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REVOLUTIONISING TOURISM ACCESSIBILITY FOR THE DEAF AND HARD OF HEARING WITH XR TECHNOLOGY

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ABSTRACT

Extended Reality (XR) technology has emerged as a powerful tool for enhancing accessibility and inclusiveness across various industries, including tourism. Despite technological advancements, deaf and hard-of-hearing individuals continue to face significant challenges in fully engaging with tourism experiences due to communication barriers and the lack of tailored accommodations. This systematic review explores the potential of XR technologies to improve accessibility for this community, evaluates their effectiveness in addressing existing challenges, and examines their impact on travel experiences. A total of 16 studies were identified through a keyword search in the Scopus and Web of Science databases. The review analyses research methodologies, types of XR technologies utilised—including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)—and the advantages and limitations of their implementation. Findings suggest that XR can bridge communication gaps by providing immersive sign language translations, real-time captioning, and interactive visual guides, thereby enabling more engaging, informative, and independent tourism experiences for deaf and hard-of-hearing travelers. However, challenges such as high development and implementation costs, usability concerns, and the absence of standardised guidelines limit widespread adoption. This review highlights the need for user-centred design, active collaboration with the deaf and hard-of-hearing community, and further empirical studies to validate XR solutions. Future research should focus on improving long-term user engagement, enhancing the usability of XR applications, and expanding their integration across different tourism sectors. By addressing these gaps, XR technology can contribute to a more inclusive, accessible, and immersive tourism landscape for all travelers.

Keywords: Extended Reality; Augmented Reality; Deaf; Hearing; Tourism; Accessibility

INTRODUCTION

Tourism is a lucrative global industry, yet it often unintentionally creates barriers for individuals who require specific accessibility accommodations. Among these individuals, the deaf and hard-of-hearing (DHH) community faces unique challenges in fully engaging with and enjoying tourism experiences. Although traditional accessibility efforts have achieved some progress, they frequently fall short in addressing the diverse and complex needs of DHH individuals.

This study explores the transformative potential of Extended Reality (XR) technology to enhance tourism experiences for the DHH community. By leveraging Virtual Reality (VR) and Augmented Reality (AR), the aim is to overcome communication barriers, reimagine the dissemination of information, and create inclusive environments where individuals with hearing disabilities can meaningfully interact with tourism spaces. Employing a user-centred design approach, this research focuses on the development, implementation, and evaluation of XR applications tailored to the specific needs of DHH users—emphasizing the importance of innovation in achieving universal accessibility within the tourism sector. The term **Extended Reality (XR)** encompasses VR, AR, and Mixed Reality (MR) technologies (Chuah, 2019). **Virtual Reality** (VR) refers to "computer-generated environments that replicate places, the presence of people and objects, or fictional worlds, allowing realistic sensory experiences by the full immersion in a digital environment" (Vaz et al., 2018, p. 39). In contrast, **Augmented Reality** (AR) overlays digital content onto the physical world, integrating virtual information with real-world objects. **Mixed Reality (MR)** represents a fusion of these technologies, offering a more immersive and interactive experience (Chuah, 2019). These technologies have been applied in various fields, such as cultural heritage and museum tourism, to enhance user engagement and immersion (Vaz et al., 2018). Globally, the number of tourists identifying as cultural travellers is rising, accounting for approximately 40% of all tourists (UNWTO, 2017). A portion of these include hearing-impaired tourists. Studies suggest that tourists who first encounter destinations via VR are more inclined to develop interest in visiting them in real life (Kim et al., 2020). VR tourism not only increases tourists' desire to learn more about the destination but also enhances their intention to revisit or recommend it (Kim et al., 2020). Oakley (2019) found that VR technologies positively influence visitor behaviour and engagement in theme park settings by offering novel experiences. Similarly, Kim et al. (2020) concluded that embedded tools such as VR significantly impact tourist behavioural intentions.

