Hindawi
Human Behavior and Emerging Technologies
Volume 2024, Article ID 6494944, 39 pages
https://doi.org/10.1155/2024/6494944

Review Article

Voice Assistant Utilization among the Disability Community for Independent Living: A Rapid Review of Recent Evidence

Paola Esquivel, Kayden Gill, Mary Goldberg, S. Andrea Sundaram, Lindsey Morris, and Dan Ding

Wireless Tech Rehabilitation Engineering Research Center (RERC), Department of Rehabilitation Science and Technology, University of Pittsburgh, 6425 Penn Avenue, Suite 401 Pittsburgh, PA 15206, USA

Correspondence should be addressed to Mary Goldberg; mgoldberg@pitt.edu

Received 12 October 2023; Revised 24 February 2024; Accepted 7 March 2024; Published 12 April 2024

Academic Editor: Tze Wei Liew

The rapid advancement and widespread adoption of voice assistance technology have shown promise in benefiting individuals with disabilities, offering increased social participation, independence, and leisure activities. However, barriers to their full utilization have been identified, leading to potential abandonment by users with disabilities. This rapid review is aimed at filling the gap in the literature by investigating the utilization of voice assistants among people with disabilities for independent living and community participation. A comprehensive search was conducted in academic literature databases, including PubMed, Embase, and Web of Science, and gray data was sourced from public social media domains through Infegy. The analysis included 48 articles and 281 social media posts that met the inclusion criteria. Neurodiversity, disabilities affecting vision, and general disabilities were the most frequently discussed categories in both sources. The most common tasks performed using voice assistants were interface control, reminders, and environmental control, with a focus on enabling independence. Barriers to use mentioned in the literature included cognitive load during use, speech interpretation, lack of nonverbal control, and privacy concerns, while gray data reported limited functionality and speech interpretation as primary barriers. Amazon Alexa was the most discussed brand in both sources. The findings highlight the need for further research and innovation to fully harness the potential benefits of voice assistants for individuals with disabilities. By addressing the identified barriers and tailoring voice assistance technology to cater to the specific needs of different disability types, this technology can become a powerful tool for enhancing the lives of individuals with disabilities and promoting greater independence and community participation.

1. Introduction

The introduction and widespread usage of smartphones and smart technology over the past decade has brought growth in the use of voice assistants such as Amazon Alexa, Google Assistant, Apple Siri, and Microsoft Cortana [1]. Voice assistants heavily rely on voice recognition and artificial intelligence to provide a service to the users [2]. In addition to smartphones, voice assistants are also found in speakers equipped with a microphone called smart speakers [3].

The increasing adoption of voice assistant technology among US adults, projected to reach 48.2% by 2025 and potentially encompassing 157.1 million users by 2026, underscores its expanding role in society [4]. Amazon Alexa and Google Assistant are the most popular voice assistants among users [2]. This rapid growth presents an opportunity to leverage voice assistants as a promising tool for maintaining and boosting social participation, independence, and leisure activities for individuals with disabilities [5, 6].

Schlomann [6] identified six benefits of voice assistants for people with disabilities. First, voice assistants might facilitate access to technology for people with severe cognitive, sensory, or physical disabilities who cannot use computers or cell phones in a typical manner. Voice assistants can help to solve usability issues like small buttons or text [7]. Second, voice assistants might alleviate social isolation. People with disabilities may come to feel less lonely while talking with the voice assistant and even “personify” it (e.g., attributing the pronoun "she" to Alexa), becoming a form of social companionship [8, 9]. Third, in the health area, voice assistants might assist with health monitoring and medication management [10, 11]. Fourth, voice assistants might be a platform for leisure activities, as they can play music, tell some jokes, and even sing [9, 12]. Fifth, voice assistants might support independent living by automating activities of daily living, such as calling someone, ordering food, shopping online, and controlling lights [13, 14]. Furthermore, this technology might lessen caregiver demand by reading books, shopping, or answering simple questions [13]. Sixth, voice assistants might positively affect a person's sense of agency. These devices allow people with disabilities to perform activities on their own and feel capable of accomplishing those activities [9].

However, there are still barriers that may prevent the full use of voice assistance technology to support functionality for people with disabilities [1]. Among the most frequently mentioned barriers are technological issues, such as instability of the Internet connection and the technology not responding as requested [8, 9, 12–14]. Data privacy and surveillance are other issues raised in the literature [2, 8, 14]. There is also a lack of training and programs to teach people with disabilities to use these devices [9, 15]. Moreover, there are personal factors limiting use, such as a lack of knowledge of the capabilities and functions of voice assistants, difficulty discovering additional features, and difficulty remembering commands to interact with the technology [8, 9, 13].

All these issues can lead to a high rate of abandonment of this technology by users with disabilities. For instance, they may feel that this technology is not easy to use or that the voice assistant does not satisfy their demands, which can lead to frustration [9]. If individuals with disabilities do not feel satisfied using these devices and abandon them, this could escalate to a new form of social exclusion [14]. As more and more people continue to interact with voice assistants, people with disabilities could be left behind if the barriers mentioned above are not adequately addressed.

Two recent scoping reviews were published on how older adults use personal voice assistants and how people with disabilities use smart speakers, specifically Arnold et al. [16] and Tavares et al. [17]. However, both of these reviews do not adequately delve into the needs and challenges faced by subpopulations within the disability community. Moreover, the reviews were published over two years ago, and given the rapid pace of expansion and upgrades in voice assistance technology, it is crucial to continuously explore the use of these devices by people with disabilities to ensure accessibility and usability [12].

Hence, there exists a twofold gap in the literature: the lack of comprehensive exploration of subpopulation needs and the need for up-to-date research to keep pace with technological advancements. To address these gaps, further research is warranted to explore the potential benefits and challenges faced by individuals with disabilities using voice assistants [8, 14]. Understanding the needs of this underresearched group, it is crucial to ascertain whether voice assistants can truly serve as effective assistive technology for them [6, 9].

Given the rapid global spread of voice assistant usage, particularly amid the COVID-19 pandemic, conducting a rapid review of evidence from 2021 to the present is essential to capture the last state-of-the-art literature and usage trends [18–20]. Hence, this review is aimed at identifying what recent gray data and peer-reviewed literature have reported on the utilization of voice assistance technology for independent living and community participation among people with disabilities. Understanding the current utilization of this technology might provide valuable insights for enhancing accessibility and usefulness, ultimately supporting this population in achieving greater independence and participation in their communities.

