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The inclusivity of volcanic hazard early warning systems: Experiences of persons with disabilities in Indonesia

Pradytia Pertiwi [a,*,1], Moya Martiningtyas [a,2], Duma Manurung [a,3], Fadhliah Saprowi [a], Fega Pangestika [b,d,4], Mizan Bisri [c]

[a] Center for Indigenous and Cultural Psychology, Faculty of Psychology, Universitas Gadjah Mada, Yogyakarta, Indonesia
[b] University College London, England, United Kingdom
[c] Kobe University, Japan
[d] Cerdas Antisipasi Risiko Indonesia (CARI), Indonesia

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ABSTRACT

Early Warning Systems (EWS) is crucial to enhance the ability of persons with disabilities responding to disasters. Despite global advocacy, limited evidence exists on how persons with disabilities access and act on EWS information. This study examines the inclusivity of volcanic hazard EWS in two villages near Merapi volcano, Indonesia, through a participatory mixed-methods approach involving 182 persons with disabilities, nine representatives of OPDs (Organizations of Persons with Disabilities), and five government officials. Data were gathered via household surveys, accessibility review, and a group discussion, with thematic and spatial analyses applied. Findings reveal that while traditional and modern EWS coexist, significant gaps remain in accessibility, coverage, and message clarity. Social networks and local leaders are key information conduits, yet warnings often fail to trigger effective early action. The study underscores the role of OPDs in embedding EWS within preparedness efforts and recommends integrated approaches that combine technology, indigenous knowledge, and community-based strategies.

1. Introduction

Persons with disabilities are evidently known to be among the most at-risk in disasters (United Nations Office for Disaster Risk Reduction [1]; United Nations International Strategy for Disaster Reduction [2]. Over the past two decades, research has increasingly focused on identifying the multifaceted factors that increase the risk and exposure of individuals with disabilities during disasters [3,

* Corresponding author.
E-mail addresses: pradytia.putri.pertiwi@ugm.ac.id (P. Pertiwi), moya.aritisna@gmail.com (M. Martiningtyas), dumahardianamanurung@mail.ugm.ac.id (D. Manurung), fadhliahsofiyananoors@mail.ugm.ac.id (F. Saprowi), fega.pangestika.24@ucl.ac.uk (F. Pangestika), mbisri@people.kobe-u.ac.jp (M. Bisri).
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4]. This vulnerability arises from a complex interplay between individual factors [5,6] and the built and social environment [7–10]. Consequently, scholars argue that reducing these vulnerabilities necessitates addressing the specific needs and enhancing the capabilities of individuals [6,11,12] as well as developing physical and social infrastructure that supports better protection and preparedness for persons with disabilities in disaster situations [1].

Early Warning Systems (EWS) and preparedness measures have saved tens of thousands of lives [13] and are repeatedly reported to increase the likelihood of persons with disabilities capacity to cope with disasters [1]. In this study, we adopt the definition provided by UNDRR (2016), which describes an EWS as "an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, and the governance of them all to produce systems and processes that enable individuals, communities, governments, businesses, and others to take timely action to reduce disaster risks in advance of hazardous events.' An essential aspect of an EWS, as argued by Kelman & Glanz (2014) is that it functions as a social process aimed at preventing harm from hazards. As a social process, the 'system' within an EWS includes not only the authorities and their decision-making procedures but also a wide range of social factors that come into play before and after a hazard occurs [14], including indigenous knowledge, cultural beliefs, and community participation in all components of EWS ([14]; Levigne et al., 2011; [15]). Consequently, as argued by Kelman and Glanz (2014) communities should be the "first mile" rather than "last mile" in the end-to-end EWS.

Viewing EWS as a social process is particularly important when addressing disability inclusion, as the social dimensions of disability are shaped by deeply embedded societal perceptions and interactions (Marini et al., 2017). According to Marini et al. (2017), historical attitudes toward individuals with disabilities have frequently reflected fear, intolerance, and a lack of understanding within society. These negative perceptions have played a significant role in increasing the disaster-related vulnerability of persons with disabilities. Similarly, as has been argued by Tierney [16]; 2016) vulnerability is not static or solely inherent to individuals or groups; rather, it is shaped by dynamic social, economic, and policy contexts, and produced through systemic processes such as discrimination, exclusion, marginalization, and legislative inaction or neglect. In disaster situations, these cultural and structural factors contribute to the systemic exclusion and persistent marginalization of persons with disabilities (Krüger et al., 2015).

Recent evidence illustrates how the social processes surrounding disability significantly influence the effectiveness of EWS. The UNDRR Global Survey on Persons with Disabilities and Disasters (2023a) highlights that when early warnings are accessible, persons with disabilities are more likely to evacuate independently and with fewer difficulties. However, studies in Cambodia and Bangladesh reveal major limitations in existing EWS, particularly in response capabilities and inclusive communication. Even when individuals with disabilities receive warnings, they often cannot act due to inadequate support systems, limited access to transportation, and lack of assistive equipment [17,18]. In many contexts, modern communication technologies fall short, and traditional dissemination methods—such as through mosques or community centers—prove more effective, particularly for populations with low digital access [19]. To enhance EWS inclusivity, local actors—termed "early warning messengers"—play a critical role in bridging technological systems and grassroots communities. Their involvement fosters trusted and accessible communication, ensuring that persons with disabilities are not left behind (Dias et al., 2024).

The recent World Bank and GFDRR report [20] expands this discussion by explicitly framing EWS through an intersectional and inclusive lens. The report argues that exclusion from warning systems is not experienced uniformly; rather, vulnerability emerges through overlapping inequalities related to disability, gender, age, poverty, geographic isolation, and social marginalization. The report emphasizes that persons with disabilities often require warnings in multiple accessible formats due to their intersection functioning difficulties, including audio, visual, tactile, sign language, and assistive technologies, while women and girls may face additional risks related to caregiving burdens, restricted mobility, safety concerns, and gender-based violence during evacuation.

Importantly, Yore et al. [20] highlights that effective EWS should not only disseminate warnings but also ensure people have the capacity and resources to act upon them, including accessible transportation, trusted communication channels, social support, and inclusive shelter arrangements. It further stresses that one-size-fits-all warning approaches frequently fail to address intersecting vulnerabilities, particularly in disaster-prone low-resource settings, where people depend heavily on informal social networks and community-based warning systems [20].

As such, UNDRR stresses the importance of people-centered EWS and led to the launch of the Early Warning for All (EW4All) initiative in 2022 to ensure universal EWS coverage by 2030 (UNDRR, 2015; 2023c). UNDRR introduced a checklist guiding the integration and monitoring of gender and disability inclusion across four EW4All pillars—disaster risk knowledge; detection, monitoring, analysis, and forecasting; dissemination and communication; and preparedness to respond [21]. Governance was added as a flexible fifth element in the checklist. However, implementation remains inconsistent. Despite 95 out of 120 countries reported having EWS in place [13], the effectiveness of EWS to protect the persons with disabilities varies across countries. A study by Aguirre-Ayerbe et al. (2020) on four Asian nations highlights the persistent gaps such as the absence of disaggregated data, inaccessible communication channels, and inadequate public awareness strategies tailored to diverse needs.

