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The Effectiveness of Earthquake and Tsunami Evacuation Symbols and Signs for the Deaf Community in Public Spaces of Banda Aceh

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ABSTRACT

Banda Aceh, a region prone to earthquakes and tsunamis, necessitates the implementation of clear signs and symbols to facilitate evacuation during emergencies. However, individuals with hearing impairments face challenges in accessing information conveyed solely through spoken or auditory means. This study investigates the efficacy of tsunami evacuation symbols and signs in public areas of Banda Aceh in assisting deaf individuals and compares their performance to international standards. Employing a combination of quantitative and qualitative data collection methods, the study administered questionnaires, conducted in-depth interviews, and facilitated group discussions with deaf residents residing in Banda Aceh. These individuals frequently occupy public spaces such as mosques, shopping centers, and bus terminals. The findings reveal that 85.7% of the surveyed population deemed the evacuation symbols beneficial for disaster preparedness. Nevertheless, only 21.4% expressed satisfaction with the clarity of the symbols' colors and shapes. Several critical issues were identified, including the symbols' poor visibility due to inadequate color contrast, size, or damage. Additionally, the signs were not strategically positioned, and insufficient supplementary information, such as maps, visual aids, or sign language translations, was provided. Notably, 78.6% of the respondents emphasized the paramount importance of incorporating sign language into evacuation plans. Consequently, the study concludes that while the symbols in Banda Aceh offer some level of assistance, they lack full accessibility for deaf individuals. The research suggests that signs should adhere to international standards like ISO 7010, enhance readability, and incorporate additional visual tools and sign language to ensure the safety and well-being of all individuals during emergencies.

KEYWORDS

Evacuation Symbols, Deaf Community, Visual Communication, Disaster Mitigation, Banda Aceh

INTRODUCTION

Banda Aceh is situated in a region prone to frequent natural disasters, particularly earthquakes and tsunamis. Consequently, it is imperative for the population to cultivate awareness and preparedness for such events. Local communities play a pivotal role in mitigating disaster risks. They contribute by constructing enhanced infrastructure and imparting knowledge on effective responses to impending dangers. One approach to achieving this is through non-structural mitigation, which emphasizes disseminating information and education to empower individuals to cope with potential hazards (Nursyahbani, 2020). This can be achieved through the implementation of evacuation signs and symbols in public spaces.

According to the Disaster Data and Information (DIBI) system, earthquakes and tsunamis are among the disasters that cause the highest number of fatalities in Aceh. Records indicate that 19 earthquakes occurred in the province between 2010 and 2019 (N. A. Zahra et al., 2025). In response

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to these risks, the Banda Aceh City Government has implemented a series of significant disaster mitigation policies and programs aimed at protecting both residents and tourists from potential tsunami threats (N. A. Zahra et al., 2025). These include the installation of various types of informational media, such as warning signs, maps, symbols, and evacuation direction boards. Preliminary field observations revealed that these information media are distributed across several strategic and disaster-prone areas. The presence of evacuation signs and symbols is therefore crucial for improving disaster preparedness.

Despite advancements in technology, there remain significant challenges in comprehending textual and auditory communication, particularly for individuals with hearing impairments (DHH). The design and provision of public facilities must prioritize accessibility and comfort for this community to ensure their full participation in daily life. Previous research indicates that public infrastructure, including transportation, education, and healthcare services, often fails to adequately address the needs of the deaf community. Inadequate public facilities can impede mobility and restrict active engagement in society.

For the deaf community, hearing limitations pose significant challenges in interpreting audio-based information. Consequently, they heavily rely on visual information, including symbols, icons, and evacuation signs, for safety during emergencies (Wang et al., 2025; Ronzon et al., 2025). Studies have revealed that many visual symbols and signs in public spaces are not designed with accessibility in mind, rendering them difficult for the deaf to comprehend (Niode et al., 16 C.E.). Effective communication necessitates messages to be delivered clearly and precisely using appropriate media that align with the audience's needs (Niode et al., 16 C.E.). In this context, comprehending the symbolic system employed in communication is crucial to ensure accurate message reception by diverse audiences. This study is grounded in the understanding that individuals with sensory disabilities depend on non-auditory and non-verbal cues to construct cognitive maps of their environment (Fakhruddin & Sakya, 2024). Consequently, the effectiveness of evacuation symbols is evaluated through an analysis of deaf users' perceptions regarding the clarity, legibility, and directional functionality of the symbols.