It is important to note that people with disabilities often have distinct technological needs and expectations (Randolph & Hubona, 2014). Technologies like AR have been shown to shape the travel behaviours of individuals with accessibility requirements (Sheehy et al., 2019). However, responses to XR technologies may vary—individuals with mobility impairments may respond either positively or negatively depending on design and usability factors (Flavián et al., 2019; Van Kerrebroeck et al., 2017).

This paper investigates the role of XR in promoting inclusive tourism for the deaf and hard-of-hearing community. The outcomes of this study aim to answer the following research questions:

- What are the primary accessibility challenges encountered by deaf and hard-of-hearing tourists in various tourism contexts worldwide?
- How can XR technologies enhance accessibility and improve tourism experiences for deaf and hard-of-hearing travellers?
- What are the perceptions of DHH tourists regarding the effectiveness of XR tools in making tourism more accessible, and what measurable outcomes do these technologies offer in promoting inclusivity?

METHODOLOGY

Relevant articles were identified and collected using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. The data was retrieved on October 25, 2023, from two widely used academic databases: SCOPUS and Web of Science. In the initial data collection phase, key terms were identified, and their relationships were analyzed to construct effective search queries. To capture literature on XR technology, the following keywords were used: XR (Extended Reality), VR (Virtual Reality), AR (Augmented Reality), and MR (Mixed Reality). The term "XR" serves as an umbrella for VR, AR, and MR technologies. To align the search with the tourism context, the keyword "Tour" was incorporated, covering variations such as "Tourism" and "Tourist." Additionally, to target literature related to the deaf and hard-of-hearing community, the terms Deaf, Hear, Impair, and Disability were used. The term 'hard-of-hearing' was initially included but was excluded due to its limited search yield. To ensure the relevance and quality of the selected studies, several screening criteria were applied. The inclusion criteria required that articles: (1) be published in peer-reviewed academic journals, (2) be written in English to maintain linguistic consistency, and (3) have been published within the last five years (2019–2023) to reflect recent developments and avoid outdated information.

RESULTS AND ANALYSIS

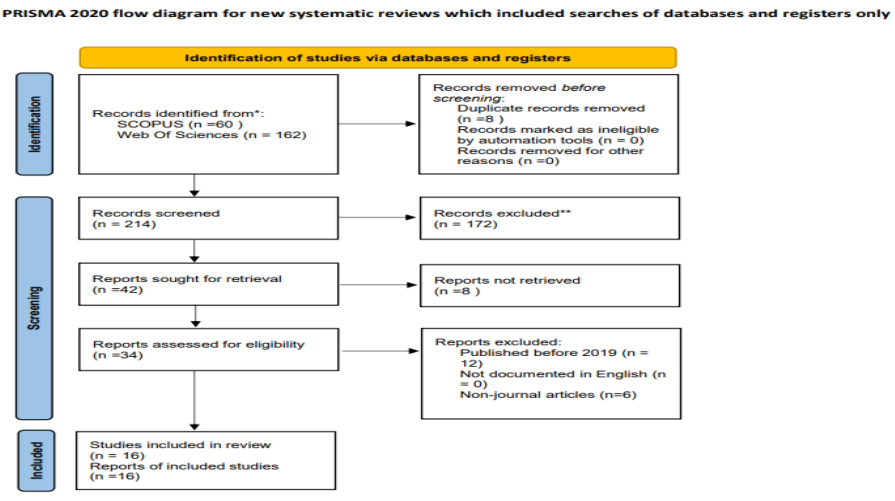
Summary of Findings

One search query was utilised for data collection from SCOPUS and Web of Science in order to obtain results relevant to the stated study concerns. A total of 60 and 162 records were found on SCOPUS and Web of Science, respectively, for the search query **("extended reality" OR "xr" OR "augmented reality" OR "ar" OR "virtual reality" OR "vr" OR "mixed reality" OR "mr") AND (deaf* OR (disab*) OR ((hear*) AND (impair*)) AND (tour*)**. The total number of records returned by the search was 222. After that, RIS files were exported from these records.