People-centered EWS is vital in the context of volcanic hazards, where the role of EWS extends beyond mere information dissemination; it is also instrumental in fostering community participation and preparedness, which are key to reducing disaster risks and bolstering community resilience, particularly among vulnerable groups [14,22,23]. Nevertheless, current EWS for volcanic hazards practices often overemphasize technological solutions and infrastructure, neglecting the social dimensions of disaster preparedness that include community involvement [24,25], and accessibility for at-risk groups [26,27]. Existing studies focus on practical recommendation rather than lived experience (see for example: [28]; The London School of Economics and Political Science, 2021), with a few research on specific needs of persons with disabilities (see for example: [18,29,30])

Drawing from case studies from two local communities in Indonesia at-risk of volcanic eruptions, we aim to understand the perspectives and experiences of persons with disabilities in accessing and responding to EWS information. The research further seeks to assess what resources are needed for persons with disabilities in response to early warning messages. By adopting a participatory mixed

method approach [31], the study addresses the following research questions: (1) what factors affect the comprehension and inclusivity of volcanic hazard early warnings for persons with disabilities?; and (2) what influences persons with disabilities to respond promptly to early warning information, and what are the resource implications of supporting such actions?

2. Methods

2.1. Study context

The study was conducted in two villages at risk of volcanic eruption, Wonokerto and Merdikorejo, located in the Sleman District of Yogyakarta Province, Indonesia (Fig. 1). Since the 1600s, Mount Merapi has erupted over 80 times, with an average interval of one eruption every four years, although this interval can vary from 1 to 71 years. The length of these intervals impacts the intensity of the eruptions: shorter intervals tend to result in lower-energy eruptions, while longer intervals lead to more powerful ones. The 2010 eruption of Mount Merapi was particularly devastating, resulting in 1705 casualties, including 1412 people with minor injuries, 293 with severe injuries, and 332 fatalities (Indonesia's National Disaster Management Agency [32]. Additionally, 4874 individuals experienced psychological trauma or disorders due to the disaster. The eruption also caused significant property damage, with 2447 houses severely damaged and 6472 moderately damaged.

Prior to the eruption, the Indonesian government and volcanology authorities had already intensified the early warning system through volcanic monitoring, sirens, evacuation orders, radio communication, mosque announcements, and community-based warning dissemination. The alert status for Mount Merapi was gradually increased to the highest level (Level IV/*Awas* or Danger) on 25 October 2010, and residents living within designated danger zones were instructed to evacuate immediately [32,33]. However, studies showed that community responses to the warnings varied considerably. While hundreds of thousands of residents evacuated following official warnings, some community members delayed evacuation, returned home prematurely, or relied more heavily on local beliefs, social networks, and traditional interpretations of natural signs than on formal warnings (Lavigne et al., 2011).

Research on the 2010 eruption highlighted that trust in local leaders, family members, neighbors, volunteers, and community-based communication systems such as mosque broadcasts and *kentongan* (bamboo slit drum) often played a critical role in shaping evacuation decisions alongside formal government warnings. In several cases, delayed evacuation contributed to fatalities, particularly among residents who underestimated the scale of the eruption or prioritized protecting property and livestock [15]. To date, there has been limited research focusing on the experiences of persons with disabilities during the 2010 Merapi eruption, particularly in understanding the barriers they faced, their capabilities, and their participation in disaster response efforts.

Both villages are situated within the Merapi volcano's Disaster Prone Areas (in Indonesia known as *Kawasan Rawan Bencana* [KRB]), with a proximity of less than 30 km from the volcano's peak. Wonokerto village is positioned between KRB 2 and 3, while Merdikorejo village lies within KRB 1 and 2. These locations are highly susceptible to volcanic hazards, including eruptions, pyroclastic flows, and ashfall, and were significantly impacted by the 2010 eruption [34], which caused considerable damage and disruption.

The villages of Merdikorejo and Wonokerto were purposively selected due to their involvement in a pilot project on disability data collection, led by the *Difabel Siaga Bencana* (DIFAGANA) volunteer community [35]. DIFAGANA also plays an active role in local disaster preparedness and response, making these villages particularly relevant for exploring the intersection of disability and disaster risk management. As part of the government's formal EWS infrastructure, Sleman district Regional Disaster Management Agency (in

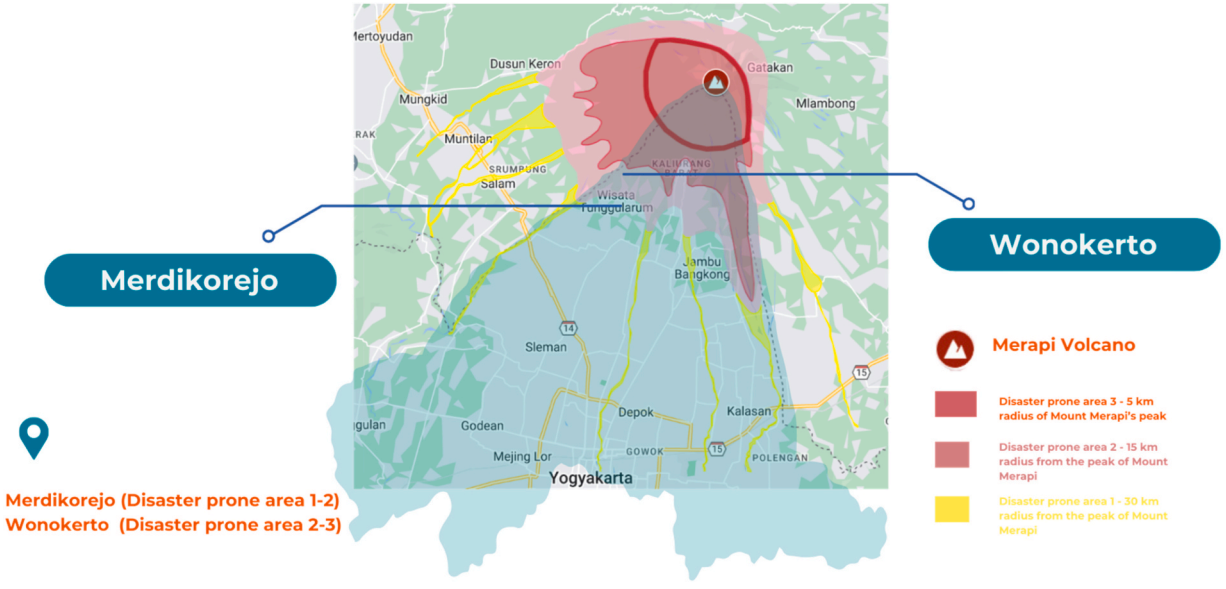

Fig. 1. Research sites and their proximity to Mount Merapi (Source: Author)

Indonesia it is known as *Badan Penanggulangan Bencana Daerah* [BPBD]) has 37 early warning systems (EWS) located around hazard-prone areas surrounding Mount Merapi. These systems primarily use sirens to warn residents when there is a disaster threat, such as a volcanic eruption. The BPBD also uses various methods to disseminate early warning information, including social media, messaging applications such as WhatsApp, and sirens. Both villages are equipped with CCTV (Closed Circuit Television) to monitor volcanic hazards, including ash, pyroclastic flow, lava, and lahars. Wonokerto also has a siren installed to issue warnings when Mount Merapi reaches alert level 3. An EWS flow has been established, with the Center for Research and Development of Geological Disaster Technology (in Indonesia is known as *Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi* [BPPTKG]) as the lead agency, disseminating information via sirens, social media, and local government channels.

2.2. Data collection

The study employed a participatory mixed-methods design, following the approach of Sendall et al. [31]. The quantitative methods involved the use of closed-ended questionnaires in a household perception survey, along with an accessibility review to evaluate the perceived inclusiveness of the EWS, which addresses the first research question. To gather the voices and experiences of persons with disabilities in responding to early warning messages, as well as the resource implications supporting early response to warning messages, as outlined in the research question two, we utilized a qualitative visual method (Fig. 2). The study received ethical approval from the Faculty of Psychology, Universitas Gadjah Mada, under approval number 1355/UN1/FPSi.1.3/SD/PT.01.04/2024.