2. Methods

A PICO format was used to guide the search process, focusing on population (P), intervention (I), comparison (C), and outcome (O). The PICO framework is commonly utilized in evidence-based practice and literature reviews to ensure a structured approach to formulating research questions and search strategies [21]. By utilizing the PICO framework, the study ensures clarity and consistency in defining the parameters for inclusion and exclusion criteria. These criteria can be seen in Table 1.

PubMed, Embase, and Web of Science were searched using a strategy that scans titles, abstracts, and text words for terms related to voice assistants and the disability community. Subject headings related to disability were also used for PubMed and Embase-specific thesaurus terms. No subject headings were used for smart technology as this has yet to be integrated into MeSH and Emtree. The scholarly literature search was run on February 14, 2023, and exported to a review software, PICO Portal (version 3.0.2023.0116) (PICO Portal, New York, NY, United States. Available at http://www.picoportal.org), shortly thereafter for deduplication.

In addition to searching academic literature sources, gray data, data sourced from public social media domains, was searched via Infegy (Infegy Atlas, 210W 19 Terrace #200, Kansas City, MO 64108. Available at http://www.infegy.com) on April 9, 2023. A search strategy for Infegy similar to the aforementioned strategy was developed. Some terms were modified to adapt the search to social media. It should be noted that search terms related to the deaf and hard of hearing community were removed from the Infegy strategy due to a high number of misnomer phrases such as "Siri is deaf," implying the device did not recognize speech, rather than about the deaf community. This did not exclude results related to the deaf community, but it also did not actively search for them. Complete search strategies and term categories can be seen in Tables 2–5.

All database records retrieved were uploaded to PICO Portal and automatically deduplicated selecting the most complete and/or recent version. Abstract screening, full-text screening, and data extraction were completed using conventional double screening by two independent reviewers followed by consolidation on any conflict. If no consensus was reached, a third reviewer served as a judicator. Full-text versions of all titles that passed abstract

Table 1: Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion criteria
Population	People with disabilities (PWD) in the home and community setting*	PWD in rehabilitation, hospital, or long-term care facilities, or no mention of PWD
Intervention	Any mainstream personal voice assistant**	Describes technical developments but not use by PWD, except for developments aimed at eliminating specific barriers of existing voice assistants Technology that requires nonvoice input or nonvoice equivalent input to accomplish the primary function
Comparison	None or control group	None
Outcome of interest	Usage and impact on independence and participation	Insufficient information on how interactions support or hinder participation and independence
Time	2021–present (via date limiters)	Pre-2021 (via date limiters)
Language	English or Spanish	Other languages

∗ includes disabilities of any type of disability (e.g., motor, sensory, speech, and intellectual) among any adult age group. ∗∗ includes Amazon Alexa, Google Assistant, Apple Siri, Microsoft's Cortana, and Samsung Bixby.

screening or needed further review were obtained for full-text screening. A PRISMA flow diagram of the screening results can be seen in Figures 1 and 2 [22]. Table 6 summarizes all included articles.

Data extraction was performed utilizing PICO Portal's customizable data extraction forms. The final data extracted was then exported to Excel for further analysis according to the domain of interest. Certain extraction categories only pertained to either the peer-reviewed or gray data, and this and the categories as a whole can be seen in Table 7.

To summarize and explain the characteristics and findings of the included literature, a synthesis was produced with information supplied in the text and tables. The synthesis investigates the relationships and findings both within and between the included evidence. Subgroup analysis was performed based on the type of disability of participants. Disability categories will include general, mobility/dexterity, hearing, vision, chronic health, and neurodiverse-based disabilities.

3. Results

3.1. Sources. The analysis included 48 articles from the academic literature and 281 media posts that met our inclusion criteria. Publishing journals and conferences along with the primary domain of articles were recorded, identifying 39 unique publishing sources, across 7 domains. The majority of articles (58.3%) came from the combined fields of technology and engineering, with significantly fewer articles sourced from the remaining fields. Of gray posts, 75.1% came from Twitter, and 36.3% of the reporters/content creators indicated having a disability. Following disabled people, news outlets (21.4%), service/medical providers (14.9%), and family members/caregivers of disabled people (12.8%) were the most common reporter types (see Figure 3 for full reporter information).

3.2. Types of Disabilities. Gray data was further analyzed to determine the types of disabilities mentioned along with device brand, type, primary utilization, tasks performed, and any barriers reported. Neurodiversity was the most frequently discussed disability category reported by 29.2% of posts, followed by disabilities affecting vision (26.3%), general (17.4%), speech (16.4%), and mobility/dexterity (12.5%). Chronic health conditions and disabilities affecting hearing were the least discussed at 1.4% and 2.1%, respectively. Due to the high frequency, neurodiverse was further broken down into subcategories, ADHD was mentioned in 47.6% of neurodiverse posts, followed by dyslexia (28.0%), and autism (17.1%). Literature data was similarly analyzed with the most common disability found in articles being speech at 50% followed by mobility/dexterity (39.6%), neurodiverse (31.3%), vision (22.9%), hearing (20.8%), and chronic health (16.7%). Neurodiversity discussed in the literature was primarily focused on dementia, which was mentioned in 60% of articles, and more broadly cognitive impairment in 46.7%. This was followed by intellectual disability (33.3%) and autism (13.3%). For a full report on the disabilities mentioned, see Figure 4.

3.3. Tasks Performed with Voice Assistants. The focus of this review was to determine how people with disabilities utilize voice assistants; across gray data, 63.7% of posts identified tasks that enable independence, which for this project is defined as being able to perform a task without the assistance of another person. Only 12.6% of posts focused on enabling participation, defined as engaging with others. The most reported tasks by posts involved interface control (28.8%), reminders (16.4%), environmental control (15.7%), communication (11.4%), and reading (10.7%). All articles in the literature discussed tasks that enable independence, while only 52.1% discussed participation tasks. The most common tasks were similar to those of the gray data, being interface control (85.4%), environment control (50%), communication (45.8%), media management (39.6%), and information retrieval (37.5%). An individual breakdown of task utilization mentioned by disability can be seen in Table 8.

3.4. Barriers. Along with tasks involved in utilization, barriers to use were also assessed. Gray data focused on a much smaller pool of barriers as seen in Figure 5, and only 26.7% of posts mentioned a barrier at all in comparison to 50%

Table 2: PubMed search strategy.

