ARTICLE

Experiences of People Who are Deaf or Hard-of-Hearing During Emergencies in OECD Countries: A Scoping Study

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Abstract

This scoping study integrates research on the experiences of deaf, Deaf or hard-of-hearing (DHH) people during extreme weather events and other emergencies in Organisation for Economic Co-operation and Development countries. The review identified 48 articles published between January 2005 and August 2024. Data charting and inductive analysis of these articles identified three factors that influence access to and participation in communication during emergencies: (1) emergency warnings, alerts, and announcements; (2) the emergency sector response; and (3) emergency preparedness. There are opportunities to leverage capabilities and facilitators to address common barriers and support increased accessibility and inclusion for DHH people before, during, and after emergencies. These include ensuring that warnings and alerts are provided in multiple formats and channels; providing training for first responders in communicating with DHH people; including the diverse needs of DHH people in emergency plans at all levels; and ensuring that training and educational materials are accessible and relevant to DHH people. There are roles for DHH community organizations and the hearing care sector to link DHH individuals with information, education, and training provided by the emergency sector. For many DHH people who do not have connections with support organizations or other DHH people, the hearing care sector may be the only linkage point between their deafness or hearing difficulties, their hearing devices, and their personal emergency awareness and preparedness.

Keywords Audiology · Deaf · Disasters · Emergencies · Hard-of-hearing · Hearing sector · Natural hazards

1 Introduction

There is growing recognition that people with disability are some of the most at risk during natural hazard events (Royal Commission into National Natural Disaster Arrangements 2020; Stein and Stein 2022) and that natural hazard preparedness, risk management plans, and public emergency responses must be inclusive of and accessible to people with disability (Commonwealth of Australia Department of Social Services 2021). Their needs must be addressed at all phases of emergencies—including preparedness (for example, individual and organizational emergency preparedness plans), early warnings and alerts (for example, alarms, directions to evacuate), response (for example, emergency sector assistance), and recovery (for example, rebuilding, long-term psychological and physical health) (Phillips 2015).

The Disability-Inclusive Disaster Risk Reduction (DIDRR) approach is anchored within the social model of disability and moves away from concentrating on impairments or vulnerability to put people with disability at the center of emergency planning, with a focus on their strengths, capabilities, and support requirements (Kailes and Enders 2007; Twigg et al. 2018; Villeneuve 2022). These capabilities and support needs are understood in relation to elements of the environment that enhance or limit an individual's ability to prepare for and respond to natural hazard emergencies (Villeneuve et al. 2021).

An estimated 3.6 million or one in six Australians experience some form of hearing difficulty (Access Economics 2006), and are often described as comprising three groups—those who identify as culturally Deaf and who use sign language (for example, Auslan, Australian sign language) as their primary language; those who are deaf or hard-of-hearing and use hearing devices (for example, hearing aids, cochlear implants), spoken language, and identify as part of

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the hearing community; and those who identify as part of both groups (Bat-Chava 2000). There is more recent recognition of the diversity in how individuals experience deafness, with personal variation in use of spoken versus signed language, and use of hearing devices (Bonventre et al. 2023). It is essential that DIDRR actions account for this diversity of experience—and do not focus on addressing some barriers (for example, access to sign language) at the exclusion of others (for example, hearing device-specific preparedness). Overall, the experiences of deaf, Deaf or hard-of-hearing (DHH)[1] people during extreme weather events and other emergencies are not well understood, and there is a need for more information to identify the unaddressed barriers that increase emergency risks for this population.

To address this gap in knowledge, this scoping study aimed to identify and integrate research about the experiences of DHH people during extreme weather events and other emergencies. This includes research about the challenges and barriers faced by DHH people before, during, and after these events, and the strategies and facilitators that have been identified as supporting accessibility and inclusion. In mapping and integrating existing research, this study also aimed to identify opportunities for future research and cross-sector collaboration that leverages the capabilities of DHH people to support specific, tailored, and contextualized emergency preparedness, thereby reducing the risks of these events.

2 Methods

This scoping study was guided by the Arksey and O'Malley methodological framework for scoping studies, designed to comprehensively map existing research on a broad topic including all study designs (Arksey and O'Malley 2005; Levac et al. 2010), and the protocol was prospectively registered with the Open Science Framework on 28 July 2023.[2]

2.1 Eligibility Criteria

To address the aims of the scoping study, a search was conducted for all articles with content specific to the experiences of DHH people before, during, and after emergencies associated with hydrometeorological and geological hazards in Organisation for Economic Co-operation and Development

(OECD) countries. These hazards are referred to as "extreme weather events and other emergencies" throughout this article, to ensure the language used is accessible to sectors that may have limited knowledge of hydrometeorological and geological hazards. In order to understand the experiences of DHH people specifically, articles were excluded if they presented materials with findings or recommendations about other disabilities only, or disability in general. Aligned with the focus of the broader project, the study also excluded materials focused on non-OECD countries, and those specific to terrorism, war, gun violence, cyber-attacks, disease outbreaks, pandemics, or biological or chemical threats. Full inclusion and exclusion criteria are available in supplementary materials.[3]

2.2 Study Selection

The search strategy was developed in consultation with a research librarian at The University of Sydney. The following bibliographic databases were searched for articles published in English between January 2005 and August 2024: MEDLINE, Scopus, Embase, CINAHL, PsycINFO, and Web of Science. The search timeframe starts with the adoption of the Hyogo Framework for Action 2005–2015, which prioritized actions to guide disaster risk reduction activities and increase resilience to disasters around the world (United Nations 2005). The research team collectively does not possess the linguistic expertise to accurately interpret and analyze articles published in languages other than English. Resources for translation and interpretation were not available for this study, so the decision to focus on English-language literature was made pragmatically to ensure a timely and feasible review process. Including such articles without proper translation or understanding could have jeopardised the methodological rigor and reliability of the study findings. Searches combined keywords and subject headings relevant to DHH people (for example, "deaf," "hearing impairment," "hearing aid," "cochlear implant") and natural hazards (for example, "disaster," "natural disaster," "fire," "flood"). The query string used in MEDLINE is included here, and full query strings used in each of the databases are available in supplementary materials.