As elucidated by R. Masri Sareb Putra, semiotics is the study of signs and symbols employed to comprehend the construction and interpretation of meaning in communication (Persson et al., 2015). In scientific communication, the utilization of effective icons and symbols facilitates the simplification of intricate materials or messages, thereby enhancing their accessibility to the general public. This necessitates that the design of visual symbols must consider the diverse comprehension abilities of the audience to ensure effective communication (Supratman, 2021). Within the realm of visual communication design, the selection of visual elements, such as color, assumes paramount significance, as it can influence users' perception, emotions, and levels of attention toward the conveyed information (Mutia Sari et al., n.d.). This becomes particularly critical in the design of evacuation symbols, which must be rapidly recognizable by individuals who are deaf.

Universal Design or Inclusive Design principles advocate for the creation of products, environments, and information systems that are universally accessible, enabling individuals with diverse abilities to use them without the need for specialized adaptations or additional design solutions. Within the realm of visual communication design, these principles establish accessibility, legibility, and equality of user experience as fundamental design foundations, particularly in public spaces frequented by users with varying sensory capabilities (Irawan & Wardoyo, 2025). Furthermore, inclusive design transcends technical approaches, embodying a design paradigm rooted in social justice and the acknowledgment of human diversity.

In this context, the phenomenon of evacuation symbols and signage cannot be dissociated from the discourse of visual arts and visual communication design. Symbols function as a visual language that constructs meaning through form, color, and spatial context (Febriyantoko et al., 2012). For deaf users, who predominantly rely on visual cues rather than auditory information, evacuation symbols assume a crucial communicative role in conveying emergency instructions. Consequently, the design of evacuation signage should be comprehended not only in terms of adherence to technical standards, but also as an inclusive visual communication system that guarantees equitable access to safety

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information and supports the cognitive and perceptual requirements of users with hearing impairments.

Previous studies that have focused on disaster preparedness among individuals with disabilities emphasize the critical importance of inclusive evacuation sign design in ensuring equal protection for all individuals (Wang et al., 2025). However, most existing studies have primarily focused on the technical aspects of evacuation systems, accessibility policies, or disaster management strategies, while limited attention has been given to how deaf individuals interpret and understand the visual symbols used in evacuation signage. In particular, empirical studies examining the effectiveness of tsunami evacuation symbols from the perspective of deaf users in disaster-prone areas remain scarce. Considering that Banda Aceh is one of the regions most vulnerable to earthquake and tsunami hazards, evaluating the comprehensibility and usability of evacuation symbols for deaf individuals is essential. Therefore, this study aims to analyze the perceptions of deaf users regarding tsunami evacuation symbols and signs in Banda Aceh by examining their clarity, visual legibility, and effectiveness in conveying evacuation directions. The findings are expected to contribute to the development of more inclusive visual communication designs and disaster mitigation systems that accommodate the needs of people with hearing impairments.

METHOD

This study employed a moxed methods approach, integrating both quantitative and qualitative methods to comprehensively evaluate the effectiveness of earthquake and tsunami evacuation symbols and signage among the deaf community in Banda Aceh. Quantitative data were collected through a structured **s**urvey designed to measure the effectiveness and comprehensibility of evacuation symbols for individuals with hearing impairments. The collected data were analyzed using descriptive statistical methods to illustrate levels of understanding and perceived effectiveness of evacuation signage. The visual audit was conducted through structured observation of evacuation symbol design elements, including color, contrast, typography, scale, physical condition, and compliance with ISO 7010 principles. The observation was supported by photographic documentation and a checklist based on visual safety standards (Clara & Swasty, 2017). Qualitative data were obtained through in-depth interviews and focus group discussions (FGDs) conducted with deaf participants and public facility managers. These sessions aimed to gain deeper insights into participants' perceptions, challenges, and interpretive experiences regarding evacuation symbols in public spaces. This analysis is employed to identify the application of visual design principles and symbol legibility, as established in previous design studies (Falahi & Larasati, 2024).