#	Term category	Query	Result
1	Disability related	"Amniotic Band Syndrome"[MH] OR "Amputation, Surgical"[MH] OR "Amputation, Traumatic"[MH] OR "Amputation Stumps"[MH] OR "Autism Spectrum Disorder"[MH] OR "Blindness"[MH] OR "Brain Injuries"[MH] OR "Cerebral Palsy"[MH] OR "Disabled Persons"[MH] OR "Dwarfism"[MH] OR "Fetal Alcohol Spectrum Disorders"[MH] OR "Glaucoma"[MH] OR "Hearing Aids"[MH] OR "Hearing Loss"[MH] OR "Macular Degeneration"[MH] OR "Multiple Sclerosis"[MH] OR "Neurocognitive Disorders"[MH] OR "Neurodevelopmental Disorders"[MH] OR "Orthopedic Equipment"[MH] OR "Osteogenesis Imperfecta"[MH] OR "Paralysis"[MH] OR "self-help devices"[MH] OR "Service Animals"[MH] OR "Spinal Cord Diseases"[MH] OR "Stroke"[MH] OR "Vision, Low"[MH] OR "Spinal Cord Diseases"[MH] OR "assistive techno∗"[TW] OR disab∗[TW] OR handicap∗[TW] OR "service animal∗"[TW] OR "service dog∗"[TW] OR "cochlear implant∗"[TW] OR deaf∗[TW] OR "hard of hearing"[TW] OR "hearing aid∗"[TW] OR "hearing impair∗"[TW] OR "hearing loss∗"[TW] OR deafblind∗[TW] OR ADHD[TW] OR asperger∗[TW] OR "attention deficit∗"[TW] OR autis∗[TW] OR "cognitive delay∗ "[TW] OR "cognitive impair∗"[TW] OR "cognitively delay∗"[TW] OR "developmental delay∗"[TW] OR "developmental dis∗"[TW] OR "developmentally delay∗"[TW] OR "down syndrome"[TW] OR "down∗s syndrome"[TW] OR "downs syndrome"[TW] OR dyslexi∗[TW] OR "fetal alcohol syndrome∗"[TW] OR "fragile X"[TW] OR "intellectual impair∗"[TW] OR "intellectually impair∗"[TW] OR "mental impair∗"[TW] OR "mentally impair∗"[TW] OR neurodiv∗[TW] OR nonverbal∗[TW] OR "Prader Willi syndrome∗"[TW] OR "Prader-Willi syndrome∗ "[TW] OR "speech impair∗"[TW] OR "traumatic brain injur∗"[TW] OR Achondroplasia[TW] OR "amniotic band syndrome∗"[TW] OR amput∗[TW] OR "Amyotrophic Lateral Sclerosis"[TW] OR cane∗[TW] OR crutch∗[TW] OR dwarf∗ [TW] OR dystroph∗[TW] OR hemipleg∗[TW] OR "limb difference∗"[TW] OR "limb loss∗"[TW] OR "little people∗"[TW] OR "little person∗"[TW] OR "Lou Gehrig∗ "[TW] OR "manual chair∗"[TW] OR "mobility aid∗"[TW] OR "mobility device∗ "[TW] OR "mobility impair∗"[TW] OR "multiple sclerosis"[TW] OR Myelitis[TW] OR "osteogenesis imperfecta"[TW] OR paraly∗[TW] OR parapleg∗[TW] OR "physical impair∗"[TW] OR "physically challenged"[TW] OR "physically impair∗ "[TW] OR polio∗[TW] OR "power chair∗"[TW] OR quadrapleg∗[TW] OR scooter∗ [TW] OR "Spinal cord injur∗"[TW] OR "spinal muscular atroph∗"[TW] OR tetrapleg∗[TW] OR walker∗[TW] OR wheelchair∗[TW] OR stroke∗[TW] OR "blind people∗"[TW] OR "blind person∗"[TW] OR blindness[TW] OR glaucoma[TW] OR "guide dog∗"[TW] OR "low vision"[TW] OR "macular degeneration"[TW] OR "people who are blind"[TW] OR "Person who is blind∗"[TW] OR "seeing eye dog∗ "[TW] OR "sight loss"[TW] OR "Vision impair∗"[TW] OR "vision loss"[TW] OR "visual disorder∗"[TW] OR "Visually impair∗"[TW] OR "auditory processing disorder∗"[TW] OR "cochlea prosth∗"[TW] OR "cognitively challenged"[TW] OR "cognitively defic∗"[TW] OR "cerebral pals∗"	2,286,090
2	Smart assistants	"alexa"[TW] OR "amazon dot"[TW] OR "amazon echo"[TW] OR "apple assistant∗ "[TW] OR "apple home∗"[TW] OR "apple voice"[TW] OR "conversational agent∗ "[TW] OR "conversational assistan∗"[TW] OR "conversational device∗"[TW] OR "conversational interfac∗"[TW] OR "conversational system∗"[TW] OR "conversational technolog∗"[TW] OR "cortana"[TW] OR "dialogue system∗"[TW] OR "digital assistan∗"[TW] OR "google assistant"[TW] OR "google home"[TW] OR "google nest"[TW] OR "homepod"[TW] OR "intelligent dialogue agent∗"[TW] OR "intelligent personal assistan∗"[TW] OR "interactive voice"[TW] OR "microsoft assistant∗"[TW] OR "ok google"[TW] OR "okay google"[TW] OR "siri"[TW] OR "smart assistant∗"[TW] OR "smart home"[TW] OR "smart speaker∗"[TW] OR "virtual assistan∗"[TW] OR "virtual home assistan∗"[TW] OR "virtual personal assistan∗"[TW] OR "voice activated "[TW] OR "voice assistan∗"[TW] OR "voice control∗"[TW] OR "voice enabl∗"[TW] OR "voice initiat∗"[TW] OR "voice interact∗ "[TW] OR "voice operat∗"[TW] OR "voice power∗"[TW] OR "samsung bixby"[TW]	7,214
3	#1 and #2	#1 AND #2	653
4	From 2021/1/1 to 2023/1/1	AND (2021/1/1:2023/1/1[pdat])	159

Table 3: Embase search strategy.