> (exp Hearing Disorders/OR exp Hearing Aids/OR exp Persons With Hearing Impairments/ OR "hearing imp*".mp. OR deaf.mp. OR exp Cochlear Implants/ OR cochlear.mp.) AND (exp Climate Change/OR exp Disasters/OR exp Natural Disasters OR natural disaster.mp. OR exp Fires/OR exp Floods/OR exp Cyclonic Storms/OR exp avalanches/or exp landslides/or exp

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[1] While we have used "deaf, Deaf and hard-of-hearing people" with "DHH people" as an abbreviation in this article, we acknowledge the wide diversity in experiences of deafness, that some readers may have other preferred terms to describe deafness or hearing difficulty, and individual preferences for identity-first and person-first language.

[2] https://osf.io/kpj4q

[3] https://collaborating4inclusion.org/publications/

tidal waves/or exp tsunamis/or exp volcanic eruptions/or exp wildfires/OR exp extreme weather OR exp Earthquakes/) (limit to yr = "2005-Current")

The results (citation details, abstracts, and keywords) of each database search were exported into EndNote. Duplicates were removed, and the EndNote library was imported to Covidence[4] for screening. Two reviewers (Brigit Maguire and Isabelle Boisvert) independently reviewed titles and abstracts, and then full text articles, against the eligibility criteria. Conflicts were resolved through discussion and subsequent agreement between the two reviewers. Articles that did not meet the eligibility criteria were excluded from the scoping study, with the reason for exclusion noted.

2.3 Data Charting and Analysis

To integrate findings from the identified research, the three authors collaboratively developed a data charting framework using Microsoft Excel. The first author extracted information about each study as well as the predicting factors influencing experiences of emergency preparedness, response, and recovery, including barriers and facilitators. Extracted textual data were analyzed using an inductive approach by the first author, iterating between the extracted information, full-text papers, and the emerging and then established themes, in consultation with the other authors. The quality of the data extraction and inductive analysis was assured by ongoing discussion with the other two authors throughout the data extraction and analysis.

This article provides the first (to the authors' knowledge) integrated overview of the experiences of DHH people during extreme weather events and other emergencies, as represented within peer-reviewed research articles. In alignment with the scoping study methodology, and to ensure that all existing research was included, including research on lived experience of deafness and hearing difficulties, no studies were excluded based on the quality of the study design.

3 Results

Figure 1 outlines the results of the searching and screening processes. After removing duplicates, 1073 articles were screened against the eligibility criteria and 48 articles were selected for inclusion in the scoping study.

The included articles reported on studies conducted in the United States (*n* = 29), Australia (*n* = 5), New Zealand (*n* = 4), Japan (*n* = 4), South Korea (*n* = 2), one study each in Canada, Denmark, England, Italy, and three studies covering

multiple countries. The majority (*n* = 28) of the articles focused on emergencies in general, with others addressing building fires (*n* = 7), earthquakes (*n* = 7), tsunamis (*n* = 2), hurricanes (*n* = 2), and one study each looking at floods, cyclones, personal traumatic events, and public health emergencies. Articles provided information about experiences well before emergency events (*n* = 13), early warnings (*n* = 9), response (*n* = 11), and recovery (*n* = 4), with an additional 14 articles discussing all phases or emergencies in general. Characteristics of the studies are summarized in Table 1.

The charting process and subsequent thematic analysis identified three factors that influence the experiences of DHH people in emergency events: (1) emergency warnings, alerts, and announcements; (2) the emergency sector response; and (3) emergency preparedness, all situated within the broader context of access to and participation in communication. The reviewed articles described barriers to and facilitators of effective communication for each of these three factors. This review discusses the barriers and impacts described in the reviewed articles (summarized in Table 2), followed by the recommended facilitators that can improve access to information and communication (summarized in Table 3). While emergency phases notionally begin with emergency preparedness, the reviewed articles most effectively highlight the barriers experienced in accessing emergency warnings, alerts, and announcements, so the review begins at that point.

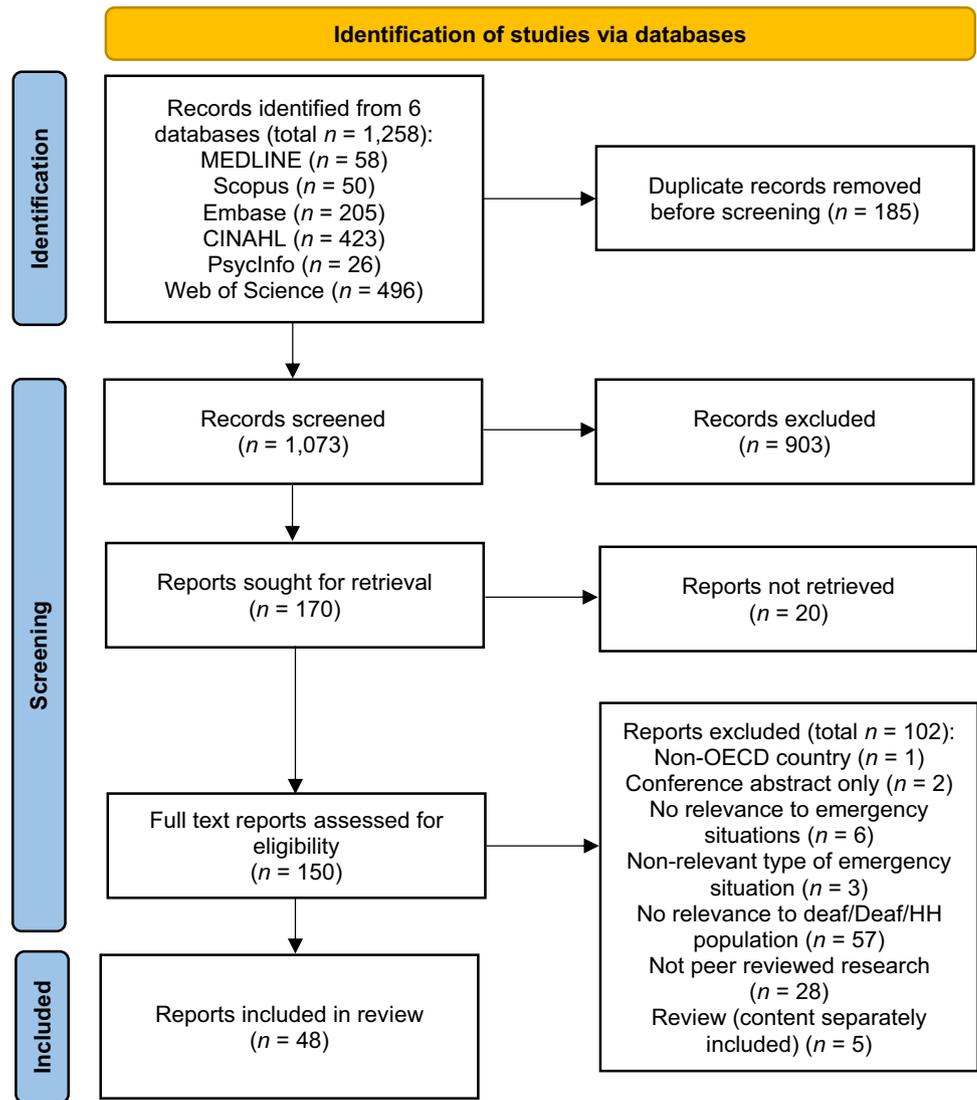## 3.1 Emergency Warnings, Alerts, and Announcements