This method is structured around the UNDRR Inclusive Early Warning and Early Action Checklist [36] (Fig. 2). The adaptation process began with translating the checklist into Bahasa Indonesia, ensuring that the language was both accurate and culturally appropriate for the local context. This translation was carried out by the third and fourth authors, with the first author, all native Indonesians, reviewing and approving the translation. Each item on the checklist was then carefully examined and adapted to address volcanic eruption hazards. The focus of the investigation was narrowed to disability, with gender considerations instead integrated into the disability aspect as part of an intersectional approach. A panel of five experts in early warning systems, volcanic eruptions, and disability inclusion then conducted a thorough review to ensure the checklist's relevance and applicability in the Indonesian context.

The review by panel experts recommended revisions, removal of irrelevant items, and division into two components targeting different audiences. The first component addresses Pillars 2, 3, and governance, and was directed to BPBD, BPPTKG, Social Affairs Department, and village governments. The second addresses Pillars 1, 3, and 4, gathering insights from persons with disabilities, their caregivers, and OPD members. This questionnaire incorporated a four-point scale (from strongly inappropriate to strongly

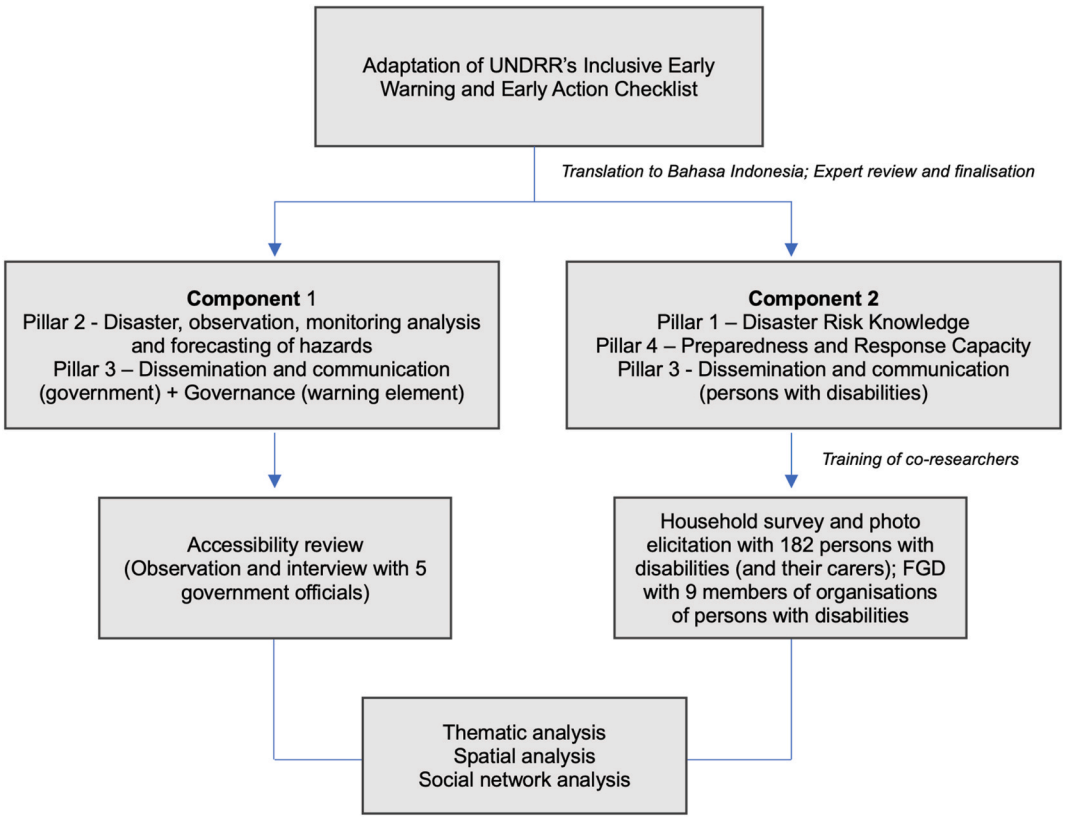

Fig. 2. Methods of the research comprising two components (Source: Authors)

appropriate) and additional items drawn from the literature, covering past eruption experiences, gap analysis, and resource implications.

To ensure participation, nine persons with disabilities from local disaster volunteer groups (DIFAGANA) were recruited as data collectors, paired with eight disaster volunteers (5 men, 3 women). Selection criteria included prior experience in volunteering, data collection, and disaster risk management. All data collectors underwent comprehensive training on methodology, ethics, communication, and accessibility. Training was followed by quasi-mentoring [37], combining field practice with reflective dialogue [38]. Each team was supported by a postgraduate researcher, and daily debriefings allowed reflection, troubleshooting, and follow-up on emerging issues.

Data collection process spanning over 5 months from March - July 2024. We began with an accessibility review involving nine government officials (8 men, 1 woman) from five institutions evaluated existing EWS practices. A household survey of 187 persons with disabilities (107 men; 75 women) (Tables 1 and 2) combined closed- and open-ended questions, geotagging of households via Open Camera, and photo elicitation [39]. Participants were encouraged to take photographs symbolising their perceptions and memories of EWS and volcanic experiences, which then stimulated deeper discussion. Finally, a focus group discussion with purposely selected nine members of OPDs (5 men; 4 women) was conducted to triangulate and explore in-depth into the findings from the household survey.

2.3. Data analysis

Due to unavailability of specific guidance for analysis of the UNDRR's [36] Early Warning and Early Action checklist, various data analysis techniques were employed in this study. First, thematic analysis was applied to extract key patterns and insights from checklist questionnaires, interviews, and FGD. This approach facilitates systematic coding and categorization of qualitative data, allowing for the identification of prominent themes emerging from participants' responses [40].

Second, spatial analysis was used to assess and visualize the geographical distribution of persons with disabilities and the reach of EWS based on a checklist questionnaire. Geographic Information Systems (GIS) integrated demographic data, infrastructure details, and EWS locations to map the distribution of persons with disabilities. Proximity analysis evaluated their access to these systems, and buffer zones estimated the effective warning range [41]. Coordinate data from household surveys were mapped using ArcGIS, layered with EWS locations from BPBD Sleman. The results were visualized in a thematic map, highlighting the accessibility of EWS for more effective emergency responses.

Social Network Analysis (SNA) utilizing Gephi software was conducted to explore the flow of early warning information and support within the social networks of persons with disabilities [42,43]. The SNA is performed as a two-modes network [44] whereby the nodes combine the means of early warning dissemination tools/channels and early warning recipients. This analysis highlights key influencers, identifies communication gaps, and suggests potential strategies for leveraging social networks in disaster preparedness and response [42].

Finally, a joint display approach [45] was used to integrate findings from thematic analysis, spatial analysis, and SNA into a unified thematic interpretation. In practice, findings from interviews, FGDs, checklist questionnaires, GIS mapping, and network visualisations were organised under shared analytical domains derived from the UNDRR Early Warning and Early Action checklist, such as

Table 1
Participants' profile.

Profile	Freq.	Percentage
Gender		
Male	107	59%
Female	75	41%
Age		
17-44 years	56	31%
45-59 years	77	42%
>60 years	49	27%
Education		
Did not participate in education/drop out	81	44.751%
Elementary school	29	16.022%
Junior high school	23	12.707%
Senior high school	44	24.309%
Diploma/bachelor and above	4	2.210%
Did not answer	1	0.001%
Status		
Single	101	55%
Married	65	36%
Divorced	4	2%
Widowed	12	7%
Employment		
Employed	41	22.5%
Unemployed	140	77%
Retired	1	0.5%

Table 2
Disability identification based on Washington Group Questions.