Participants were selected using purposive sampling, focusing on deaf individuals who frequently engage in activities within public spaces in Banda Aceh, such as mosques, shopping centers, and transportation terminals. The study involved 28 deaf respondents who reside and actively participate in public environments within Banda Aceh. The basic demographic profile of respondents is as follows:

Table 1. Demographic Characteristics of Respondents (n = 28)

Variable	Category	Frequency (n)	Percentage (%)
Age	18–30 years	16	56.0
	31–45 years	12	44.0
Amount		**28**	**100.0**
Gender	Male	15	53.6
	Female	13	46.4
Amount		**28**	**100.0**
Frequency of Visiting Public Spaces	Frequent (>3 times/week)	11	39.0
	Moderate (1–2 times/week)	12	43.0
	Infrequent (<1 time/week)	5	18.0
Amount		**28**	**100.0**

The quantitative instrument consisted of a five-point Likert-scale questionnaire (1 = strongly disagree; 5 = strongly agree), comprising 15 items categorized as follows:

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Table 2. Questionnaire Structure and Measurement Dimensions

Dimension	Indicator Description	Number of Items
Understanding of Evacuation Symbols	Respondents' ability to recognize, interpret, and understand the meaning of evacuation symbols and signs	5
Readability of Visual Design	Respondents' perceptions of the clarity, visibility, color contrast, typography, and overall visual appearance of the symbols	4
Placement and Distance of Symbols	Respondents' perceptions regarding the location, visibility range, and accessibility of evacuation symbols in public spaces	3
Need for Supplementary Media	Respondents' perceptions of the necessity for additional visual information, digital media, or supporting communication tools to improve understanding	3
Amount		**15**

The qualitative instrument included in-depth interviews with 10 respondents and one FGD session involving 12 participants from the deaf community and public facility administrators.

The instrument's content validity was evaluated through expert judgment by two lecturers in Visual Communication Design (VCD) and one disaster mitigation specialist. Reliability testing using Cronbach's Alpha yielded a coefficient of $\alpha = 0.842$, indicating a high level of internal consistency and reliability. Inform briefly about the materials and methods used in the research, including the subjects/materials studied, the tools used, the experimental design or design used, sampling techniques, variables to be measured, data collection techniques, analysis and statistical models used.

RESULT AND DISCUSSION

1. Effectiveness and Comprehension of Evacuation Symbols

The questionnaire results reveal that the majority of respondents perceived evacuation symbols as beneficial in enhancing their preparedness for disasters, with 85.7% expressing agreement or strong agreement with this assertion. However, when it comes to the distinctiveness of color and shape, only 21.4% of respondents concurred, while 35.7% disagreed and 50% remained neutral. This indicates that the visual design of evacuation symbols still necessitates substantial refinement.

Furthermore, 78.6% of respondents indicated a strong desire for the integration of sign language into the evacuation process, underscoring the critical need for accessible information for the deaf community. This finding is consistent with (Cooper et al., 2024), who highlighted the inequitable access that deaf and hard of hearing individuals face to earthquake information, warning systems, training, and participation in disaster decision-making.

In summary, the majority of respondents demonstrated the ability to comprehend and identify existing evacuation symbols. However, a significant portion still encountered challenges or uncertainty in interpreting their meanings and directions. This finding corroborates previous research indicating that the deaf and hard-of-hearing (DHH) community remains susceptible due to restricted access to emergency information (Engelman et al., 2013; Calgaro et al., 2021).