The first factor identified through thematic analysis relates to emergency warnings, alerts, and announcements. These are critical means of communication with the public, advising of an emergency situation and that they should take action for their own safety (Calgaro et al. 2021; Cooper et al. 2024).

3.1.1 Barriers and Impact

Reviewed articles highlighted the inaccessibility of emergency warnings and alerts for many DHH people because they are typically auditory in nature. These include sirens, alarms, announcements through public address systems and on radio and television, telephone calls, door knocking, and shouted orders on the street (Engelman et al. 2017; Takayama 2017; Calgaro et al. 2021; Tannenbaum-Baruchi et al. 2024). Beyond initial warnings and alerts, DHH people also face barriers in accessing public announcements during all stages of an emergency, such as information about where to access services, announcements and instructions, and public health messages (Nick et al. 2009; Zod et al. 2014; Takayama 2017; Koch et al. 2019; Calgaro et al. 2021). Impacts of

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Fig. 1 Preferred reporting items of systematic reviews and meta-analyses (PRISMA) flow diagram (Page et al. 2021)

Identification of studies via databases

Identification

Records identified from 6 databases (total *n* = 1,258):
MEDLINE (*n* = 58)
Scopus (*n* = 50)
Embase (*n* = 205)
CINAHL (*n* = 423)
PsycInfo (*n* = 26)
Web of Science (*n* = 496)

Duplicate records removed before screening (*n* = 185)

Screening

Records screened
(*n* = 1,073)

Records excluded
(*n* = 903)

Reports sought for retrieval
(*n* = 170)

Reports not retrieved
(*n* = 20)

Full text reports assessed for eligibility
(*n* = 150)

Reports excluded (total *n* = 102):
Non-OECD country (*n* = 1)
Conference abstract only (*n* = 2)
No relevance to emergency situations (*n* = 6)
Non-relevant type of emergency situation (*n* = 3)
No relevance to deaf/Deaf/HH population (*n* = 57)
Not peer reviewed research (*n* = 28)
Review (content separately included) (*n* = 5)

Included

Reports included in review
(*n* = 48)

being unable to access warnings, alerts, and announcements include increased fear and uncertainty, slower evacuation speeds, not knowing which locations are safe to evacuate to, not evacuating at all, not accessing services, and possibly higher mortality rates (Takayama 2017; Horiike et al. 2019; Choi et al. 2020; Calgaro et al. 2021; Lumsden and Black 2022; Lee and First 2024). Compounding the inaccessibility of auditory warnings and alerts, the systems that DHH people use to obtain information in their everyday lives are often not available during emergency situations. For example, while television captioning may usually be effective, the availability or quality of captioning is frequently reduced during an emergency (McKee 2014; Calgaro et al. 2021).

There are additional barriers experienced by DHH people who use a sign language for communication, including not having access to sign language interpreting in emergency communications in the media, and when an interpreter is included, not always showing the full image of the

interpreter's face and hands on screen, which negatively impacts access to emergency information (McKee 2014; Calgaro et al. 2021). These barriers arise due to a lack of awareness of the importance of interpreters, insufficient training in working with interpreters, negative responses from the public, limited availability of interpreters including when interpreters have also been affected by the emergency situation, high costs of interpreting, and poor communication about where and when interpreters will be available (McKee 2014; Zod et al. 2014; Phibbs et al. 2015; Calgaro et al. 2021).

3.1.2 Increasing Accessibility of Alerts and Warnings

The reviewed articles highlighted that the accessibility of alerts and warnings can be improved by including visual warnings and alerts such as flashing lights and text information in public areas and by sending information directly to