EndNote20 was used to import the RIS files and perform screening. The records were combined into a single document before the abstracts were screened. After identification, 8 duplicate records were deleted. 172 records that were not relevant to the literature review were removed out of the 214 that were examined based on their abstracts.

The remaining 42 records' reports are evaluated for eligibility based on the exclusion criteria. 12 reports were released before 2019; six of them were published as non-journal publications, and 8 of the records are not retrievable. Only 16 of the 222 records were deemed suitable for analysis. The 16 qualifying records fall in the categories of VR/AR/MR, Tourism, and Deaf or Hard of Hearing.

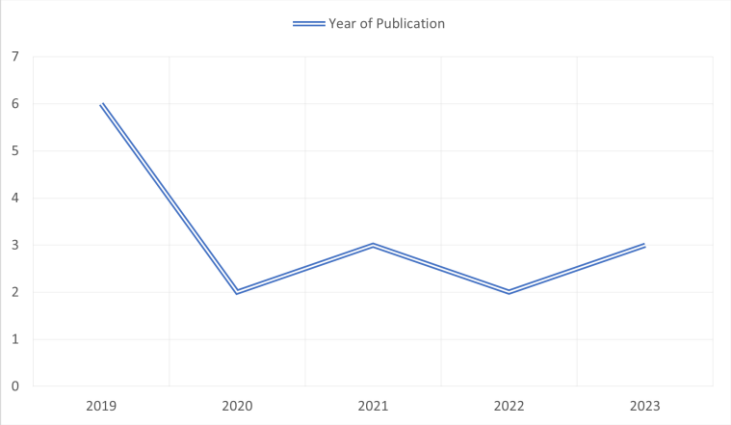
Figure 1: PRISMA Flow Diagram



Data Extraction

The data extracted from the selected journal articles included the year and country of publication, the key accessibility challenges faced by deaf and hard-of-hearing tourists in Malaysia, the level of development and implementation of XR-based technologies designed to enhance accessibility and improve tourism experiences for this group, and the perceptions of deaf and hard-of-hearing individuals regarding the effectiveness of these technologies in promoting accessibility and inclusivity.

Figure 2: Year of publication for journals



Using the defined inclusion and exclusion criteria, Figure 2 illustrates the publication trend of journal articles from 2019 to 2023 retrieved from SCOPUS and Web of Science. The number of publications declined sharply between 2019 and 2020, followed by a slight increase in 2021. This was succeeded by a modest decrease in 2022 before rising again in 2023. XR technology is an emerging trend in the tourism sector, and it is increasingly important to consider accessibility for individuals with disabilities, especially those who are deaf or hard of hearing. The significant drop in publications in 2020 can be attributed to the travel restrictions imposed globally and locally due to the COVID-19 pandemic. A slight recovery in 2021 reflects the gradual easing of movement restrictions during that period.

Figure 3: Publication by authors from different countries

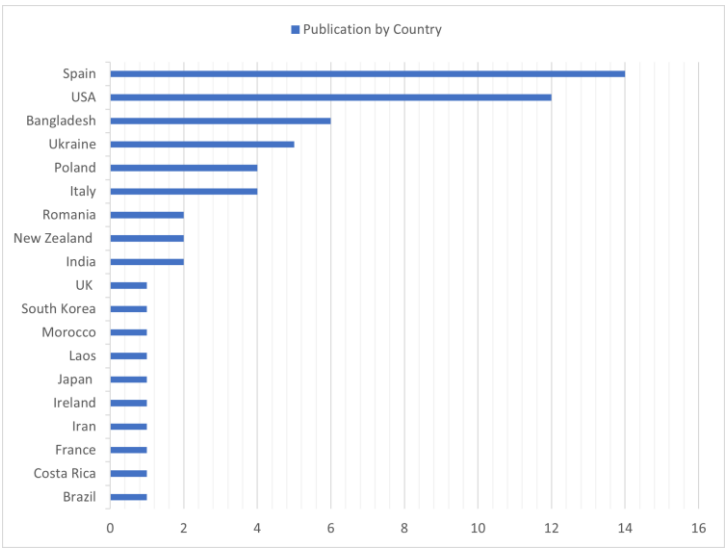


Figure 3 presents the distribution of publications by authors from various countries. Spain leads with the highest number of contributing authors (14), followed by the USA with 12 authors. Bangladesh ranks third, and Ukraine fourth. Poland and Italy share the fifth position, each with 4 contributing