#	Term category	Query	Result
1	Disability related	("assistive techno*":ti,ab,kw OR disab*:ti,ab,kw OR handicap*:ti,ab,kw OR "service animal*":ti,ab,kw OR "service dog*":ti,ab,kw OR "cochlear implant*":ti,ab,kw OR deaf*:ti,ab,kw OR "hard of hearing":ti,ab,kw OR "hearing aid*":ti,ab,kw OR "hearing impair*":ti,ab,kw OR "hearing loss*":ti,ab,kw OR deafblind*:ti,ab,kw OR adhd:ti,ab,kw OR asperger*:ti,ab,kw OR "attention deficit*":ti,ab,kw OR autis*:ti,ab,kw OR "cognitive delay*":ti,ab,kw OR "cognitive impair*":ti,ab,kw OR "cognitively delay*":ti,ab,kw OR "developmental delay*":ti,ab,kw OR "developmental dis*":ti,ab,kw OR "developmentally delay*":ti,ab,kw OR "down syndrome":ti,ab,kw OR "down*s syndrome":ti,ab,kw OR "downs syndrome":ti,ab,kw OR dyslexi*:ti,ab,kw OR "fetal alcohol syndrome*":ti,ab,kw OR "fragile x":ti,ab,kw OR "intellectual impair*":ti,ab,kw OR "intellectually impair*":ti,ab,kw OR "mental impair*":ti,ab,kw OR "mentally impair*":ti,ab,kw OR neurodiv*:ti,ab,kw OR nonverbal*:ti,ab,kw OR "prader willi syndrome*":ti,ab,kw OR "prader-willi syndrome*":ti,ab,kw OR "speech impair*":ti,ab,kw OR "traumatic brain injur*":ti,ab,kw OR achondroplasia:ti,ab,kw OR "amnion band syndrome*":ti,ab,kw OR amput*:ti,ab,kw OR "amyotrophic lateral sclerosis":ti,ab,kw OR cane*:ti,ab,kw OR crutch*:ti,ab,kw OR dwarf*:ti,ab,kw OR dystroph*:ti,ab,kw OR hemipleg*:ti,ab,kw OR "limb difference*":ti,ab,kw OR "limb loss*":ti,ab,kw OR "little people*":ti,ab,kw OR "little person*":ti,ab,kw OR "lou gehrig*":ti,ab,kw OR "manual chair*":ti,ab,kw OR "mobility aid*":ti,ab,kw OR "mobility device*":ti,ab,kw OR "mobility impair*":ti,ab,kw OR "multiple sclerosis":ti,ab,kw OR myelitis:ti,ab,kw OR "osteogenesis imperfecta":ti,ab,kw OR paraly*:ti,ab,kw OR parapleg*:ti,ab,kw OR "physical impair*":ti,ab,kw OR "physically challenged":ti,ab,kw OR "physically impair*":ti,ab,kw OR polio*:ti,ab,kw OR "power chair*":ti,ab,kw OR quadrapleg*:ti,ab,kw OR scooter*:ti,ab,kw OR "spinal cord injur*":ti,ab,kw OR "spinal muscular atroph*":ti,ab,kw OR tetrapleg*:ti,ab,kw OR walker*:ti,ab,kw OR wheelchair*:ti,ab,kw OR stroke*:ti,ab,kw OR "blind people*":ti,ab,kw OR "blind person*":ti,ab,kw OR blindness:ti,ab,kw OR glaucoma:ti,ab,kw OR "guide dog*":ti,ab,kw OR "low vision":ti,ab,kw OR "macular degeneration":ti,ab,kw OR "people who are blind":ti,ab,kw OR "person who is blind*":ti,ab,kw OR "seeing eye dog*":ti,ab,kw OR "sight loss":ti,ab,kw OR "vision impair*":ti,ab,kw OR "vision loss":ti,ab,kw OR "visual disorder*":ti,ab,kw OR "visually impair*":ti,ab,kw OR "auditory processing disorder*":ti,ab,kw OR "cochlea prosth*":ti,ab,kw OR "cognitively challenged":ti,ab,kw OR "cognitively defic*":ti,ab,kw OR "cerebral pals*":ti,ab,kw) OR ("assistive technology":exp OR "disability":exp OR "service animal":exp OR "service dog":exp OR "hearing aid":exp OR "hearing impairment":exp OR "visual disorder":exp OR "attention deficit hyperactivity disorder":exp OR "autism":exp OR "cognitive delay":exp OR "cognitive defect":exp OR "developmental delay":exp OR "mental deficiency":exp OR "language disability":exp OR "intellectual impairment":exp OR "neurodiversity":exp OR "speech disorder":exp OR "brain injury":exp OR "achondroplasia":exp OR "amputation":exp OR "paralysis":exp OR "mobility device":exp OR "dwarfism":exp OR "muscular dystrophy":exp OR "limb loss":exp OR "multiple sclerosis":exp OR "myelitis":exp OR "osteogenesis imperfecta":exp OR "disabled person":exp OR "poliomyelitis":exp OR "spinal cord injury":exp OR "cerebrovascular accident":exp OR "glaucoma":exp OR "macular degeneration":exp)	3,506,070
2	Smart assistants	"alexa":ti,ab,kw OR "amazon dot":ti,ab,kw OR "amazon echo":ti,ab,kw OR "apple assistant*":ti,ab,kw OR "apple home*":ti,ab,kw OR "apple voice":ti,ab,kw OR "conversational agent*":ti,ab,kw OR "conversational assistan*":ti,ab,kw OR "conversational device*":ti,ab,kw OR "conversational interfac*":ti,ab,kw OR "conversational system*":ti,ab,kw OR "conversational technolog*":ti,ab,kw OR "cortana":ti,ab,kw OR "dialogue system*":ti,ab,kw OR "digital assistan*":ti,ab,kw OR "google assistant":ti,ab,kw OR "google home":ti,ab,kw OR "google nest":ti,ab,kw OR "homepod":ti,ab,kw OR "intelligent dialogue agent*":ti,ab,kw OR "intelligent personal assistan*":ti,ab,kw OR "interactive voice":ti,ab,kw OR "microsoft assistant*":ti,ab,kw OR "ok google":ti,ab,kw OR "okay google":ti,ab,kw OR "siri":ti,ab,kw OR "smart assistant*":ti,ab,kw OR "smart home":ti,ab,kw OR "smart speaker*":ti,ab,kw OR "virtual assistan*":ti,ab,kw OR "virtual home assistan*":ti,ab,kw OR "virtual personal assistan*":ti,ab,kw OR "voice activated":ti,ab,kw OR "voice assistan*":ti,ab,kw OR "voice control*":ti,ab,kw OR "voice enabl*":ti,ab,kw OR "voice initiat*":ti,ab,kw OR "voice interact*":ti,ab,kw OR "voice operat*":ti,ab,kw OR "voice power*":ti,ab,kw OR "samsung bixby":ti,ab,kw	9,499
3	#1 and #2	#1 AND #2	1,093
4	From 2021/1/1 to 2023/1/1	AND [2021-2023]/py	236

Table 4: Web of Science search strategy.