Table 1 Scoping study results: characteristics of reviewed studies

Source	Country of focus	Type of emergency	Phase of emergency	Refers to signed language	Refers to hearing devices
Abdulhalim et al. (2021)	New Zealand	Earthquake	Well before	No	No
Arena et al. (2024)	USA	All	Well before	No	No
Ashley (2007)	USA	Building fire	Early warnings	No	No
Bruck and Thomas (2009)	Australia	Building fire	Early warnings	No	No
Bryan et al. (2014)	USA	Building fire	Early warnings	No	No
Calgaro et al. (2021)	Australia	All	All	Yes	No
Choi et al. (2020)	South Korea	Building fire	Early warnings, Response	No	No
Cooper et al. (2024)	Multiple	Earthquake	Early warnings	Yes	No
Cripps et al. (2016)	USA	All	Well before	Yes	No
Elmannai et al. (2020)	USA	Building fire	Early warnings	No	No
Engelman (2012)	USA	All	Well before	Yes	No
Engelman et al. (2022)	Multiple	All	All	Yes	No
Engelman et al. (2013)	USA	All	Well before	Yes	No
Engelman et al. (2017)	USA	All	All	Yes	No
Fox et al. (2010)	USA	Hurricane	All	No	Yes
Harkins et al. (2010)	USA	All	Early warnings	Yes	No
Hasegawa et al. (2015)	Japan	Earthquake, Tsunami	Response	No	No
Hay and Pascoe (2019)	New Zealand	All	All	Yes	No
Horiike et al. (2019)	Japan	Tsunami	Well before	No	No
Hosono et al. (2015)	Japan	All	Response	Yes	No
Ivey et al. (2014)	USA	All	Well before	Yes	No
Kailes and Enders (2007)	USA	All	All	Yes	No
Kamau et al. (2018)	USA	All	Well before	Yes	No
Kent and Ellis (2015)	Australia	All	All	No	No
Koch et al. (2019)	USA	All	All	No	No
Landrum (2009)	USA	Building fire	Well before	Yes	Yes
Lee and First (2024)	USA	Tornado	Recovery	No	No
Lumsden and Black (2022)	England	All	Response	Yes	No
Malmin and Eisenman (2024)	USA	Hurricane	Recovery	No	No
McKee (2014)	Australia, New Zealand	Earthquake, flood, cyclone	Response, recovery	Yes	No
Morris et al. (2014)	USA	All	All	No	Yes
Neuhauser et al. (2013)	USA	All	Well before	Yes	No
Nick et al. (2009)	USA	All	Well before	No	No
Owens et al. (2013)	USA	All	Well before	Yes	Yes
Park et al. (2024)	South Korea	Heat	Response	No	No
Petinaux and Yadav (2013	USA	All	Response	No	No
Phibbs et al. (2015	New Zealand	Earthquake, all	All	Yes	No
Putkovich (2013)	USA	All	Early warnings	No	No
Rotoli et al. (2022)	USA	All	Response	Yes	No
Rotondi et al. (2019)	Italy	Earthquake	Response, recovery	Yes	No
Rutkow et al. (2015)	USA	All	All	Yes	No
Sherratt (2023)	General	All	All	No	Yes
Skøt et al. (2017)	Denmark	Personal traumatic events	Response	Yes	Yes
Smedberg et al. (2022)	USA, Canada	Building fire	Early warnings	No	No
Takayama (2017	Japan	Earthquake, All	All	Yes	No
Takayama et al. (2022)	USA	All	Well before	Yes	No
Tannenbaum-Baruchi et al. (2024)	USA, Australia	Bushfire	All	Yes	Yes

Table 1 (continued)

Source	Country of focus	Type of emergency	Phase of emergency	Refers to signed language	Refers to hearing devices
Zod et al. (2014)	USA	Public health emergency	Response	Yes	No

Table 2 Scoping study results: Barriers and impacts experienced by deaf, Deaf or hard-of-hearing (DHH) people in emergencies

Factors	Barriers	Impacts	Sources
Emergency warnings, alerts, and announcements	- Inaccessibility of audio-based warnings, alerts, and announcements - Inadequate availability, reliability, or quality of captioning - No accessible sign language interpreting	- Increased fear, uncertainty - Unable to access, understand, or act on safety information including about when, where, and how to evacuate - Unaware of or unable to find out about available services - Not able to access public health messages	Calgaro et al. (2021) Choi et al. (2020) Cooper et al. (2024) Engelman et al. (2017) Horiike et al. (2019) Koch et al. (2019) Lee and First (2024) Lumsden and Black (2022) McKee (2014) Nick et al. (2009) Petinaux and Yadav (2013) Phibbs et al. (2015) Putkovich (2013) Takayama (2017) Tannenbaum-Baruchi et al. (2024) Zod et al. (2014)
Emergency sector response	- Communication difficulties between DHH people and first responders - Issues with technological solutions - Inaccessibility of phone calls	- Unable to communicate needs - Unable to receive appropriate services - Increased fear, uncertainty, and frustration for DHH individuals - First responders feel uncomfortable, frustrated, and fearful - Missed or inaccurate diagnoses - Quality of care affected	Calgaro et al. (2021) Cripps et al. (2016) Engelman (2012) Engelman et al. (2013) Ivey et al. (2014) Kamau et al. (2018) Koch et al. (2019) Lumsden and Black (2022) Malmin and Eisenman (2024) Rotoli et al. (2022) Skøt et al. (2017) Takayama (2017) Tannenbaum-Baruchi et al. (2024)
Emergency preparedness	- Inaccessibility of preparedness materials and training activities - No content specific to deafness or hearing difficulties - Needs of DHH people not included in emergency preparedness plans - Lack of engagement with DHH people in emergency planning	- Low levels of emergency knowledge and preparedness	Calgaro et al. (2021) Cooper et al. (2024) Engelman (2012) Hay and Pascoe (2019) Ivey et al. (2014) Kamau et al. (2018) Landrum (2009) Neuhauser et al. (2013) Owens et al. (2013) Phibbs et al. (2015) Rutkow et al. (2015) Takayama (2017) Takayama et al. (2022) Tannenbaum-Baruchi et al. (2024)

personal devices (Calgaro et al. 2021; Tannenbaum-Baruchi et al. 2024). Authors emphasized that it is important that all potential recipients can access emergency warnings, understand what an alert means, and what actions should be taken in response (Cooper et al. 2024). Accessible warnings should therefore advise of risk, convey information about where to go and what to do, and provide details of how to find more information (Putkovich 2013; Horiike et al. 2019; Calgaro et al. 2021). When referring recipients to further information sources, it is important that text-based alternatives to a phone number are included, such as email addresses or SMS-based options (Phibbs et al. 2015; Calgaro et al. 2021).