authors. Romania, India, and again Italy appears in sixth place, each with 2 authors. The UK, South Korea, Morocco, Laos, Japan, Ireland, Iran, France, Costa Rica, and Brazil occupy the seventh position, each represented by a single author.

The strong representation from Spain and the USA highlights their active engagement in the development and implementation of XR technology within the tourism sector. While this does not necessarily indicate full inclusivity for individuals with disabilities, it does reflect a growing awareness of XR as an emerging tool to enhance accessibility and inclusivity in tourism experiences. Their high contribution suggests a forward-looking approach, integrating XR as a complement to existing accessibility initiatives.

Main Accessibility Issues Experienced by Deaf and Hard-of-Hearing Tourists in Malaysia

RQ1: What are the primary accessibility challenges encountered by deaf and hard-of-hearing tourists in various tourism contexts worldwide?

Although this research question is framed within the Malaysian context, the accessibility challenges faced by deaf and hard-of-hearing (DHH) tourists are largely universal. Regardless of the country from which the data originates, the findings are broadly applicable to the Malaysian DHH community, as these individuals tend to experience similar barriers across global tourism environments. Based on the reviewed literature, five key challenges have been identified:

1. **Communication Barriers**: DHH tourists often struggle to communicate with individuals who do not use sign language, including fellow travellers, tour guides, and hospitality staff.
2. **Limited Access to Information**: Information provided in verbal or audio formats—such as directions, rules, or historical content—may not be accessible to DHH individuals, placing them at a disadvantage.
3. **Lack of Sign Language Interpreters**: Many tourist attractions, events, and cultural sites do not offer sign language interpretation, which hinders the ability of DHH tourists to fully engage and understand.
4. **Inadequate Communication Technology**: Some destinations may lack assistive technologies like captioning, video relay services, or induction loop systems, limiting effective communication for DHH visitors.
5. **Emergency Preparedness**: Traditional emergency alert systems, such as audible alarms, may not adequately notify DHH tourists. The absence of visual or vibrating alerts poses significant safety risks.

According to Table 1, the issue of **Communication Barriers** was discussed by four contributing authors: Iftikhar et al. (2023), Benjamin et al. (2020), Khan et al. (2019), and Tecău et al. (2019). **Limited Information Access** was highlighted by three authors: Iftikhar et al. (2023), Benjamin et al. (2020), and Wang et al. (2019). **Lack of Sign Language Interpreters** had two contributing authors: Gharibi et al. (2022) and Benjamin et al. (2020). **Emergency Preparedness** was mentioned by three authors: Iftikhar et al. (2023), Thangaraj & Gomathi (2019), Folgado-Fernández et al. (2023). The challenge with the highest number of contributors was **Inadequate Communication Technology**, discussed by six authors: Iftikhar et al. (2023), Benjamin et al. (2020), Pérez et al. (2020), Khan et al. (2019), Wang et al. (2019), and Tecău et al. (2019).