	Difficulty seeing	Difficulty hearing	Difficulty walking/ climbing steps	Difficulty remembering or concentrating	Difficulty with self-care	Difficulty communicating
No – No difficulty	76%	72%	68%	40%	73.1%	49.5%
Yes – Some difficulty	16%	13%	18%	30%	13.7%	23.6%
Yes – a lot of difficulty	6.5%	12%	11%	25%	8.8%	24.2%
Cannot do at all	1%	3%	3%	2%	3.9%	2.2%
Did not answer	0.5%	0%	0%	3%	0.5%	0.5%

accessibility of warning information, dissemination pathways, evacuation support, and communication barriers. Thematic findings regarding participants' experiences and perceptions were interpreted alongside spatial analysis showing the geographical distribution of persons with disabilities and the reach of EWS infrastructure, as well as SNA findings illustrating the role of family members, neighbors, volunteers, mosque announcements, and local leaders in disseminating warning information.

3. Findings

3.1. Theme 1: varied understandings and meanings of EWS

A considerable number of participants exhibited a lack of awareness or understanding regarding EWS. The majority (31%) did not know what an EWS was, or they confused it with general emergency signals due to lack of participation in EWS socialization. A noticeable gender disparity emerges in terms of participation in EWS socialization with men are more likely to attend (55.5%) compared to women (44.4%) across both villages. Participation rates vary across disabilities with the highest is among those with sensory disabilities (52.3%), followed by physical (27%), multiple (23.5%), and intellectual disabilities (17.6%). The lowest rate is among individuals with mental disabilities (16.6%)

For those who had some awareness, EWS was often interpreted as direct, immediate signals that indicated the need for evacuation. "The EWS, as I understand it, is a warning to evacuate quickly or save ourselves.' One participant, M, 56-year-old female respondent with a physical disability who echoed a similar sentiment in her photo elicitation (Fig. 3). She recounted that receiving the early warning was a clear signal for immediate evacuation: "I was scared when I got the early warning message from the hamlet leader, but I quickly evacuated with my family using a motorbike, with four of us riding on one bike, all wearing helmets."

Confusion and miscommunication about the purpose and function of EWS were also evident. Some (29%) caregivers or persons with disabilities misunderstood these systems as merely general alerts without specific instructions on what actions to take, or they were unaware of any structured process for early warnings. A participant recounted:

> … a volunteer warned me to be ready when the siren sounds. They informed me, but I wasn't sure where to go, so we just left in a hurry out of fear … Whenever the siren went off, we were confused about where to go, and we then only stayed at home.."

In some cases, the understanding of EWS was partial (32%), with respondents recognizing certain aspects, such as the sound of sirens, but not fully grasping the broader system or the importance of timely action. This conditional awareness often depended on previous experiences or proximity to formal information sources.

The level of understanding was often influenced by the social and environmental contexts in which the respondents lived. Those in more isolated or less-educated communities showed lower awareness and understanding of EWS, highlighting the need for targeted education and communication strategies. One participant said ".[I] do not understand [early warning], only know from information from local residents, mosque loudspeakers, and volunteer teams.". The exclusionary nature of the existing system had a significant psychological impact, leading to confusion, anxiety, and a sense of helplessness among persons with disabilities. One respondent emphasized, "the warning information message is very helpful and necessary in making decisions related to evacuation."

3.1.1. Risk awareness and message comprehension

The majority of survey participants (67.96%) found the messages easy to understand, yet 28.73% still faced difficulties. Similarly, while 61.54% of respondents found the early warning messages easy to access, 34.62% did not. In terms of message delivery, slightly more than half of the respondents (53.30%) felt that the early warning messages were appropriately tailored to their disabilities, while a notable 42.86% disagreed. Align with this data, a BPPTKG official observed that government-installed EWS has not yet fully addressed the specific needs of individuals with disabilities in their dissemination and communication efforts. Similarly, Sleman district's BPBD official has not yet developed a fully inclusive communication strategy to ensure disaster-related information is accessible to all types of disabilities. Sleman district's BPBD official considered the development of a "flashlight/blinking light' EWS for Deaf individuals, though this has not yet been implemented.

The survey revealed that a majority of respondents (79%) were aware of the risk of volcanic eruptions in their area, and 77% acknowledged awareness of common volcanic hazards (such as Lava and pyroclastic flow). However, when it comes to less common volcanic hazards (such as toxic gas), knowledge appears to be lower, with only 59% of respondents indicating that they were aware of

Fig. 3. M's photo elicitation depicting motorbike as a sign for evacuation

these risks. For example, M, a 79-year-old male with a physical disability, exemplified the importance of this awareness. When he noticed early signs of an impending volcanic eruption, he acted quickly to protect himself and his family. He recounted, "I was in the snake fruit garden when I noticed the mountain started to shake. I immediately ran away from the garden to save myself and evacuate with my family." Po, a 54-year-old male with low vision, shared a different experience. Initially, Po underestimated the danger posed by the volcanic eruption because he believed his home was in a safe zone. Reflecting on the community's reaction, he said:

> I don't think there was anything (related to receiving early warning messages). Our community thought that early warning messages were not for me, not for us, but for the people who lived up there (pointing to villages closer to the mountain). (Before the 2010 eruption) We were not disaster refugees; we still remember our cousins who were evacuated (from the previous eruption) were from up there, not us. That's why our concern (about the danger) was always for the people living up there.

The survey also explored respondents' perceived abilities to assess their own risks, vulnerabilities, and needs in the face of volcanic

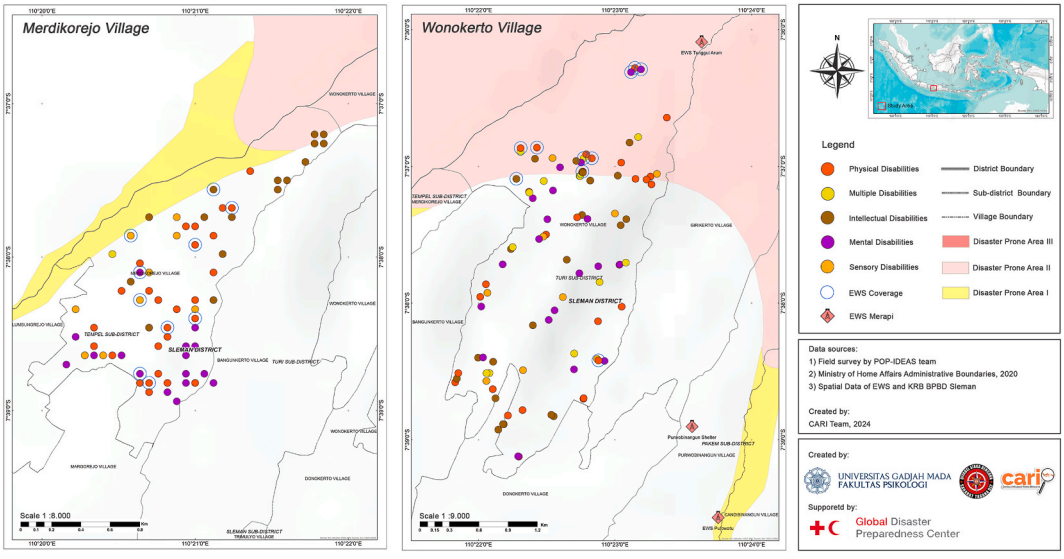

Fig. 4. Spatial analysis of government-installed siren coverage for persons with disabilities in the two villages (Source: Authors)

hazards. While 67% felt capable of evaluating their own exposure to risks, and 63% could assess their vulnerability as persons with disabilities, there remains a notable portion of respondents who may not feel fully equipped to handle such situations. Moreover, understanding how their disability affects their ability to access and use disaster risk information is also crucial, as 64% of respondents agreed that they grasped this aspect.

Specifically, regarding evacuation-action guidelines for people with disabilities, 47.80% of respondents found them clear, while nearly half (49.45%) did not. For caregivers, 56.59% agreed that the guidelines were clear, but 41.21% still found them lacking. When asked about the clarity of information on how people with disabilities should prepare for a volcanic eruption, just over half (51.65%) agreed that the EWS provided sufficient guidance, with 44.51% disagreeing.