Table 3 Scoping study results: recommendations that can facilitate access to communication and information for deaf, Deaf or hard-of-hearing (DHH) people in emergencies

Factors	Recommendations	Sources
Emergency warnings, alerts, and announcements	- Include visual warnings and alerts and text information in public areas - Send information directly to personal devices - Ensure that it is clear what an alert means, what actions should be taken in response, and where to get more information - Provide emergency related information o in different formats (written text, pictorial information, captions, local sign language) o through multiple channels (radio, TV, telephone, text message/SMS emergency warning alerts, email, video-chat, social media platforms) o ensure all information and channels are current - Include text-based alternatives to a phone number when directing to further information	Calgaro et al. (2021) Choi et al. (2020) Cooper et al. (2024) Engelman et al. (2017) Engelman et al. (2022) Harkins et al. (2010) Horiike et al. (2019) Kamau et al. (2018) Kent and Ellis (2015) McKee (2014) Morris et al. (2014) Nick et al. (2009) Phibbs et al. (2015) Putkovich (2013) Rotondi et al. (2019) Takayama (2017) Tannenbaum-Baruchi et al. (2024)
Emergency sector response	Education for first responders and other professionals: - Cultivating connections with and learning from DHH people in local community - Understanding the barriers experienced in everyday lives and in emergency situations - Understanding the strengths and capabilities of DHH people - How to receive a phone call through a relay service - How to adapt communication for different DHH conversation partners: o use respectful communication o ensure good lighting o remove masks o gain a person's attention by respectfully gesturing within their line of sight or touching their shoulder or arm o remain in the person's line of sight o use gestures or written notes if needed o use apps to translate speech to text o for sign users: learn some basic signs and sentences, learn how to work with an interpreter (be aware some people are Deafblind, and may use a tactile form of sign language) o for people who use speech: ensure face and lips are visible, look directly at the person, speak clearly at a comfortable pace to support lip reading	Calgaro et al. (2021) Cripps et al. (2016) Engelman (2012) Engelman et al. (2013) Engelman et al. (2017) Ivey et al. (2014) Kamau et al. (2018) Lumsden and Black (2022) Rotoli et al. (2022) Skøt et al. (2017) Takayama (2017) Tannenbaum-Baruchi et al. (2024) Zod et al. (2014)

Table 3 (continued)

Factors	Recommendations	Sources
Emergency preparedness	- Include needs of DHH people in emergency plans across all levels of government and the emergency sector - Test plans before an emergency occurs - Consider intersectionality with other demographic characteristics - Plan for accessibility in evacuation shelters - Ensure that educational materials and training activities are accessible for DHH individuals (including for lower literacy levels) - Ensure that materials and activities include content relevant to DHH-specific challenges and preparedness - Ensure that training and materials are consistent, regularly updated, and well publicized - Work in partnership between DHH community organizations and the emergency sector to facilitate access to preparedness educational materials and training - Information campaigns to increase use of accessible (and effective) smoke alarms among DHH people - Learn from high levels of adaptability and resilience of many DHH people, and benefit from the contributions of DHH individuals to emergency preparedness planning	Arena et al. (2024) Ashley (2007) Bruck and Thomas (2009) Bryan et al. (2014) Calgaro et al. (2021) Cooper et al. (2024) Cripps et al. (2016) Engelman (2012) Engelman et al. (2017) Engelman et al. (2022) Ivey et al. (2014) Kailes and Enders (2007) Kamau et al. (2018) Lumsden and Black (2022) Morris et al. (2014) Neuhauser et al. (2013) Rotoli et al. (2022) Rutkow et al. (2015) Skøt et al. (2017) Smedberg et al. (2022) Takayama (2017) Takayama et al. (2022) Tannenbaum-Baruchi et al. (2024) Zod et al. (2014)

Beyond alerts and warnings, the reviewed research showed that it is essential that emergency-related information is available in different forms and shared through multiple channels, reflecting the diverse ways in which DHH people access information and communication (Cooper et al. 2024). Formats include written text, pictorial information, captions, and the local sign language. Communication channels include traditional media such as radio, TV, and telephone calls; and more accessible channels including emergency warning alerts direct to personal devices, email, video-chat; and all currently available social media platforms (Takayama 2017; Kamau et al. 2018; Calgaro et al. 2021; Engelman et al. 2022; Cooper et al. 2024; Tannenbaum-Baruchi et al. 2024). Authors suggest that DHH people may have a greater reliance on social media than other groups, so it is important that social media content is accessible (Morris et al. 2014; Kent and Ellis 2015; Rotondi et al. 2019). Some of the social media platforms referred to in the reviewed articles have changed since publication, highlighting the need to review and update plans regularly as technology and social media change (Kamau et al. 2018).

3.2 Emergency Sector Response

The second factor that influences access and participation in communication during emergencies is the emergency sector response. This involves two-way communication between members of the public and first responders and other professionals in a variety of settings as the emergency develops, including the initial ground response, contacting emergency services, public meetings, and in evacuation centers (Calgaro et al. 2021; Tannenbaum-Baruchi et al. 2024).

3.2.1 Barriers and Impact

Several articles described experiences of communication challenges between DHH individuals and first responders and other professionals (Skøt et al. 2017), including with police (Engelman 2012; Lumsden and Black 2022), fire fighters (Tannenbaum-Baruchi et al. 2024), emergency medical services (Rotoli et al. 2022), and mental healthcare providers (Takayama 2017). These include DHH individuals not being able to understand the professional, not being able to express their needs, and misunderstandings between the two parties (Skøt et al. 2017; Koch et al. 2019; Lumsden and Black 2022). Tannenbaum-Baruchi et al. (2024) described the importance of their sense of sight for many DHH people as they rely on seeing faces, signs, and other visual cues when communicating—highlighting additional barriers to communication at night, in the dark, or when a communication partner's face is obscured by masks or breathing apparatus.

Accessing and using interpreters to interact with first responders is a key barrier DHH people who use sign language face during emergencies, particularly when first responders do not understand the importance of having an interpreter available, or do not know how to work with an interpreter (Skøt et al. 2017; Lumsden and Black 2022;

Rotoli et al. 2022). While it may sometimes be necessary for first responders to communicate with a DHH individual through hearing relatives (Rotoli et al. 2022) this can lead to privacy breaches, the DHH individual not accessing full information about their own care, and increased feelings of dependency (Skøt et al. 2017).