Respondents aged 18-30 years exhibited superior symbol comprehension (mean score = 4.2) compared to those aged 31-45 years (mean score = 3.6). A Chi-square test revealed a statistically significant difference ($p < 0.05$) in symbol legibility between respondents with secondary education and those with higher education levels, suggesting that visual literacy plays a crucial role in symbol comprehension.

2. Visual Design Readability

Several evacuation symbols exhibited readability challenges, including poor color contrast, diminutive dimensions, and physical degradation, which diminished their efficacy. Consequently, enhancements in color contrast, size, and placement are imperative. Furthermore, respondents' comprehension and interpretation of tsunami evacuation signs are influenced by their prior experience. Within the realm of visual communication design, the selection of visual elements, such

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as color, holds significant importance. It has the potential to impact users' perception, emotions, and levels of attention toward the conveyed information.

The efficacy of messages conveyed through technical media, such as evacuation symbols, must adhere to several fundamental criteria: (1) visibility and accessibility to observers, where the placement and technical aspects of message dissemination hold paramount significance; (2) interpretability, encompassing the users' capacity to accurately comprehend the core message intended by the communicator; and (3) readability, which is influenced by cultural context, users' cognitive capabilities, and the quality of the visual language employed (Irawan & Wardoyo, 2025).

This aspect is particularly critical in the design of evacuation symbols, which must be rapidly recognizable by individuals who are deaf. Such perceptions are understood through three interrelated psychological dimensions: brightness, hue, and saturation, which collectively shape how visual information is interpreted (Sumema et al., 2023). Individuals with prior knowledge are able to interpret the symbols and textual information on the signs more quickly than those who have never encountered such signage before (Meutia, 2023). Additionally, typographic elements and letterforms within a visualization should ideally demonstrate a high level of visual legibility, which is determined by their anatomical structure (Yulius et al., 2024).

Based on the observation results, three dominant color tendencies were identified: blue, brick red, and dark green. Colors that are closely related to red or orange are categorized as warm colors, as they are commonly associated with elements such as the sun, blood, and fire, which tend to stimulate emotional and psychological responses. In contrast, colors that are closer to bluish-green tones are classified as cool colors, frequently found in natural elements such as the sky, mountains, or cold water, and are therefore associated with calming and soothing effects. This distinction warrants further investigation, as environmental color contexts vary across regions. For instance, desert areas tend to be dominated by brown hues, while colder regions may be characterized by white due to snow or gray due to overcast conditions. Regarding the use of blue, although this color is often linked to feelings of sadness, it is also widely associated with positive emotions and is among the most commonly preferred colors in both English-speaking and non-English-speaking countries (N. Zahra & Mansoor, 2024).

The analysis of interview data revealed that evacuation symbols were frequently installed at insufficient intervals, thereby hindering continuous wayfinding guidance along evacuation routes. Respondents recommended increasing the frequency of sign placement (every 10-15 meters) or supplementing them with directional ground markings to enhance clarity.

Figure 1. Symbol of Gathering Point in Kuta Alam District

Figure 2. Evacuation Symbol in front of the Aceh Tsunami Museum

Figure 3. Evacuation Direction Symbol

Figure 4. Direction to Evacuation Symbol

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Table 3. Visual Analysis of Evacuation Symbols