Table 1: Main accessibility challenges faced by deaf and hard-of-hearing

Main Challenges	Author(s)	Frequency Mentioned in Literature	Impact on Tourists	Proposed Solutions
Communication Barriers	Iftikhar et al., 2023; Benjamin et al., 2020; Khan et al., 2019; Tecău et al., 2019	Very Common (4 mentions)	High difficulty in interactions with service providers and other tourists	Training in sign language for staff; Use of communication boards and apps
Limited Information Access	Iftikhar et al., 2023; Benjamin et al., 2020; Wang et al., 2019	Common (3 mentions)	Informational disadvantage: Inability to access audio or written guides	Provision of information in visual formats; Use of AR for visual guides
Lack of Sign Language Interpreters	Gharibi et al., 2023; Benjamin et al., 2020	Less Common (2 mentions)	Barriers in understanding and participation at events and attractions	Employment of on-site or remote sign language interpreters
Inadequate Communication Technology	Iftikhar et al., 2023; Benjamin et al., 2020; Pérez et al., 2020; Khan et al., 2019; Wang et al., 2019; Tecău et al., 2019	Most Common (6 mentions)	Communication challenges; Lack of technology for assistance	Installation of induction loops; Use of video relay services and captioning
Emergency Preparedness	Iftikhar et al., 2023; Thangaraj & Gomathi, 2019; Folgado-Fernández et al., 2023	Less Common (3 mentions)	Safety risks due to inadequate alert systems	Implementation of visual and vibrating alert systems

The extent to which developed XR-based technologies improve accessibility and enhance the tourism experience for deaf and hard-of-hearing tourists in Malaysia.

RQ2: How can XR technologies enhance accessibility and improve tourism experiences for deaf and hard-of-hearing travellers.

The research question also focuses on a context that specifically affects Malaysian deaf and hard-of-hearing (DHH) tourists. However, the enhancement of tourism experiences for this group has broader implications and benefits for the global DHH community, including those in Malaysia.

Extended Reality (XR) technologies—which encompass Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)—show great potential in improving accessibility and enriching tourism experiences for DHH travellers. Several key contributions of XR technologies include:

- **Enhancing Visual Communication**
  XR technologies enable information to be delivered visually, reducing dependence on auditory cues. Tools such as virtual tours, AR-enhanced signage, and immersive environments improve accessibility for individuals who are deaf or hard of hearing.
- **Integrating Captions and Subtitles in XR Content**
  XR platforms can support real-time captions or subtitles, allowing DHH users to access spoken content. This feature improves understanding during virtual tours or AR-based experiences.
- **Providing Personalised Experiences**
  XR applications can be customised to meet individual user needs. This may include adjusting display settings, selecting preferred languages, or choosing specific content types, thereby creating a more inclusive experience.

- **Creating Inclusive Gaming and Simulations**
  XR technologies open up the possibility for games and simulations that do not rely heavily on audio, enabling DHH tourists to engage with interactive entertainment as part of their travel experiences.
- **Facilitating Real-Time Communication**
  Devices such as AR glasses can support instant communication between DHH tourists and individuals unfamiliar with sign language. This can be achieved through integrated translation tools, text-based communication, or virtual sign language avatars.
- **Implementing Wearable XR Devices**
  Wearable XR devices, such as AR and VR headsets, merge digital content with the physical environment or immerse users in entirely virtual spaces. These technologies enhance how DHH tourists interact with their surroundings by offering alternative ways to access and process information.

Based on Table 2, **Enhancing Visual Communication** received the highest number of contributions, with six authors (Iftikhar et al., 2023; Zaifri et al., 2023; Giaconi et al., 2021; Tserklevych et al., 2021; Shaker et al., 2020; Thangaraj & Gomathi, 2019). **Personalised Experiences** followed with four contributing authors (Iftikhar et al., 2023; Zaifri et al., 2023; Roman et al., 2022; Pérez et al., 2020), while **Inclusive Gaming and Simulations** and **Wearable XR Devices** each had five contributing authors (Iftikhar et al., 2023; Zaifri et al., 2023; Roman et al., 2022; Tserklevych et al., 2021; Pérez et al., 2020.) and(Zaifri et al., 2023; Gharibi et al., 2022; Giaconi et al., 2021; Thangaraj & Gomathi, 2019; Wang et al., 2019) respectively. **Adding Captions and Subtitles to XR Conten**t had three contributors (Khan et al., 2019; Thangaraj & Gomathi, 2019), while **Real-Time Communication Assistance** had the fewest contributors, with only one author (Zaifri et al., 2023).