#	Term category	Query	Result
1	Disability related	ALL=("assistive techno*" OR disab* OR handicap* OR "service animal*" OR "service dog*" OR "cochlear implant*" OR deaf* OR "hard of hearing" OR "hearing aid*" OR "hearing impair*" OR "hearing loss*" OR deafblind* OR ADHD OR asperger* OR "attention deficit*" OR autis* OR "cognitive delay*" OR "cognitive impair*" OR "cognitively delay*" OR "developmental delay*" OR "developmental dis*" OR "developmentally delay*" OR "down syndrome" OR "down*s syndrome" OR dyslexi* OR "fetal alcohol syndrome*" OR "fragile X" OR "intellectual impair*" OR "intellectually impair*" OR "mental impair*" OR "mentally impair*" OR neurodiv* OR nonverbal* OR "Prader Willi syndrome*" OR "Prader-Willi syndrome*" OR "speech impair*" OR "traumatic brain injur*" OR Achondroplasia OR "amniotic band syndrome*" OR amput* OR "Amyotrophic Lateral Sclerosis" OR cane* OR crutch* OR dwarf* OR dystroph* OR hemipleg* OR "limb difference*" OR "limb loss*" OR "little people*" OR "little person*" OR "Lou Gehrig*" OR "manual chair*" OR "mobility aid*" OR "mobility device*" OR "mobility impair*" OR "multiple sclerosis" OR Myelitis OR "osteogenesis imperfecta" OR paraly* OR parapleg* OR "physical impair*" OR "physically challenged" OR "physically impair*" OR polio* OR "power chair*" OR quadrapleg* OR scooter* OR "Spinal cord injur*" OR "spinal muscular atroph*" OR tetrapleg* OR walker* OR wheelchair* OR stroke* OR "blind people*" OR "blind person*" OR blindness OR glaucoma OR "guide dog*" OR "low vision" OR "macular degeneration" OR "people who are blind" OR "Person who is blind*" OR "seeing eye dog*" OR "sight loss" OR "Vision impair*" OR "vision loss" OR "visual disorder*" OR "Visually impair*" OR "auditory processing disorder*" OR "cochlea prosth*" OR "cognitively challenged" OR "cognitively defic*" OR "cerebral pals*")	2,800,200
2	Smart assistants	ALL=("alexa" OR "amazon dot" OR "amazon echo" OR "apple assistant*" OR "apple home*" OR "apple voice" OR "conversational agent*" OR "conversational assistan*" OR "conversational device*" OR "conversational interfac*" OR "conversational system*" OR "conversational technolog*" OR "cortana" OR "dialogue system*" OR "digital assistan*" OR "google assistant" OR "google home" OR "google nest" OR "homepod" OR "intelligent dialogue agent*" OR "intelligent personal assistan*" OR "interactive voice" OR "microsoft assistant*" OR "ok google" OR "okay google" OR "siri" OR "smart assistant*" OR "smart home" OR "smart speaker*" OR "virtual assistan*" OR "virtual home assistan*" OR "virtual personal assistan*" OR "voice activated "OR "voice assistan*" OR "voice control*" OR "voice enabl*" OR "voice initiat*" OR "voice interact*" OR "voice operat*" OR "voice power*" OR "samsung bixby")	50,450
3	#1 and #2	#1 AND #2 Editions: WOS.SCI,WOS.SSCI,WOS.AHCI,WOS.ISTP,WOS.ISSHP,WOS.BSCI,WOS.BHCI,WOS.ESCI	5,083
4	From 2021/1/1 to 2023/1/1	Editions: WOS.SCI,WOS.SSCI,WOS.AHCI,WOS.ISTP,WOS.ISSHP,WOS.BSCI,WOS.BHCI,WOS.ESCI Timespan: 2021-01-01 to 2023-02-14	883

of articles. The most common gray data-reported barriers were speech interpretation (11.4%), limited functionality (8.9%), lack of voice control in existing devices and apps (4.3%), privacy (3.2%), and assistive features removed (2.8%). The literature identified far more barriers, the most frequent being cognitive load during use (41.7%), speech interpretation (39.6%), lack of nonverbal control (33.3%), cognitive load during setup (25%), privacy (25%), limited functionality (20.8%), and maintenance (20.8%). A full breakdown of barriers by disability type can be seen in Table 9.

3.5. Voice Assistant Brands and Environments in Which They Are Used. Device type and brand utilized were also collected. Amazon, Google, and Apple were the only widespread brands mentioned throughout all posts and articles. Reliability and functionality varied greatly by both post and article, often contradicting one another, so no conclusion can be made in that regard without further investigation. Alexa was the most discussed product spanning 43.1% of gray posts. Google and Siri had similar frequencies at 19.9% and 19.2%, respectively. Most posts did not specify the exact device type (i.e., smartphone and smart speaker) nor what environment it was used in, but of those that did 21.7% mentioned home-specific use, while only 3.9% mentioned community use. Among the literature, Alexa and Google products were equally represented at 41.7%, prototype products were involved in 37.5% of articles, and Apple products were seen in 16.7%. Academic articles reported setting usage more, with 62.5% reporting use in the home, while only 14.6% reported community.

4. Discussion

This rapid review provided a comprehensive overview of the current landscape of voice assistant utilization among the disability community. It also provided a unique opportunity to compare the focus of academic, peer-reviewed literature

Table 5: Infegy search strategy.