Figure	Key Visual Elements	Composition & Typography Analysis	Material Color Analysis	Design Implications (Art and Inclusivity)
1. **Gathering Points**	Group human figure icon, four arrows pointing to center, bold square plane	The symmetrical and centralized composition establishes a collective meaning as a rallying point. However, the distance between human icons is relatively close so that the details of the figures are integrated at a long distance. There is no supporting text so the entire meaning is loaded on the icon.	Greenish-blue background with white icons; The blue color appears to be close to #2F6FA3 but has decreased saturation due to weather exposure. Reflective materials start to get dull.	Semiotically strong, but the color degradation decreases the contrast. For the deaf, this symbol is still legible but loses the instant visual appeal that is important in an emergency.
2. **Evacuation Symbol**	Large arrow to the left, text "EVACUATION DIRECTION", small running person icon	The composition is dominated by horizontal arrows that are supposed to guide the direction, but the visual hierarchy is disrupted due to the lack of text and icons. The kerning in the text looks tight and the letters have been depleted by stroke due to weathering.	The yellowish-brown base color is close to #C2A44A but fades drastically, almost blending in with the background. Low light reflection due to dull surfaces.	The arrows are still legible, but the text is barely legible. From an inclusive design perspective, the reliance on faded text weakens key visual functions for deaf users.
3. **Evacuation Direction Symbol**	Wave icon and human figure running, arrow additional sign	The composition of the icons is quite obvious, but the scale of the icons is relatively small to the surrounding environment. The visual relationship between the tsunami icon and the directional arrow is not compositionally integrated.	The dark blue background is close to #1F4E79 with a white icon. The colors are still relatively contrasting, but there are smudges and reflections of water that interfere with readability.	Moving figure icons effectively convey urgency. However, the absence of text integration or advanced visual systems reduces effectiveness as part of continuous wayfinding.
4. **Direction to Evacuation Symbol**	Right arrow, bilingual text "Evacuation Route", tsunami icon	The elongated horizontal composition is quite clear and communicative. However, bilingual text placement lowers visual focus due to space competition between text and icons. Text kerning is relatively good but the font size is small for highway readability.	The dark green color is close to #2E7D32 with white text. Some areas show fading and scratching on the surface.	By design it is closest to universal standards, but the scale and visual maintenance need to be improved to be effective for users with high visual dependency such as the deaf.

In accordance with FEMA's 2019 guidelines, the continuity of wayfinding is paramount to ensure the safe evacuation of individuals, particularly vulnerable groups, from hazardous areas. This underscores the necessity for Banda Aceh to establish an integrated evacuation route map system that harmonizes with existing road signage, rather than relying solely on static boards.

Field observations also identified several common problems, including low color contrast, small symbol size, and physical damage to information boards. These barriers reduce the readability of evacuation symbols, particularly during emergency situations characterized by panic, limited

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lighting, or adverse weather conditions. The United Nations Office for Disaster Risk Reduction (UNDRR, 2022) emphasizes that the effectiveness of safety signage depends on visibility, legibility, and durability. Therefore, the design of evacuation symbols in Banda Aceh should adhere to established graphic design standards by using high-contrast green-and-white color combinations as recommended in ISO 7010, ensuring a minimum symbol height of 20–30 cm to maintain visibility from distances of at least 10 meters, and employing weather-resistant materials to prevent deterioration and maintain long-term functionality. Implementing these design principles can enhance the accessibility and effectiveness of evacuation signage, particularly for deaf individuals who rely primarily on visual information during emergency situations.

Table 4. Visual Effectiveness Assessment

	Aspects	Condition of Banda Aceh (Research Results)	International Standards (ISO 7010/UNDRR/FEMA)	Gap Notes
1.	**Visual design (color and form)**	The symbols exhibit inconsistency, insufficient color contrast, and non-uniform shapes.	According to ISO 7010, safety signage should employ green–white color schemes, standardized arrow forms, and globally consistent visual structures.	Therefore, Banda Aceh needs to adopt international graphic standards to ensure that evacuation symbols are universally recognizable and easily understood.
2.	**Size and legibility**	The symbols are relatively small, some are physically damaged, and overall legibility is low under emergency conditions.	According to UNDRR guidelines, evacuation signage should be visible from a minimum distance of 10–15 meters, use weather-resistant materials, and apply high-contrast colors.	Updates in both material quality and size are necessary to meet visibility standards.
3.	**Placement and spacing**	The symbols are placed far apart, and evacuation routes are inconsistently marked.	According to FEMA guidelines on wayfinding continuity, evacuation signage should be installed at intervals of every 10–15 meters along evacuation routes.	This finding indicates a significant gap in maintaining route continuity.
4.	**Additional information media**	The information is limited to static signage, with no supporting infographics, maps, or floor-based evacuation routes.	According to UNDRR recommendations, evacuation communication should integrate multiple media formats, including maps, route markings, educational videos, and interactive digital media	The findings indicate minimal media diversification, highlighting the need for innovation grounded in visual and digital approaches.
5.	**Sign language and inclusivity**	Sign language support is not available; 78.6% of respondents expressed the need for sign language integration.	Cooper et al. (2024) emphasize that the inclusion of sign language is essential in disaster communication protocols.	Banda Aceh needs to incorporate official sign language interpreters or sign-language–based visual systems into its evacuation communication framework.
6.	**Community participation**	The involvement of deaf individuals in socialization activities and planning processes is minimal.	Calgaro et al. (2021) argue that the participation of vulnerable groups is essential in disaster mitigation policies.	This finding indicates a lack of inclusion of the deaf community in local policy development.