These communication difficulties lead to adverse impacts such as DHH people being unable to receive appropriate crisis assessments, missing out on services or support; missed or inaccurate diagnoses; increased fear, uncertainty, and frustration; and feelings of vulnerability and needing to rely on others (Takayama 2017; Lumsden and Black 2022; Malmin and Eisenman 2024;Tannenbaum-Baruchi et al. 2024). DHH people often have low levels of trust in first responders, sometimes avoiding or delaying contacting emergency services (Engelman 2012). This lack of trust is linked to previous negative experiences in communicating with and receiving support from emergency services (Calgaro et al. 2021). First responders with little experience in communicating with DHH people also reported feeling uncomfortable, frustrated and fearful when responding to an emergency with a DHH individual for the first time, and that communication barriers sometimes affect the quality of care they can provide to DHH patients (Engelman 2012; Rotoli et al. 2022). These difficulties can be linked to a paucity of training for the emergency response sector in how to communicate with DHH people (Engelman et al. 2013).

There are technologies that support in-person communication between individuals and emergency professionals, such as speech-to-text apps, video sign language interpreting and relay services for making phone calls (Engelman 2012; Skøt et al. 2017; Kamau et al. 2018; Calgaro et al. 2021; Lumsden and Black 2022). However, there are barriers identified in using these options, including reliance on power and connectivity, slowness, cross-jurisdictional inconsistency, and a lack of awareness that these options exist (Koch et al. 2019; Calgaro et al. 2021; Lumsden and Black 2022).

3.2.2 Improving Accessibility of Emergency Response Sector

Authors emphasized the importance of first responders and other professionals adapting their communication to better meet the needs of DHH people. Training for emergency response personnel was found to be effective in improving knowledge and understanding of how to adapt communication for a DHH conversation partner, to make the "invisible disability" aspect of deafness or hearing difficulties more visible to the emergency sector, and to lead to better ongoing relationships between the sector and DHH people, including in subsequent emergency situations (Cripps et al. 2016; Calgaro et al. 2021). Articles suggested that education for professionals should include information about connecting with DHH people in the local community to learn about the barriers experienced by DHH people in their everyday lives and in emergency situations, and the strengths and capabilities of DHH people (Cripps et al. 2016; Kamau et al. 2018). Adapting communication for DHH conversation partners includes maintaining respectful and non-condescending communication, ensuring good lighting, removing masks, gaining a person's attention by respectfully gesturing within their line of sight or touching their shoulder or arm, remaining in the person's line of sight, using gestures or written notes if needed, and using apps to translate speech to text (Zod et al. 2014; Tannenbaum-Baruchi et al. 2024).

Some authors focused on culturally Deaf people who use sign language, for example suggesting that first responders and professionals learn some basic signs and sentences (in the local sign language) relevant to an emergency, and learn how to work with an interpreter (Cripps et al. 2016; Skøt et al. 2017; Kamau et al. 2018; Tannenbaum-Baruchi et al. 2024). Awareness-raising is particularly needed for people who are Deafblind and who use a tactile form of sign language (Calgaro et al. 2021). Skøt et al. (2017) and Tannenbaum-Baruchi et al. (2024) recognized that DHH individuals have diverse communication needs, and that a first responder or other professional should use various strategies for different individuals, depending on whether they use sign, speech, or both, and whether they use hearing devices. Additional suggestions for communicating with people who use speech and/or hearing devices included ensuring that the face and lips are visible, looking directly at the person, and speaking clearly at a comfortable pace to support lip reading.

3.3 Emergency Preparedness

The third factor arising from thematic analysis is individual and household emergency preparedness. Proactive emergency preparedness at the individual and household level significantly enhances resilience to emergencies and facilitates more effective response and recovery. Preparedness measures, such as developing emergency plans (including for communication and access to information) and maintaining essential supplies, contribute to public safety by alleviating pressure on emergency services during crises (Takayama et al. 2022; Villeneuve 2022).

3.3.1 Barriers and Impact

Several of the reviewed articles described low levels of emergency knowledge and preparedness among DHH individuals—including limited understanding of essential risk and preparedness terms, poor knowledge of risks in the local area, limited awareness of emergency preparedness activities and low levels of practical preparedness including having an escape plan (Landrum 2009; Calgaro et al. 2021; Takayama

et al. 2022). There was also an observed lack of understanding among some DHH people that individuals have a role to play in preparing for their own safety in emergencies— observed in both Australian (Calgaro et al. 2021) and U.S. (Engelman 2012) research.

These low levels of emergency knowledge and preparedness can be linked to inaccessibility or irrelevance of preparedness materials and training activities (Kamau et al. 2018; Hay and Pascoe 2019). DHH individuals are excluded from emergency management and training activities or are unable to access the content of these because of accessibility barriers (Kamau et al. 2018; Calgaro et al. 2021; Takayama et al. 2022). Even when information is generally accessible, it is not always relevant or does not include information about how to manage experiences specific to deafness or hearing difficulties during an emergency (Landrum 2009; Owens et al. 2013; Phibbs et al. 2015).

Insufficient access to educational materials and training in the relevant sign language is a key barrier for many DHH people. A lack of sign language interpretation limits DHH people's participation in training activities, and therefore their emergency preparedness (Calgaro et al. 2021; Takayama et al. 2022). In developing written emergency preparedness materials, authors should be aware that some people who use a sign language for communication experience barriers in accessing information in written English. Inaccessible education systems have led to many culturally Deaf people having low literacy levels. Sign languages have their own syntax and grammar and for many culturally Deaf people, English is their second language (Neuhauser et al. 2013; Calgaro et al. 2021; Cooper et al. 2024).

Several reviews conducted in the 2010s of existing emergency preparedness and operations plans found insufficient (or absent) planning for alerting and communication with DHH people during emergencies (Ivey et al. 2014; Rutkow et al. 2015). Planning for access within evacuation shelters was identified as being particularly lacking (Rutkow et al. 2015; Takayama 2017). This lack of planning for the needs of DHH people is attributed to a failure to include DHH people in emergency planning, technology development, education, and research (Cooper et al. 2024). This review did not identify any more recent research that may show improvements in the inclusion of DHH people's needs in emergency planning since the 2010s.