#	Term category	Query	Results
1	Disability related	"the disabled" OR "disabled people" OR "disabled person" OR "disabled peoples" OR "disabled persons" OR "disability" OR "disabilities" OR "disabled community" OR "disabled individual" OR "disabled vet*" OR "assistive technologies" OR "assistive technology" OR "assistive tech" OR "handicap" OR "handicaps" OR "handicapped" OR "cochlear implant" OR "cochlear implants" OR ADHD OR "attention deficit*" OR autistic OR autistics OR autism OR "cognitive delay" OR "cognitive delays" OR "cognitive impairment" OR "cognitive impairments" OR "cognitively delayed" OR "developmental delays" OR "developmental delay" OR "developmental disorder" OR "developmental disorders" OR "developmentally delayed" OR "down syndrome" OR "down's syndrome" OR "downs syndrome" OR "learning disability" OR "learning disabilities" OR dyslexics OR dyslexic OR dyslexia OR "intellectual impairments" OR "intellectual impairment" OR "intellectually impaired" OR "mental impairments" OR "mental impairment" OR "mentally impaired" OR neurodivergent OR neurodivergents OR neurodivergence OR neurodiversity OR neurodiverse OR nonverbal OR "speech impaired" OR "speech impairment" OR "speech impairments" OR "traumatic brain" OR amputees OR amputee OR "ALS" OR dwarfism OR dystrophy OR dystrophies OR "limb difference" OR "limb loss" OR "little people" OR "little person" OR "Lou Gehrig" OR "manual chair" OR "manual chairs" OR "mobility aid" OR "mobility aids" OR "mobility device" OR "mobility devices" OR "mobility impairment" OR "mobility impairments" OR "mobility impaired" OR "multiple sclerosis" OR myelitis OR "osteogenesis imperfecta" OR paralysis OR paralyzed OR paraplegic OR paraplegics OR paraplegia OR "physical impaired" OR "physical impairment" OR "physical impairments" OR "physically challenged" OR "physically impaired" OR polio OR "power chair" OR "power chairs" OR quadriplegia OR quadriplegic OR quadriplegics OR "Spinal cord injuries" OR "Spinal cord injury" OR "spinal muscular atrophy" OR tetraplegic OR tetraplegics OR tetraplegia OR wheelchair OR wheelchairs OR stroke OR "blind people" OR "blind person" OR blindness OR "low vision" OR "people who are blind" OR "Person who is blind" OR "sight loss" OR "Vision impaired" OR "Vision impairment" OR "Vision impairments" OR "vision loss" OR "visual disorder" OR "visual disorders" OR "Visually impaired" OR "auditory processing disorder" OR "cognitively challenged" OR "cerebral palsy"	N/A
2	Smart assistants	NEAR/6 ("alexa" OR "amazon dot" OR "amazon echo" OR "apple assistant" OR "apple home" OR "apple voice" OR "cortana" OR "digital assistant" OR "digital assistants" OR "google assistant" OR "google home" OR "google nest" OR "homepod" OR "intelligent personal assistant" OR "intelligent personal assistants" OR "interactive voice" OR "microsoft assistant" OR "ok google" OR "okay google" OR "siri" OR "smart assistant" OR "smart assistants" OR "smart home" OR "smart speaker" OR "smart speakers" OR "virtual assistant" OR "virtual assistants" OR "virtual home assistant" OR "virtual home assistants" OR "virtual personal assistant" OR "virtual personal assistants" OR "voice activated" OR "voice assistant" OR "voice assistants" OR "voice control" OR "voice enabled" OR "voice initiated" OR "voice interactive" OR "voice operated" OR "voice powered")	N/A
3	Misnomer phrases	NOT ("disabled siri" OR "disabled microphone" OR "disabled alexa" OR "disabled google" OR "disable siri" OR "disable microphone" OR "disable alexa" OR "disable google" OR "disable gravity" OR music OR "tone deaf" OR "alexa is deaf" OR "siri is deaf" OR "gift card" OR "giftcard" OR "gift cards" OR "giftcards" OR "giveaway" OR "give away" OR "win" OR "Big Time Rush" OR "siri is dyslexic" OR "alexa is deaf" OR "siri is deaf" OR "kids" OR "children")	N/A
4	Language	English, Spanish	N/A
5	From 2021/1/1 to 2023/1/1	Start Date 2021 January 1st End Date 2023 April 9th	4041

with unfiltered community discussion. Overall, both groups touched on similar usage patterns and pain points that need improvement, but the frequency of topics discussed varied considerably among the subpopulations of the disability community. While the data collected provides a wide breadth of new information, caution must be taken in its interpretation, as the nature of this review does not lend itself to establishing causation or drawing definitive conclusions. Instead, it is meant to allow for broader themes and connections to be found to help guide future research.

4.1. Use of Voice Assistants for Independence. The analysis revealed that the majority of posts and articles focused on tasks that enable independence, such as interface control, reminders, communication, and environmental control. This aligns with the potential benefits of voice assistants for individuals with disabilities, including facilitating access to technology, affecting positively a person's sense of agency, and supporting independent living [6]. Furthermore, the literature also expounded upon the relevance of these devices in facilitating participation tasks, which involve engagement

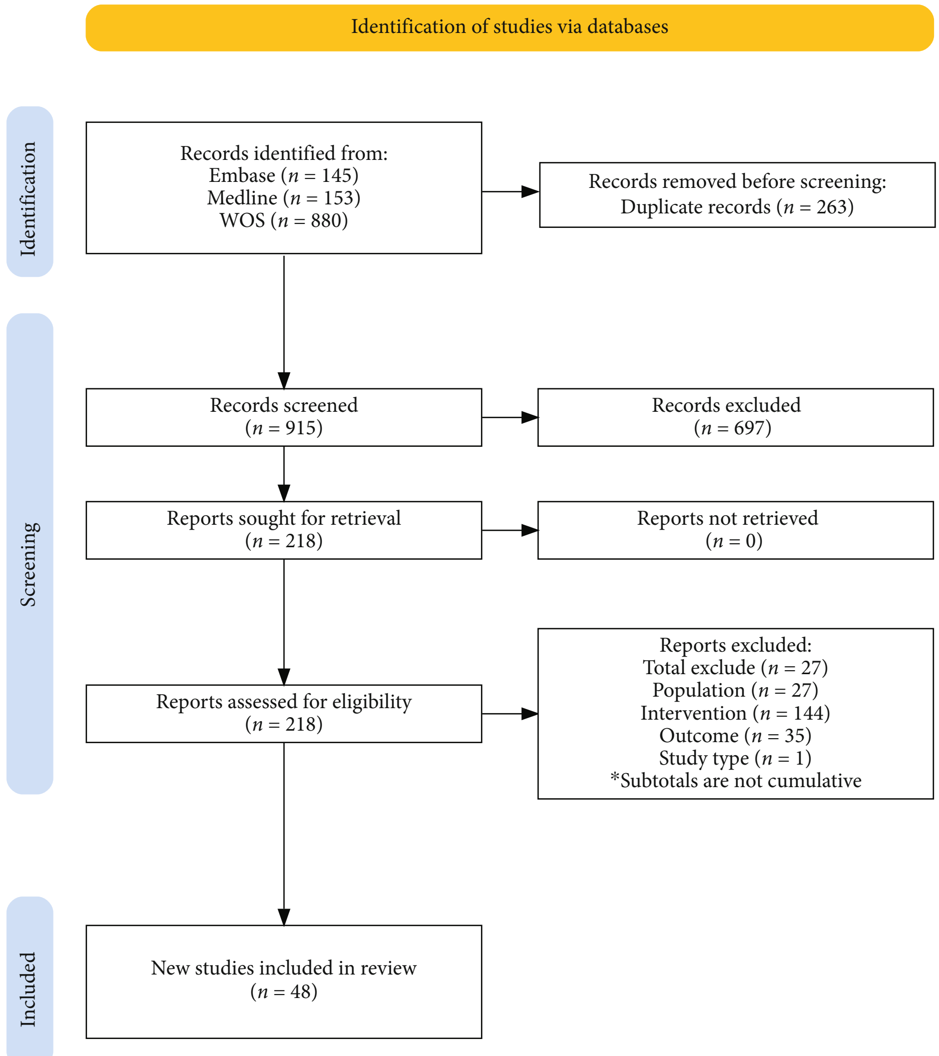

Figure 1: Literature PRISMA flow diagram.

with others, thus underscoring their capacity to augment the overall quality of life for individuals with disabilities.