3. Placement and Distance of Symbols

Field observations indicated that evacuation symbols were frequently installed at excessive distances, leading to a lack of uninterrupted guidance along evacuation routes. Participants highlighted that this discontinuity could cause confusion during emergencies when prompt decision-making is imperative. Respondents recommended that symbols be positioned at shorter intervals, ideally every 10–15 meters, and be supplemented with directional markings on the ground or walls to maintain route continuity. Such measures align with the concept of wayfinding consistency as outlined by FEMA (2015), which emphasizes the significance of clearly visible and regularly

positioned signage in ensuring safe and efficient evacuation, particularly for vulnerable populations such as the deaf and hard of hearing.

4. Need for Additional Visual Information

The majority of respondents indicated a need for supplementary visual communication media to enhance the clarity of evacuation instructions. Deaf participants specifically emphasized the significance of infographics, visual route maps, videos featuring sign language interpreters, and ground markings to facilitate comprehension of evacuation procedures.

This finding aligns with recommendations from (Calgaro et al., 2021), which assert that accessible disaster communication must incorporate multi-modal visual strategies to ensure inclusivity for individuals with hearing impairments. Integrating sign language videos and route-based visual aids would not only enhance comprehension but also augment participants' confidence and sense of security during emergencies.

5. Role of Socialization and Community Involvement

Numerous participants underscored the paramount significance of routine socialization activities and the proactive participation of sign language interpreters within disaster education initiatives. Sustained community engagement can augment disaster awareness and preparedness, particularly among marginalized communities.

This finding corroborates the conclusions of (Engelman et al., 2013) and UNDRR (2022), both of which emphasize that participatory approaches in disaster mitigation, particularly those involving disabled communities, are indispensable to attaining equitable resilience. The inclusion of interpreters and visual educators in awareness campaigns can facilitate more inclusive disaster communication practices, ensuring that no group is excluded from the process.

CONCLUSION

This study demonstrates that the effectiveness of earthquake and tsunami evacuation symbols in Banda Aceh depends not only on their availability but also on their visual clarity, consistency, placement, and accessibility for users, particularly the Deaf community who rely primarily on visual information during emergencies. The findings indicate that while most respondents understand the importance and function of evacuation symbols, many experience difficulties related to symbol visibility, readability, color contrast, maintenance, and consistency across locations. These issues reduce the ability of the symbols to serve as effective wayfinding tools in emergency situations. Therefore, evacuation signage should be developed based on inclusive design principles that prioritize visual clarity, consistency, durability, and the specific perceptual needs of Deaf users.

This study is limited to Deaf respondents in Banda Aceh and focuses primarily on perceptions of existing evacuation symbols and signage. Future research should involve larger and more diverse disability groups, incorporate experimental evaluations of alternative symbol designs, and examine the effectiveness of digital and multimodal evacuation communication systems. Such studies would provide broader evidence for developing more inclusive and accessible disaster mitigation strategies that ensure equal access to safety information for all community members.

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