Table 2: Improvement in XR Technology accessibility and enhance the tourism experience for deaf and hard-of-hearing tourists in Malaysia

XR Technology Applications	Specific Features/Benefits	Contributing Authors	Frequency Mentioned
Enhancing Visual Communication	Use of visual elements in virtual tours and AR-enhanced signage; immersive experiences without relying on auditory cues	Iftikhar et al., 2023; Zaifri et al., 2023; Giaconi et al., 2021; Tserklevych et al., 2021; Shaker et al., 2020; Thangaraj & Gomathi, 2019	6
Adding Captions and Subtitles	Real-time captioning and subtitles in XR platforms for accessing spoken information	Khan et al., 2019; Thangaraj & Gomathi, 2019	2
Personalized Experiences	Tailoring XR applications to individual preferences; adjusting settings, language selection, specific information display	Iftikhar et al., 2023; Zaifri et al., 2023; Roman et al., 2022; Pérez et al., 2020	4
Inclusive Gaming and Simulations	Gaming and simulation experiences designed without dependency on audio; interactive participation	Iftikhar et al., 2023; Zaifri et al., 2023; Roman et al., 2022; Tserklevych et al., 2021; Pérez et al., 2020	5
Wearable XR Device	Integration of physical and digital worlds through wearable devices; immersive VR environments and AR information overlays	Zaifri et al., 2023; Gharibi et al., 2022; Giaconi et al., 2021; Thangaraj & Gomathi, 2019; Wang et al., 2019	5
Real-time Communication Assistance	AR glasses or devices enabling instant communication; translation services, text-based communication, or sign language avatars	Zaifri et al., 2023	1

Perceptions of Deaf and Hard-of-Hearing Tourists on the Effectiveness of XR-Based Technologies in Enhancing Accessibility and Promoting Inclusive Experiences

RQ3: What are the perceptions of DHH tourists regarding the effectiveness of XR tools in making tourism more accessible, and what measurable outcomes do these technologies offer in promoting inclusivity?

The issues addressed in this research are quite niche, resulting in a notable research gap. Consequently, answers to this research question were drawn from broader studies that include various disabilities and the use of XR technology within the tourism context. The following are some key perceived effectiveness aspects extracted from these studies:

- **Visual Information Enhancement**
  XR technologies, especially augmented reality (AR), provide real-time visual information that assists hard-of-hearing travellers in navigating and understanding their surroundings.
- **Immersive Experiences**
  Virtual reality (VR) offers immersive experiences with features such as subtitles and sign language interpretation, improving accessibility and engagement during tours and at attractions.
- **Communication Bridging**
  XR technologies can reduce communication barriers and enhance interaction between service providers and locals through real-time translation or transcription services.
- **Educational Opportunities**
  XR serves as an educational tool by delivering interactive and visual resources that inform users about historical sites, cultural nuances, and safety measures.
- **Awareness and Inclusivity**
  The increasing adoption of XR technology encourages service providers to better understand and accommodate the needs of deaf and hard-of-hearing individuals, fostering a more inclusive tourism sector.
- **Real-time Accessibility Features**
  XR can offer live captioning and visual alerts, improving real-time accessibility for people with hearing impairments.
- **Cultural Connection**
  XR technology enhances cultural connection for deaf and hard-of-hearing travelers by delivering multimedia content that highlights the richness and diversity of cultures.

Table 3 indicates that **Visual Information Enhancement** has three contributing authors (Giaconi et al., 2021; Checa et al., 2019; Tecău et al., 2019). **Immersive Experiences** has the highest number of contributing authors, with five (Folgado-Fernández et al., 2023; Iftikhar et al., 2023; Checa et al., 2019; Pérez et al., 2019; Tecău et al., 2019). **Communication Bridging** and **Cultural Connection** each have the fewest contributing authors, with one author each (Tecău et al., 2019 and Pérez et al., 2019, respectively). **Educational Opportunities** has three contributing authors (Iftikhar et al., 2023; Pérez et al., 2019; Tecău et al., 2019), and **Real-time Accessibility Features** has two (Iftikhar et al., 2023; Khan et al., 2019).

