiles, rodents, fish and more.	<ul style="list-style-type: none"> • Shelters designs should consider which types of pets will be brought into the sheltering environment and where they will stay while there. 	Austin, J., 2020; Austin, J. 2013
Service animals should remain with their owners in shelter environments.	<ul style="list-style-type: none"> • Accommodations should be made in shelters for service animals. 	Twigg, 2020