3.3.2 The Role of the Government

The reviewed articles highlighted the key role of governments in removing or mitigating barriers for DHH people in relation to emergency events by effectively including the needs of DHH people in emergency plans across all levels, and by testing plans before an emergency occurs (Ivey et al. 2014; Rutkow et al. 2015). The reviewed research

revealed different views about registries of people with disability— while registries may be useful in identifying and locating people who may need assistance in an emergency (for example, Takayama 2017; Rotondi et al. 2019), there are risks to privacy and concerns about being identified as a person with disability (Engelman et al. 2017). Suggestions for planning for evacuation shelters include procedures for communicating with DHH people (Rutkow et al. 2015), such as setting up systems to post text versions of announcements in a well-publicized and consistent location, and providing interpreters at specified times and locations to communicate this information (Kailes and Enders 2007). Governments and the emergency sector must be cognizant of intersectionality between deafness or hearing difficulties and other demographic characteristics, including age, gender, cultural, and linguistic background, other disabilities, poverty, and literacy levels (Engelman et al. 2022; Lumsden and Black 2022). Being aware of these spheres of intersectionality helps to ensure that information dissemination, communication, and technologies used are accessible to all.

3.3.3 Accessibility and Relevance of Emergency Preparedness Materials and Training Activities

Authors discussed how improving the low levels of knowledge and preparedness among many DHH people requires access to both awareness-raising and practical training in disaster risk reduction (Takayama et al. 2022). There are two distinct but mutually supporting goals: (1) ensuring that educational materials and training activities are accessible for DHH individuals; and (2) that materials and activities include content relevant to DHH-specific challenges and preparedness activities. Educational materials and training activities should ensure that recipients are provided with information they need to effectively plan and respond to emergencies, including information about risks, how to prepare for them, and what to do during an emergency (Calgaro et al. 2021). This includes information about what early warning messages mean and what actions should be taken in response; how to access and interpret information about weather conditions and hazards; how to contact emergency services; and information about psychological first aid (Takayama 2017; Calgaro et al. 2021; Cooper et al. 2024). Articles suggested that educational materials and training should contain reliable and accurate information from credible sources; be distributed widely and well publicized; be consistent across all levels of government and the emergency sector; and be regularly updated to keep pace with advancements in technologies (Engelman et al. 2017; Kamau et al. 2018; Calgaro et al. 2021).

Educational materials and activities must be adapted to the literacy levels of the population (Neuhauser et al. 2013; Kamau et al. 2018; Calgaro et al. 2021). While written or

text information is accessible for (and preferred by) many DHH people, it is essential that emergency preparedness materials are also provided in an accessible signed format (Neuhauser et al. 2013; Calgaro et al. 2021; Cooper et al. 2024; Tannenbaum-Baruchi et al. 2024). If signed information is not available, a combination of pictorial and written (in uncomplicated language) emergency information can be accessible for DHH people with lower literacy levels (Zod et al. 2014; Hosono et al. 2015; Calgaro et al. 2021; Rotoli et al. 2022).

3.3.4 Accessibility of Household Smoke Alarms

As one element of personal emergency preparedness, there is a body of research on accessibility of household smoke alarms, with studies testing the effectiveness of different alerting signals in waking sleeping DHH people. Studies show that a specific type of auditory signal is more effective for most people, including those with lower levels of hearing loss (that is, a low frequency square wave auditory signal), and that vibrating signals are most effective for people with severe-to-profound hearing loss (Ashley 2007; Bruck and Thomas 2009; Bryan et al. 2014). Visual alarms were found to be the least effective at waking sleeping people (Ashley 2007; Bruck and Thomas 2009). However, many DHH people do not have accessible smoke alarms in their homes, and continued information campaigns are needed to increase uptake (Smedberg et al. 2022; Arena et al. 2024).

3.3.5 Contributions of Deaf or Hard-of-Hearing (DHH) People to Emergency Preparedness, Response, and Recovery

Several articles emphasized the high levels of adaptability and resilience of many DHH people (Ivey et al. 2014; Engelman et al. 2022), highlighting that when information was accessible, DHH people were often self-sufficient and capable of managing their own emergency preparedness and response (Kailes and Enders 2007; Engelman et al. 2017; Tannenbaum-Baruchi et al. 2024). Emergency preparedness initiatives can benefit by learning from DHH people as they are known to be early adopters of new technologies that have now become mainstream, including communication technologies (for example, videoconferencing) and media (for example, social media for sharing information about emergency situations) (Ivey et al. 2014; Morris et al. 2014). DHH people also use a diversity of communication methods, for example when DHH people who use sign language develop effective ways of communicating with people who do not sign (Tannenbaum-Baruchi et al. 2024).

The reviewed research also highlighted the contribution that DHH people can make to emergency preparedness, response, and recovery, at all levels of government and throughout the emergency sector. DHH people can co-design educational materials; and can review existing preparedness materials, increase their accessibility, and disseminate them through the community (Neuhauser et al. 2013; Takayama 2017; Cooper et al. 2024; Tannenbaum-Baruchi et al. 2024). DHH people can also contribute to the development, testing, and review of emergency plans and processes; alerting and communication technology; emergency training exercises including for emergency response personnel and community members, and can contribute to research (Engelman 2012; Cripps et al. 2016; Kamau et al. 2018; Cooper et al. 2024).

4 Discussion

This is the first study to integrate research on the experiences of DHH people during extreme weather events and other emergencies. Findings highlight barriers and facilitators related to (1) emergency warnings, alerts, and announcements; (2) the emergency sector response; and (3) emergency preparedness, and offer practical strategies to improve each of these. Integration of these findings reveals opportunities to deepen contextual understanding of DHH people's experiences of emergencies, and to do further work to move beyond generic recommendations in emergency planning to more tailored risk-reduction strategies. The next sections describe opportunities to adopt a collaborative person-centered approach that recognizes the diversity of experience of hearing difficulties and identify a role for two additional sectors in this collaborative approach.