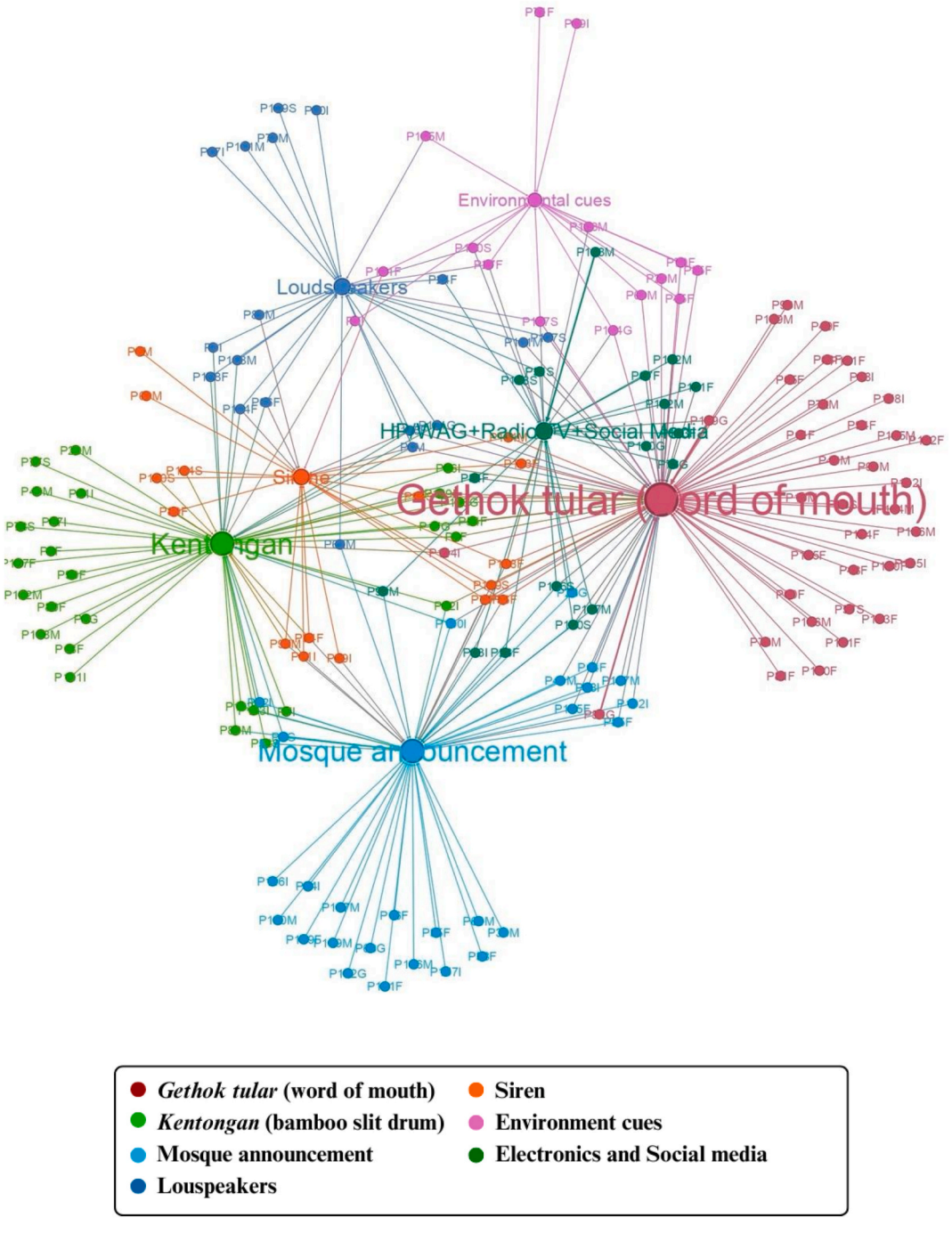

Fig. 5. Social Network Analysis of early warning information flow in the two villages (Source: Authors)

3.2. Theme 2: social networks enhanced the reach of warning messages

Data from household surveys reveals that a great portion of respondents (60.44%) agreed that they consistently received early warning messages before a volcanic eruption in their village. However, of the 60.44% of participants, data from spatial analysis (Fig. 4) shows coverage of the government-installed siren highlighting only 12% of persons with disabilities from the two villages were reached, indicated in Fig. 4 by dots surrounded by a blue rings representing participants who received the warning. The limited coverage of early warnings was due to the sparse EWS infrastructure in the two villages, as interviews with government officials revealed that only a few EWS have been installed, with just one siren in Wonokerto village. The Sleman BPBD official added that its institution managed 37 EWS infrastructures installation of these systems is prioritized in areas designated as Disaster Prone Area (KRB) level 3.

Concerns were raised about the accessibility and functionality of EWS devices, with only 43.96% of participants agreeing that these devices are accessible and functioning properly, while 51.10% disagreed. Interviews revealed that the government-installed EWS primarily relies on auditory signals, making it challenging for Deaf individuals to fully grasp the situation, leaving them reliant on others for evacuation assistance. One participant shared, "The early warning message did not consider people like me who cannot hear. I had to depend on others to help me evacuate, and it was frightening.' Informal warning systems thus played a crucial role in compensating for the deficiencies of formal systems. Information was typically disseminated through word of mouth, involving neighbors, community leaders, or volunteers, which proved vital for those unable to access official warnings (Fig. 5).

The Social Network Analysis (Fig. 5) highlights the central role of this *gethok tular*[#] (word of mouth) method (dark pink color). In this *gethok tular* process, local community leaders, especially the head of sub-village (*Dukuh*) were repeatedly mentioned as crucial figures in spreading information quickly and effectively. Their extensive connections indicate that they are trusted sources within the community, capable of reaching a broad audience through direct interaction. Participants frequently mentioned receiving vital information from *Dukuh* through loudspeakers and from neighbors and community interactions, demonstrating a strong dependence on community ties and village organizational structures for the dissemination of urgent information. As an 18-year-old woman with a sensory disability recounted, "(Early warning was from) someone who goes around the village informing people to evacuate." Similarly, SI, a 55-year-old woman with multiple disabilities, shared through her photo elicitation (Fig. 6) that the *Dukuh* always announces warnings and designates the evacuation point at the sub-village head's house.

The role of volunteers in the *gethok tular*, including volunteers with disabilities, were prominently highlighted by participants. OPDs in two villages adopted different strategies, reflecting their critical role in disaster preparedness and response. In Wonokerto, the OPD was deeply integrated into the village's disaster preparedness volunteers. Their involvement was essential in participating in preparedness activities and ensuring the inclusive dissemination of information. They acted as a vital communication link, relaying information from village authorities—such as the neighborhood head or via WhatsApp groups—directly to persons with disabilities and their families. It ensured that at-risk groups received timely and accessible information, which is crucial during emergencies. In contrast, in Merdikorejo, the OPD employed a more preventive approach. The organization facilitated regular meetings with families and caregivers of persons with disabilities. These meetings served as a platform to disseminate disaster-related information, raise awareness, and prepare these families for potential hazards, as such proactively built preparedness and resilience among persons with disabilities, ensuring they are involved in disaster response. Despite being proactively involved in disseminating the information, however, unfortunately according to the BPPTKG who is in charge of Mount Merapi monitoring asserted that persons with disabilities are not involved in detection and hazard monitoring.