Table 3: Perceptions of Deaf and Hard-of-Hearing Tourists on the Effectiveness of XR-Based Technologies

XR Technology Application	Contributing Authors	Frequency Mentioned	Impact on Accessibility	Impact on Inclusivity	Descriptive Comments
Visual Information Enhancement	Giaconi et al., 2021; Checa et al., 2019; Tecău et al., 2019	3	Enhances navigation and comprehension	Improves independent exploration	VR/AR provides real-time visual information aiding in navigation and understanding surroundings
Immersive Experiences	Folgado-Fernández et al., 2023; Iftikhar et al., 2023; Checa et al., 2019; Pérez et al., 2019; Tecău et al., 2019	5	Increases engagement in tours and attractions	Allows for deep immersion in experiences	VR creates immersive environments with subtitles and sign language for better engagement
Communication Bridging	Tecău et al., 2019	1	Reduces communication barriers	Facilitates interaction with service providers and locals	Incorporation of real-time translation or transcription services to aid communication
Educational Opportunities	Iftikhar et al., 2023; Pérez et al., 2019; Tecău et al., 2019	3	Enhances learning experiences	Provides interactive educational content	Interactive and visual resources used for educational purposes at historical and cultural sites
Awareness and Inclusivity	Folgado-Fernández et al., 2023; Giaconi et al., 2021; Khan et al., 2019	3	Improves understanding between deaf people and regular people.	Not provided	A more inclusive tourism sector is being facilitated by service providers' growing awareness of the needs of people who are deaf or hard of hearing as XR technology become more widely used.
Real-time Accessibility Features	Iftikhar et al., 2023; Khan et al., 2019	2	Offers live accessibility tools	Improves real-time experience	Features like live captioning or visual alerts cater to real-time accessibility needs
Cultural Connection	Pérez et al., 2019	1	-	Fosters a sense of belonging and understanding	XR provides multimedia information to enhance cultural understanding and connection

DISCUSSION AND LIMITATIONS

Discussions

Based on the findings obtained from the research questions, it is evident that the use of XR technology in tourism for the deaf and hard-of-hearing (DHH) community is still in its early stages. Current implementations do not yet address all—or even the majority—of the challenges faced by this group. However, as XR technologies continue to evolve and become more widely adopted in the tourism sector, there has been a noticeable increase in involvement from key stakeholders, including government agencies and non-governmental organizations (NGOs). These entities are beginning to emphasize the importance of inclusivity for persons with disabilities, particularly those who are deaf or hard of hearing. This growing recognition is not limited to Malaysia but is part of a broader global trend. To truly enhance accessibility for the DHH community in tourism, especially within cultural institutions such as museums, active intervention from museums and government bodies is essential. These institutions play a vital role in implementing and improving XR-based accessibility measures, contributing to a more inclusive and engaging experience for all visitors. Museums can support accessibility by designing exhibits that incorporate multimedia elements, including sign language interpretation, subtitles, and interactive features tailored to various sensory needs. Providing written materials, visual aids, and digital guides with captioning and sign language support empowers deaf and hard-of-hearing visitors to explore museum content independently and meaningfully. Equally important is the training of museum staff to ensure a welcoming environment. This includes education in communication techniques, basic sign language, and strategies for effectively assisting DHH visitors. Collaborating directly with the DHH community during the design of accessible exhibits ensures that their preferences and needs are authentically represented. From a governmental perspective, legislation and regulatory frameworks mandating accessibility standards in public spaces, including museums, are crucial. Governments can promote universal design principles in both infrastructure and exhibit development, while also offering financial support through funding and grants to help institutions implement necessary accessibility features. Public awareness campaigns further aid in educating administrators and the general public about the diverse needs of the DHH community. Finally, ongoing monitoring and evaluation efforts ensure long-term commitment to accessibility, fostering a more inclusive tourism environment overall.