Voice assistants serve as accessible interfaces that enable individuals with disabilities to interact with various digital devices and services using voice commands, thereby reducing barriers to technology access and enhancing digital inclusion. By providing hands-free control and assistance with daily tasks such as setting reminders, managing schedules, and accessing information, voice assistants empower individuals with disabilities to perform activities independently, fostering a sense of autonomy and self-efficacy [9]. Additionally, voice assistants can assist individuals with disabilities in managing their home environment, controlling smart home devices, and accessing essential services, such as ordering groceries or scheduling transportation, thereby streamlining daily living activities and improving overall quality of life [12]. Finally, these devices facilitate communication and social interaction by enabling individuals with disabilities to make phone calls, send messages, and access social media platforms using voice commands, thereby promoting greater connectivity and community participation [16].

4.2. Where to Use Voice Assistants. Teasing out the setting in which these devices were used proved to be difficult, with many gray and literature-based sources reporting nonspecific environments. Neither the gray reports nor literature articles focused heavily on community use, suggesting a lack of community-based applications being explored in depth. This might be explained by smart speakers being restricted to Wi-Fi-enabled locations but would not explain the lack of information on voice assistant use on smartphones. Similarly, workplace-specific applications of voice assistants were absent from the academic literature. In the media posts, however, there was a small (2.1% of posts), but present interest in potential workplace use, suggesting that research could be expanded to a higher level of instrumental activities of daily living. Most of the posts and articles also focused more on primary devices (speakers and smartphones) rather than secondary applications (such as apps and skills). This could be due to a lack of apps/skills available, the fact that some assistants such as Siri do not have add-on apps, or even that participants may view them collectively and not distinguish a built-in feature from an add-on application.

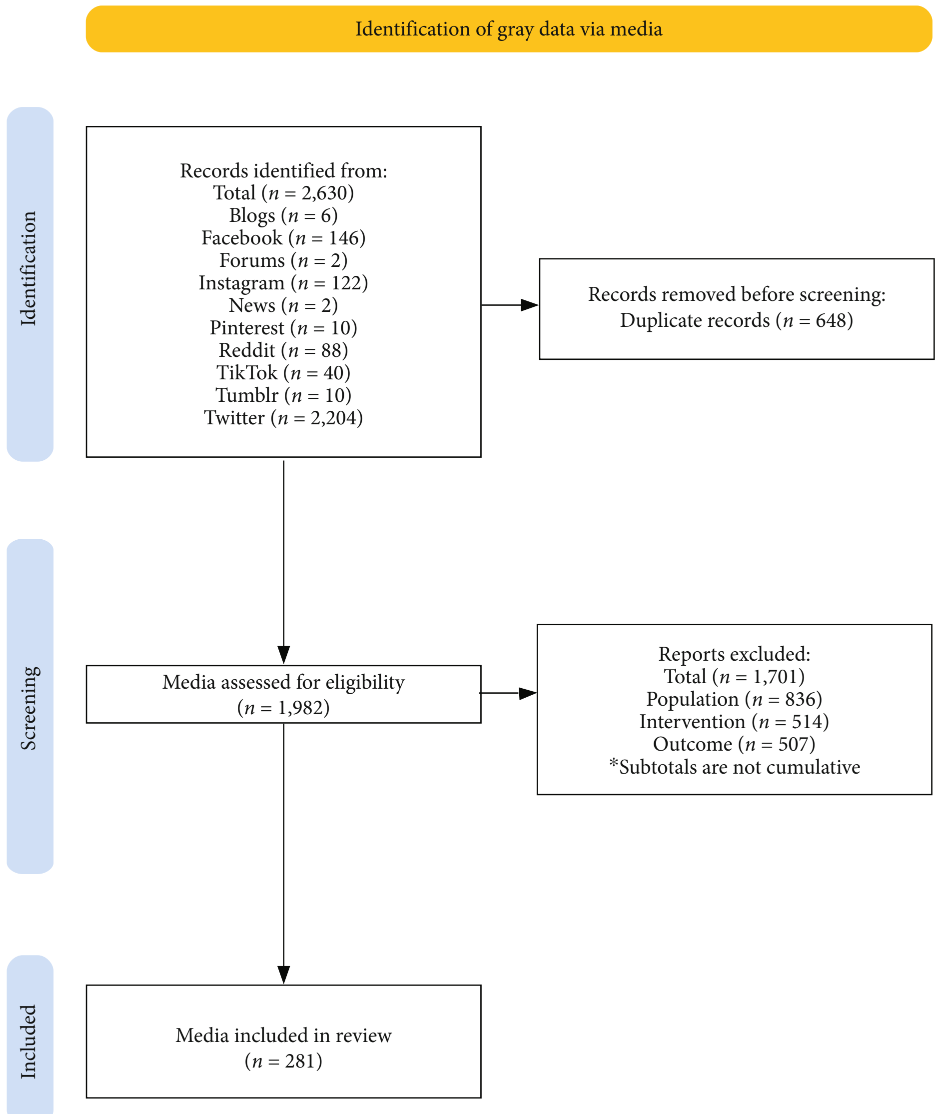

Figure 2: Gray data PRISMA flow diagram.

4.3. Barriers. Despite the promising benefits, the study also shed light on the barriers that may hinder the full utilization of voice assistants among individuals with disabilities. These barriers include limited functionality, data privacy concerns, a lack of training programs, and personal factors such as a limited understanding of the device's capabilities and difficulty remembering commands. Among these challenges, speech interpretation and the removal of assistive features were noteworthy in the data.