Fig. 5 highlights several other significant communication methods, which were also reported by officials. Mosque announcements (light blue) emerge as another vital channel, with numerous connections to individuals. This method likely leverages the existing infrastructure of mosques, which serve as both religious and community centers, making them a natural hub for disseminating urgent information. The mosque broadcasted an announcement advising residents to prepare for potential evacuation, including readying motorcycles by parking them in the yard and gathering important documents and clothing. The use of *kentongan* (green color), a traditional wooden or bamboo slit drum, also remains prominent. Modern communication tools, such as loudspeakers (dark blue color), sirens (red color), and digital technologies like mobile phones, WhatsApp Groups, radio, TV, and social media (dark green), are also represented in the figure.

Environmental cues (purple color) or natural signs that the community observes as indicators of volcanic activity were also present. These environmental cues serve as immediate and tangible warnings, prompting the community to take protective measures. For instance, residents have reported noticing the presence of *"wedus gembel'* or pyroclastic flows, which are dense clouds of volcanic ash and gasses, as well as ash-covered plants, signaling an imminent threat. One respondent mentioned, "We noticed the ashfall and the sudden change in the environment, like volcanic ash covering the plants, which signaled us to prepare.' Additionally, the community members have recounted experiences of observing hot lahar floods and ashfall, which, along with news reports and direct observation of lava eruptions, contribute to their awareness of the escalating danger.

3.3. Theme 3: capacity and challenges to respond to EWS information

The survey revealed that 68.13% of participants agreed that the early warning messages aided them in making evacuation

[#] *"Gethok Tular"* is communication that integrates the power of specific values where the recipient of the message will grasp its meaning, accept it well, and do it seriously (Cakir & Cetin, 2013; [57])

Fig. 6. SI' photo elicitation of *Dukuh* backyard for evacuation

decisions, although 25.82% disagreed, indicating that the guidance provided may not always be clear or actionable for everyone. Further, the capacity of persons with disabilities during disasters is shaped by a range of factors that influence how individuals can respond to early warning messages and evacuate in a timely manner.

Access to suitable transportation emerged as one of the most significant enablers of early action. Participants noted that having a vehicle available for evacuation reduced their anxiety and facilitated a smoother evacuation process. This included both private vehicles and sufficient public transportation to move all people at risk. However, access to transportation remains a major challenge faced by the majority (26%) of participants. The respondents reported not owning transportation during the Merapi eruption and, therefore, struggled to evacuate. One caregiver expressed this frustration, saying, "Yes, the challenge was the lack of transportation. I wondered how to take my kids and my father. It was frustrating since we didn't have any vehicles." The scarcity of transportation not only delayed evacuation but also led to overcrowded vehicles, compromising safety during the process. As PN, 48 years old with physical disability, PN recalled in his photo elicitation (Fig. 7), "It was Friday night; we evacuated side by side, with a three-wheeled motorbike that carried eight people. I wondered at that time what would happen if Merapi erupted while we were still on the road."

Lack of transportation was also compounded by poor environmental conditions such as ash rain, darkness, and overcrowded roads during evacuation further complicated the process. These factors often made navigation difficult and decreased the ability to move quickly. Some (24%) participants reported breathing difficulties and vision problems due to volcanic ash, while others faced obstacles such as blocked roads from fallen trees. One participant described the situation (Fig. 8), "The road was slippery due to the ash rain and covered with fallen trees, which made it impossible to ride a bicycle. Moreover, there were so many people evacuating that the road was crowded and full of people."

Concerns about disaster shelters—particularly the lack of disability-friendly facilities—also became a significant consideration. Inadequate toilets and inaccessible shelter designs deterred a few of (4%) individuals from evacuating, as they feared the difficulties they might face upon arrival. This issue is especially pressing when combined with individual factors such as physical or health conditions, particularly among older adults and persons with disabilities. Shelters often fail to accommodate assistive technologies or devices tailored to individuals' needs. One caregiver explained, "There was a challenge for the family to take care of the person with a disability. Persons with disabilities require specific facilities in shelters. For example, if they want to bathe or clean themselves, it cannot be done in the same way as for persons without disabilities."

Support from local authorities and NGOs played a significant role in influencing the decision to evacuate. Clear directions from trusted authorities made respondents feel more prepared and confident to take action, knowing that the guidance came from a reliable source. Further, assistance from NGOs such as fleets and aids provided a sense of security and allowed for more structured and efficient evacuations. In case of unavailability of support from formal institutions, assistance from neighbors and fellow OPDs were also identified as critical factors in motivating individuals to evacuate. One participant described how her fellow OPDs assisted her during the evacuation using a three-wheeled motorbike, noting, "(My) evacuation was assisted by my disabled friends with a three-wheeled motorbike. (We) Evacuated to Maguwo. Because it will be difficult (for me) to evacuate by riding (an open) truck, right?"

Fig. 7. PN' photo elicitation of a three-wheeled motorbike for evacuation

Fig. 8. PW' photo elicitation of environmental condition barriers (PW, 54 years old, sensory disability)

And last, the participation of persons with disabilities in EWS discussion is considered by participants as essential to ensure their voices and needs are represented for several reasons: the unique perspectives and experiences of persons with disabilities can enhance the effectiveness of these systems; their involvement empowers them and fosters a sense of ownership and responsibility for their safety; and it strengthens community resilience by contributing to the creation of supportive networks and resources. However, despite

the recognized importance of their participation, 75% of respondents reported being either unaware of or uninvolved in disaster planning or socialization efforts. DM, a 26-year-old male participant with a physical disability, shared, “We have never had any (volcanic disaster) socialization or education about the EWS in my area."

3.4. Theme 4: resource gaps for early action

The survey asked participants to identify which resources were necessary to support early action and to report on their availability during the disaster. Table 3 presents the results of the gap analysis, with each resource described according to the level of gap.

The most severe gaps are concentrated in government assistance and health-related resources. Cash assistance before disasters shows the widest deficit at 86.4%, followed closely by cash assistance after disasters at 76.7% and social protection schemes at 73.9%. Health needs also display critical shortfalls, with medical equipment recording a 63.1% gap and medicines 55.9%. Energy-related resources mirror this pattern, as batteries show a 59.8% gap, torches or emergency lights 49.5%, and adapters 37.0%. Portable supports for persons with disabilities also remain limited, with batteries for assistive tools showing a 46.2% gap, highlighting persistent deficiencies in essential emergency supplies.

Slightly higher gaps are seen in social networks, shelters, and evacuation logistics. Trained disability organizations have a 42.2%

Table 3
Gap analysis of resources for early action.

Caregivers in emergency			
Description	Needed (%)	Available (%)	Resource Gap (%)
Family	98.89	92.78	6.11
Neighbor	96.70	95.53	1.17
Community	77.22	65.29	11.93
Volunteer	92.18	85.21	6.97
Evacuation plan and infrastructure			
Description	**Needed (%)**	**Available (%)**	**Resource Gap (%)**
Transportation and mobility	100.00	74.30	25.70
Evacuation route	100.00	85.96	14.04
Assembly point	99.45	84.83	14.62
Portable and accessible emergency tools			
Description	**Needed (%)**	**Available (%)**	**Resource Gap (%)**
Medicine	95.58	39.66	55.92
Medical equipment	90.06	27.01	63.05
Battery for aid tools	70.17	24.00	46.17
Emergency energy resources			
Description	**Needed (%)**	**Available (%)**	**Resource Gap (%)**
Battery	88.89	29.14	59.75
Torch/emergency light	97.22	47.75	49.47
Adapter	67.22	30.18	37.04
Assistive technologies			
Description	**Needed (%)**	**Available (%)**	**Resource Gap (%)**
Hearing aids	19.89	8.24	11.65
Mobility aids	50.28	35.09	15.19
Visual aids	21.67	12.57	9.10
Accessible shelter facilities			
Description	**Needed (%)**	**Available (%)**	**Resource Gap (%)**
Accessible toilet in the shelter	80.00	49.72	30.28
Special toilet for kids and women	76.67	37.78	38.89
Self-care facilities	89.33	58.19	31.14
Social and community network			
Description	**Needed (%)**	**Available (%)**	**Resource Gap (%)**
Trained local disability organization	93.30	51.12	42.18
Government emergency services	96.65	61.02	35.63
Volunteers	96.65	62.86	33.79
Government assistance			
Description	**Needed (%)**	**Available (%)**	**Resource Gap (%)**
Social protection scheme	95.29	21.39	73.90
Health insurance	100.00	92.86	7.14
Cash assistance after disaster	98.87	22.16	76.71
Cash assistance before disaster	97.18	10.80	86.38