Study Implications

Theoretical Implications

The exploration of Extended Reality (XR) technologies in the tourism context for the deaf and hard-of-hearing (DHH) community presents substantial opportunities to expand existing theoretical frameworks related to technology adoption, accessibility, and inclusive tourism. This emerging field highlights the dynamic intersection between technological innovation and social inclusion, signalling a paradigm shift toward a more holistic understanding of accessibility that encompasses not only physical but also digital and experiential dimensions. The active participation of diverse stakeholders—including government agencies, NGOs, technology developers, and the DHH community—reflects the complex and interdependent nature of inclusive tourism ecosystems. This complexity necessitates the development of theoretical models that address the multifaceted challenges of accessibility, stakeholder collaboration, and the co-creation of technological solutions. Future frameworks should extend beyond evaluating the functional impact of technology, to also consider the broader socio-cultural, economic, and policy contexts that influence XR adoption. A more nuanced and integrative theoretical approach is essential for advancing research and informing practice in the development of inclusive and accessible tourism experiences powered by XR.

Practical Implications

On a practical level, the integration of XR technologies to enhance tourism accessibility for the DHH community requires coordinated action among key stakeholders. Museums and cultural institutions are encouraged to embed accessibility considerations into the design and implementation of XR-based exhibits from the outset. This involves not only incorporating accessible content—such as captions, sign language, and visual enhancements—but also ensuring that staff are trained in DHH communication practices and that exhibit design is carried out in collaboration with DHH individuals. Government agencies play a pivotal role in driving these efforts by establishing clear accessibility regulations, offering financial incentives and grants for XR adoption, and facilitating cross-sector partnerships. These partnerships—connecting technology developers, cultural institutions, and the DHH community—are vital to creating XR solutions that are user-centred, culturally appropriate, and responsive to the specific needs of the DHH population. Technology developers, meanwhile, must integrate inclusivity into the design process from the earliest stages of development. This requires ongoing engagement with DHH users to ensure that the resulting tools are not only functionally accessible but also linguistically and culturally adaptable. Altogether, these practical implications underscore the importance of a collaborative, innovative, and policy-driven approach to creating a more inclusive tourism environment through the use of XR technologies.

Limitations

This study was limited to searches conducted exclusively within two major academic databases, SCOPUS and the Web of Science, thereby narrowing the breadth of potential literature reviewed. The scope was further restricted to peer-reviewed journal articles, omitting potentially valuable insights from other sources such as news articles, periodicals, conference proceedings, and serial publications. Financial limitations also impacted access to full records, confining the literature pool to those journals and publications available through institutional subscriptions. Moreover, the study's specialized focus reflects the niche nature of the topic, given the limited body of existing research and academic discourse surrounding inclusivity for the deaf and hard-of-hearing community in tourism.

CONCLUSION AND FUTURE RESEARCH

This study has highlighted the significant potential of Extended Reality (XR) technologies in enhancing accessibility for deaf and hard-of-hearing (DHH) individuals within the tourism sector. By exploring the application of XR across various tourism contexts, the research demonstrates how these technologies can break down communication barriers and create more inclusive and engaging experiences for the DHH community. The collaborative efforts of museums, government agencies, and technology developers are crucial to realizing this potential. However, it is important to acknowledge the ongoing limitations—ranging from technological constraints and cultural differences to the need for continuous refinement of user experience design. Future research should focus on advancing XR technologies to address these challenges effectively, ensuring alignment with accessibility standards and sensitivity to the diverse needs and preferences of DHH users. Moreover, investigating the long-term impacts of XR-enabled tourism on cultural understanding and public attitudes toward disability can provide deeper insights into the broader implications of this technological integration. Continued innovation and cross-sector collaboration are essential to developing fully inclusive and immersive tourism experiences. This study lays a foundational framework for future efforts aimed at building a tourism landscape that is accessible, equitable, and enriching for individuals of all abilities.

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