4.1 Benefits of a Collaborative Person-Centered Approach

DHH individuals have diverse communication needs and preferences, influenced by whether they use sign language, speech, or both, and whether or not they use hearing devices (Bat-Chava 2000; Skøt et al. 2017; Bonventre et al. 2023; Tannenbaum-Baruchi et al. 2024), but this diversity is not well acknowledged across the reviewed articles (see Table 1). The stories of people who use a sign language are strong throughout the literature, with 27 of the included 48 articles referring specifically to experiences in using sign language in emergencies. However, many DHH people do not use a sign language, and many DHH people use and rely on hearing devices such as hearing aids and cochlear implants (Skøt et al. 2017; Tannenbaum-Baruchi et al. 2024). Hearing devices received cursory mention in the reviewed literature (Fox et al. 2010; Owens et al. 2013), and Skøt et al. (2017) and Tannenbaum-Baruchi et al. (2024) were the only reviewed articles that included information about communicating with DHH people who use hearing aids. This review did not identify any research exploring

the experiences of people using hearing devices in emergency situations, and this is urgently needed. While DHH people who use hearing devices and spoken language benefit from many of the recommendations made throughout the reviewed articles, there is a gap in the research in how to support emergency preparedness specific to the use of hearing devices. This includes understanding how resilient hearing devices are to different types of emergencies (for example, bushfires, floods, extreme heat), identifying steps that can be taken to increase hearing device-specific preparedness (for example, managing reliance on electricity for charging), and the impact on communication and accessing information when hearing devices are damaged or not available (Tannenbaum-Baruchi et al. 2024). For example, most people who use cochlear implants cannot access any auditory information without their hearing devices (that is, when sleeping, if batteries are flat or not charged, or if devices are broken or lost). Many cochlear implant users are also reliant on spoken or written communication and are unlikely to know a sign language.

A person-centered approach to emergency management provides an opportunity to ensure that this individual diversity is reflected at all stages of emergency preparedness. Drawing on DIDRR principles, this approach emphasizes the importance of collaborative partnerships to emergency preparedness between individuals with disability, the emergency sector, their support networks, and other organizations that support those individuals (Villeneuve 2021, 2022). All of these have roles to play in ensuring that DHH people have full access to effective emergency preparedness, response, and recovery, and thereby to increased safety and well-being during emergencies.

The benefits of effective collaboration between DHH individuals and the emergency sector are described throughout the reviewed research, and many of the practical recommendations for increasing accessibility come from DHH individuals themselves, when they are included as active participants in disaster risk reduction. However, the emergency sector must remain cognizant of individual variability in the experience of deafness, and the wide range and contextual variability of communication preferences—ensuring that multiple accessibility options are included at every phase of an emergency. For example, it is not sufficient to simply include a sign interpreter to improve the accessibility of public announcements. DHH people who do not use sign language are not able to access this information and may benefit from captioning (noting this is not always reliable), appropriate acoustics, and considerations around lighting to support lip reading (Tannenbaum-Baruchi et al. 2024). Other DHH people may use hearing devices and listening alongside signed keywords or fingerspelling (without being proficient signers) to supplement other information (Hodge and Goswell 2023). There is a role for two additional sectors

in this collaboration that can support meaningful inclusion in emergency planning, and work to remove communication barriers: (1) community organizations and (2) the hearing care sector.

4.2 A Role for Community Organizations

DHH-specific community organizations hold a position of trust and respect, and play a role in facilitating access to emergency preparedness materials and training activities—for both DHH individuals and for the emergency sector (Engelman et al. 2017; Takayama 2017; Calgaro et al. 2021). While the emergency sector remains the expert in emergency preparedness, response, and recovery, assistive technology manufacturers and suppliers are the experts in their products, and DHH individuals are the experts in their own lives—DHH-specific community organizations are in a unique position to connect these areas of expertise. However, throughout the reviewed literature, DHH-specific community organizations were usually discussed as having a role in facilitating access for clients who used a sign language (McKee 2014; Calgaro et al. 2021). DHH people who do not use a sign language, or those who have difficulty hearing but do not identify as having a disability (Kailes and Enders 2007) likely do not have connections with DHH-specific community organizations and may not access the benefits of these organizations in linking to emergency preparedness contacts and resources.

4.3 A Role for the Hearing Care Sector

There is an additional linking role for the hearing care sector, particularly hearing care professionals (audiologists, otologists, teachers of the deaf, and others) and hearing device manufacturers. The hearing care sector has a remit to ensure that hearing support services are informed by the realities of a changing climate (Sherratt 2023), and that hearing devices are designed to be as resilient as possible to increasing risks of extreme heat, bushfires, floods, and severe storms. There is an opportunity for the hearing care sector to link DHH individuals with information, education, and training provided by the emergency sector. This should include raising awareness of assistive technology options and other adaptations that support safety and access to information and communication throughout emergencies (for example, accessible smoke alarms and information channels) and promoting ideas for a personalized and flexible approach to communication for situations when devices are not useable. For many DHH people who do not have connections with community support organizations or other DHH people, this sector may be the only linkage point between their deafness or hearing difficulties, their hearing devices, and their personal emergency awareness and preparedness.

4.4 Limitations

This review has identified recommendations relevant to the three broad phases of emergencies—before, during, and after—however, these cover only what was identified in the reviewed articles and is not a comprehensive list of all the facilitators that could be effective in increasing access and inclusion. While this was a thorough review of the existing research, it is possible that some relevant articles were not captured by the selected databases, including potential related research discussing experiences and recommendations in non-OECD countries or within a humanitarian context, which were not included in this study focused on OECD countries. The exclusion of non-English articles may also have led to the omission of relevant studies—while language bias is an inherent limitation of this study, the scoping study methodology aims to provide an overview of the literature rather than a comprehensive synthesis. This scoping study also does not examine barriers and facilitators discussed in the grey literature, which will be examined in a later phase of the broader project. As this study aimed to provide an integrated overview of the experiences of DHH people as represented within peer-reviewed research articles, this review outlines the recommendations presented in those articles as they were reported based on the experiences and preferences of DHH people—but does not independently assess the effectiveness of the recommendations provided, or the quality of the study designs.

5 Conclusion

This scoping study has outlined existing research on the experiences of DHH people during extreme weather events and other emergencies. In line with the DIDRR approach, there is an opportunity for more research to better understand the adaptive capacities of DHH people and how these can be supported and leveraged within emergency management. There is a particular need for research to explore the experiences of DHH people who do not have connections with community organizations, and DHH people who use hearing devices, during emergencies.

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