gap, while government emergency services (35.6%) and volunteer networks (33.8%) show similar shortfalls. Shelter facilities are another area of concern: toilets for women and children show a 38.9% gap, self-care facilities 31.1%, and accessible toilets 30.3%. Evacuation resources are somewhat better but still inadequate, with transportation and mobility at 25.7%, compared to smaller but notable gaps for assembly points (14.6%) and evacuation routes (14.0%). Assistive technologies overall show lower percentages, though gaps remain for mobility aids (15.2%), hearing aids (11.7%), and visual aids (9.1%).

The smallest gaps appear in informal caregiving, which remains the most reliable source of support in emergencies. Neighbors show the lowest gap at 1.2% (needed 96.7%, available 95.5%), and family support follows with 6.1% (needed 98.9%, available 92.8%). Volunteers (7.0%) and community support (11.9%) also rank among the better-resourced areas compared to other categories. Together, these figures demonstrate that while formal systems reveal large deficits—particularly in government assistance, health, energy, and shelter—the most consistent availability comes from family and neighbor networks, which show almost universal coverage and minimal gaps.

4. Discussion

This study examines factors influencing the comprehension and inclusivity of early warnings for persons with disabilities in two volcanic eruption-prone villages in Yogyakarta, Indonesia, and the determinants and resource implications of their responses. It emphasizes that EWS are multifaceted tools operating not only in the technical sphere but also within the social and cultural contexts of the communities they serve. Findings highlight both systemic gaps and community strengths in the inclusivity and effectiveness of volcanic EWS for persons with disabilities. Levels of awareness and understanding of EWS remain uneven, with respondents unfamiliar with the concept or confusing it with general emergency signals. Participation in EWS socialization disparities, particularly across gender and disabilities, while comprehension and accessibility of warning messages are inconsistent. Formal EWS coverage is limited, with government-installed devices reaching only a fraction of respondents, leaving informal social networks—such as neighbors, community leaders, and OPDs—central to information flow. At the same time, respondents' ability to act on warnings is constrained by transportation shortages, environmental barriers, and inaccessible shelters. The most severe resource shortfalls are in government assistance, medical supplies, and energy resources, contrasted with strong reliance on family and neighbor support, which emerge as the most consistently available sources of early action.

Three key themes emerged as important learnings to be discussed further in this section: co-existence of technology and indigenous knowledge and practices, EWS as a social process and the role of social networks, and addressing the disconnect between early warning and effective response.

4.1. Co-existence of technology and indigenous knowledge and practices

A key finding is the coexistence of technology based EWS with indigenous knowledge and social networks, which emerges as a crucial aspect of disaster preparedness and response. While modern technological systems—such as sirens and CCTVs—form the backbone of formal EWS infrastructure, their effectiveness is often limited by physical, social, and environmental barriers. As findings show, the reach of auditory warnings is restricted in both coverage and access as evidenced by the study's spatial analysis showing that only 12% of persons with disabilities were within the coverage area of government-installed sirens. In an earlier study, Chisty et al. [17] found that relying solely on technology, without considering the diverse needs of at-risk populations, often results in gaps in coverage and accessibility. Moreover, in rural or isolated areas where technological infrastructure is limited or non-existent, these gaps become even more pronounced.

Complementing the limitations of technology, local and indigenous practices provide contextually relevant and accessible means of disseminating early warnings. This echoes Krüger et al. (2015), who argue that culture is not an external add-on but central to how societies prepare for and respond to disasters. Culture—through traditions, local practices, and indigenous knowledge—shapes both risk perception and coping strategies, meaning that disaster response capacities are often already embedded in communities themselves. In this study, *gethok tular* (word of mouth), mosque announcements, and the *kentongan* (bamboo slit drum) exemplify how cultural practices function as trusted and widely recognized channels for warning dissemination, alongside the use of environmental cues to interpret volcanic activity [46,47].

The *kentongan*, deeply rooted in communal life, serves as a low-cost and reliable warning tool, effective even during power outages has been a reliable warning since 2013 [15,48,49]. Mosques, as both religious and social centers, extend this function by repurposing loudspeakers for urgent broadcasts, leveraging their legitimacy and reach across diverse groups [50,51]. These practices reaffirm Krüger's assertion that disaster preparedness is not solely technical but inherently cultural, drawing on shared norms, trusted institutions, and familiar signals to mobilize action.

Although auditory methods such as the *kentongan* and mosque announcements are not fully accessible to Deaf individuals, their effectiveness lies in their integration with social networks. Through *gethok tular*, caregivers, neighbors, and community leaders relay messages further, ensuring broader coverage and complementing modern EWS. These findings resonate with the Sendai Framework [52], which underscores the role of indigenous and local knowledge in DRR, demonstrating that resilience is enhanced when formal systems engage with culturally embedded practices.

4.2. EWS as a social process and the role of social networks

Findings emphasize that EWS are most effective when integrated into the everyday lives of the communities they serve, supported

by ongoing education, training, and preparedness activities that build resilience and reduce vulnerabilities. Meanwhile, the reactive nature of EWS, as perceived by many participants in this study, poses a challenge to effective disaster preparedness for persons with disabilities. The study finds that early warnings are often understood as last-minute alerts, rather than tools for proactive disaster preparedness. This perception limits the potential of EWS to foster long-term risk reduction behaviors and anticipatory actions, as highlighted by Kelman and Glantz [24]. Evidently, a large proportion of persons with disabilities in the two villages were either unaware of or not involved in EWS and disaster preparedness planning or socialization efforts.

It is important to note that even though it served as last-minute alerts and positioned persons with disabilities as the "last mile" in the end-to-end EWS design, the majority (64%) of persons with disabilities in the two villages were reached by some form of early warning prior to volcanic eruption. In this case, social networks, including local leaders, volunteers, and community organizations, play a pivotal role in bridging the gap between government-installed EWS and persons with disabilities. This finding aligns with the work of Baudoin et al. [27] and Sufri et al. [23] who argue that community-centric approaches to EWS, which emphasize the involvement of local actors and social networks, are essential for improving disaster risk reduction outcomes. This is especially crucial in circumstances where disability data is not consistently accessible [11].

The findings underscore the importance of local social structures, particularly the *gethok tular* (word of mouth) method, in the dissemination of early warning information within the community. The analysis reveals that the *Dukuh*, or head of the sub-village, plays a pivotal role in this process, leveraging their extensive social connections and trusted position to effectively communicate urgent warnings to a broad audience. The *Dukuh*'s ability to reach community members through direct interaction, such as loudspeaker announcements and neighborly interactions, highlights the critical role of community leaders in ensuring that early warning messages are both heard and acted upon. This is especially significant in rural or tightly-knit communities where formal communication channels may be limited or less effective [53]. Stories of participants further illustrate the reliance on the *Dukuh's* role not only as a disseminator of information but also as a figure of authority and trust who can guide the community during emergencies, particularly in contexts where formal EWS may not fully meet the needs of all community members [54].

The participation of volunteers, including those with disabilities, introduces an additional layer of complexity and effectiveness to the community's disaster preparedness efforts, which deserves commendation in both villages. The study highlights the different strategies employed by OPDs in the two villages, showcasing the adaptability and importance of these organizations in enhancing disaster response inclusivity. In Wonokerto, the integration of the OPD into the village's disaster preparedness volunteer network illustrates a model of inclusivity where persons with disabilities are not just passive recipients of aid but active participants in disaster management [11]. By acting as vital communication links between village authorities and the persons with disabilities in the community, these volunteers ensure that critical information reaches those who are most vulnerable [11,55]. In contrast, the preventive approach adopted by the OPD in Merdikorejo, where regular meetings with families and caregivers of persons with disabilities are held, highlights a proactive strategy in disaster preparedness. This approach not only raises awareness but also builds resilience by preparing families for potential hazards, ensuring that persons with disabilities are well-informed and involved in disaster response efforts.

Practices of OPD in both villages point to a possible practice of integrating EWS into volcanic eruption disaster preparedness and ensuring the long-term risk reduction behaviors and anticipatory actions of persons with disabilities [56]. Further, involvement of persons with disabilities in EWS social networks is particularly significant, as it empowers them to actively engage in disaster preparedness and response, highlighting their potential as the "first mile' in the end-to-end EWS [14,24]. By participating in disaster volunteer groups and local organizations, individuals with disabilities can influence the design and implementation of EWS, ensuring that these systems are more inclusive and responsive to their needs, as has been promoted by the Sendai Framework [52] for over a decade. Nevertheless, to what extent these two modalities have impacted differently to persons with disabilities' ability to act during disasters was not explored and requires further scrutiny. Further, it is also important to note that OPDs' involvement in the two villages is currently limited to persons with disabilities who serve as disaster volunteers, with their role primarily concentrated on the dissemination and communication pillar, as well as the preparedness and response pillar of EWS, while their participation in the detection, observation, monitoring, analysis, and forecasting of hazards remains minimal.

4.3. Addressing the disconnect between early warning and effective response

The warning–action gap observed in this study aligns with the social vulnerability approach, which sees disaster risk as produced through structural, policy, and socio-economic arrangements rather than residing within individuals ([16]; 2016). The shortfalls we document—transport and energy constraints, inaccessible shelters, and limited assistive devices—are not merely logistical hiccups; they are manifestations of structurally produced vulnerability that dampen the capacity to convert a received warning into protective action [9,17,23]. In this framing, the problem is not that persons with disabilities fail to respond, but that systems fail to furnish the means to respond. Thus, inclusivity in EWS must be judged not by message transmission alone but by whether material supports exist to enable timely evacuation and safe sheltering.

How persons with disabilities are seen in Indonesia further mediates warning–action dynamics. Consistent with broader literature, lingering everyday stigma can narrow expectations of agency, reduce consultation, and justify one-size-fits-all communication (Marini et al., 2017; [6]). Our findings show that OPDs already act as brokers of inclusion, yet involvement is often confined to dissemination and preparedness rather than upstream monitoring, analysis, and governance—limiting the potential to reshape systems from within [11,12]. Disparities across gender and disability categories are evident, suggesting that efforts to ensure inclusion for all persons with disabilities across diverse identity groups have not fully succeeded. However, this research is limited in its analysis of gender and disability criteria, which constrains further discussion. A rights-based, capability-oriented view supplemented by intersectional lens in

addressing systemic challenges would reposition inclusion as routine system quality rather than exceptional accommodation [1,20,24].

Taken together, bridging the warning–action gap requires shifting from informing to enabling. Practically, this means coupling accessible, plain-language, multi-format warnings (including visual/vibration modalities) with guaranteed resources: pre-arranged accessible transport, assistive device support and power, inclusive shelter facilities, and staffed social support ([18,26]; UNDRR, 2023b; 2023c). It also means institutionalizing OPD participation across all EW4All pillars—risk knowledge, monitoring/analysis, dissemination, and preparedness—so that cultural assets and disability expertise co-produce anticipatory action rather than last-minute reaction. In short, warnings save lives only when societies resource the capacity to act.

5. Conclusion

Despite the presence of formal EWS infrastructure, such as sirens and CCTVs, these systems often fall short in meeting the specific needs of persons with disabilities, resulting in limited understanding and delayed responses during disasters. The findings emphasize the need to integrate modern technologies with indigenous knowledge and social networks to enhance the inclusivity and effectiveness of EWS. Additionally, the role of OPDs in incorporating EWS into disaster preparedness is critical for fostering long-term risk reduction and anticipatory actions among persons with disabilities. Social networks, especially community leaders and volunteers, are vital in spreading early warnings, compensating for the shortcomings of formal systems. However, challenges such as inaccessible communication formats, transportation issues, and unclear evacuation guidelines persist, hindering the ability of persons with disabilities to respond promptly and effectively.

Based on these findings, several recommendations are proposed. First, Geographic Information Systems (GIS) should be systematically used to integrate disability data into EWS planning. Mapping households of persons with disabilities alongside hazard zones, evacuation routes, and the coverage of existing sirens can help identify underserved areas and guide the prioritization of resources. This approach not only highlights inequities in current infrastructure but also enables more inclusive risk assessments and planning processes. Second, communication methods need to diversify beyond auditory and digital channels. Visual signals, vibration-based alerts, and plain-language messages should be developed to ensure that persons with hearing, visual, or cognitive impairments can equally access life-saving information.

Third, evacuation infrastructure must be strengthened to support early action. Pre-arranged vehicles, clear evacuation routes, and shelters with accessible toilets, self-care facilities, and provisions for assistive devices are essential for enabling persons with disabilities to act promptly on warnings. Fourth, the role of OPDs should be institutionalised across all pillars of EWS, from monitoring and governance to preparedness and response. Current involvement is largely limited to dissemination, but deeper engagement would allow OPDs to shape systems proactively and ensure that inclusion becomes embedded rather than an afterthought.

Fourth, indigenous practices such as *gethok tular* and mosque announcements should not be seen as secondary to technology but as complementary systems that enhance trust, redundancy, and community ownership of EWS. Government assistance must also be improved, particularly in addressing severe gaps in medical supplies, energy resources, and cash assistance that are crucial for sustaining evacuation and recovery. Warnings save lives only when supported by the resources and infrastructures that allow people to act. Embedding disability inclusion into EWS planning—through tools like GIS, multi-format communication, accessible infrastructure, and OPD leadership—will move Indonesia closer to building anticipatory, equitable, and rights-based disaster preparedness.

Finally, beyond the specific context of Mount Merapi, this study also demonstrates the value of combining the UNDRR Early Warning and Early Action checklist with mixed-method approaches, including thematic analysis, GIS-based spatial analysis, and SNA, to identify gaps in the inclusivity and accessibility of early warning systems for persons with disabilities. The integration of these methods provides not only a contextual understanding of how warning systems function in practice, but also a practical analytical framework that can be adapted and replicated in other hazard-prone settings. By linking policy-oriented assessment tools with community experiences, spatial mapping, and social communication networks, the study offers a more comprehensive approach for identifying structural, social, and infrastructural barriers within disaster preparedness systems. This contributes not only to academic discussions on disability-inclusive disaster risk reduction, but also to practitioner-oriented efforts seeking to operationalise inclusive early warning systems through evidence-based planning, monitoring, and implementation.

CRediT authorship contribution statement

Pradytia Pertiwi: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Moya Martiningtyas:** Writing – review & editing, Supervision, Methodology, Investigation. **Duma Manurung:** Writing – original draft, Visualization, Methodology, Investigation. **Fadhliah Saprowi:** Project administration, Methodology, Investigation. **Fega Pangestika:** Visualization, Investigation. **Mizan Bisri:** Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Pradytia Pertiwi reports financial support was provided by Global Disaster Preparedness Center, American Red Cross. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2026.106199.

Data availability

Data will be made available on request.

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