4.3.1. Speech Interpretation. The barrier of speech interpretation is most evident in the literature, as it became evident that the deaf and hard of hearing communities indeed have an interest in using smart assistants similar to voice assistants. While all three major voice assistants available (Google Assistant, Siri, and Alexa) have keyboard alternatives to voice, this does not appear to meet the needs of deaf individuals. Many articles noted that a desire for such systems to be able to recognize sign language, or at the very least develop gesture-based interactions exists within the deaf community. This topic was the focus of multiple development-based research articles which all succeeded in creating functional early-stage models. Despite the success of development models, there appears to be little evidence of translation occurring in commercial products to spur any discussion on social media.

This same issue existed within the speech-related category where brain control interfaces (BCI) can be seen being used as a solution for the lack of nonverbal control options across 14.3% of speech-related articles, and 12.3% of all gray data mentioned the barrier of lack of nonverbal control, but discussion on BCI is completely absent on social media. While there has been limited discussion on nonverbal control across media data, efforts have been made to improve commercial devices' speech interpretation for users with speech impairments. Initially, multiple posts advertised and discussed new add-on skills for Alexa devices that improved speech interpretation. Not long after, user reactions flowed

Table 6: Summary of included articles.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Lancioni et al. (2021) [24]	To set up a new technology system (smartphone working in combination with a motion sensor) that supports the performance of people with disabilities in multistep activities	Adults with intellectual disabilities and sensory impairments ($n = 7$)	Amazon/Alexa	(i) Cognitive aid (ii) Instruction	Independence aid	Cognitive load during setup	The new system, with a higher mean percentage of correct responses, has the potential to enhance participants' activity engagement and satisfaction, making it a more effective method for multistep instruction compared to the control system
Driesse et al. (2022) [25]	To explore the experience and response of older adults using voice assistant systems	Older adults with mild cognitive impairment and dementia ($n = 79$)	Amazon/Alexa	(i) Information retrieval (ii) Interface control/device interaction	Independence aid	(i) Cognitive load during setup (ii) Cognitive load during use (iii) Unique and quickly changing user needs	Older adults are enthusiastic about voice assistant use, but uptake declines with cognitive impairment. Cognitively intact individuals show greater potential for effectively utilizing these devices. 85.9% desire to have a voice assistant in their homes in the future
Turrisi et al. (2021) [26]	To create a database of dysarthric speech to train voice assistants on	Adults with dysarthria ($n = 31$) and healthy adults ($n = 24$)	(i) Development/ prototype (ii) Generic/ nonspecific (iii) Microsoft/ Cortana	(i) Communication (ii) Dictation (iii) Interface control/device interaction	Independence aid and participation aid	Speech interpretation	The poor performance of commercial voice assistant systems emphasizes the necessity for dysarthric speech corpora to develop better assistive technologies
Omata et al. (2021) [27]	To explore the features required in spoken dialogue systems used by people with dementia and to present a system to improve their quality of life	Older adults with dementia ($n = 7$) and caregivers ($n = 1$)	Google	(i) Cognitive aid (ii) Scheduling (iii) Information retrieval	Independence aid	(i) Unique and quickly changing (ii) User needs	Positive interaction and personalized adaptation are vital for supporting people with disabilities. A prototype outing assistant with voice and visual interactions, encouraging activities over intervention, demonstrates the significance of dementia-friendly technologies

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Mande et al. (2021) [28]	To explore wake-up interactions for deaf and hard of hearing users for potential personal assistant devices that understand sign language commands	Deaf and hard of hearing adults ($n = 33$)	Amazon/Alexa	Interface control/device interaction	Independence aid	(i) Lack of nonverbal control (ii) Privacy (iii) Sign language	Participants preferred the sign name option for waking up Alexa due to convenience and reliability. Hands-free talk-to-talk techniques were favored for equivalence to voice-based interactions. Privacy and accidental wake-ups with camera-based interactions were concerns
Jaddoh et al. (2023) [29]	To identify studies of automatic speech recognition systems and analyze the interactions between people with dysarthria and those systems/devices	Adults with dysarthria	(i) Amazon/Alexa (ii) Apple/Siri (iii) Google (iv) Microsoft/Cortana	Interface control/device interaction	Independence aid	(i) Response time interval (ii) Speech interpretation	Automatic speech recognition systems struggle with dysarthric speech due to its complexity, limited data, and varied severity. Involving dysarthric users in design and testing is crucial to addressing the challenges faced by voice assistants
Gordon et al. (2022) [30]	To assess the outcomes of the implementation of the codesigned intervention with older people using a technology and coaching package	Older adults ($n = 30$)	(i) Amazon/Alexa (ii) Google	(i) Communication (ii) Environmental controls (iii) Health management (iv) Interface control/device interaction (v) Reminders (vi) Safety	Independence aid and participation aid	(i) Cognitive load during setup (ii) Cognitive load during use (iii) Cost (iv) Internet connection (v) Lack of nonverbal control (vi) Limited functionality	In-home technology coaching empowers older adults with enhanced skills and confidence in using devices, fostering effective integration of assistive technologies through a user-centered approach, resulting in improved well-being, quality of life, and a greater sense of safety and security

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Oliveira et al. (2023) [31]	To explore the habits, preferences, expectations, and experiences of individuals with visual impairments with their daily activities at home and experiences with smart home technologies in a Brazilian context	Adults with visual impairments ($n = 20$)	Generic/nonspecific	(i) Environmental controls (ii) Interface control/device interaction (iii) Media management (iv) Safety	Independence aid	(i) Cost (ii) Limited functionality (iii) Low market availability (iv) Privacy (v) Speech interpretation	Visually impaired individuals seek affordable smart home tech for enhanced independence: identifying lights' status, appliance information, environment details, and comprehensive appliance control. Cost and availability remain barriers
Balasubramanian et al. 2021 [10]	To explore user experiences with a smart speaker to better understand the device's potential for everyday living and potential impact on health and well-being	Adults with diabetes, dementia, Parkinson's disease, asthma, Behçet's disease, Cushing's syndrome, phenylketonuria, liver disorders, low mood, depression, anxiety, dyslexia, cognitive impairment, or severe visual impairment ($n = 44$) and caregivers ($n = 7$)	Amazon/Alexa	(i) Communication (ii) Companionship/connection (iii) Health management (iv) Information retrieval (v) Interface control/device interaction (vi) Learning (vii) Media management (viii) Reminders (ix) Safety (x) Scheduling	Independence aid and participation aid	Speech interpretation	Patients and carers showed optimistic attitudes towards the assistive device, reporting positive impacts on health and well-being
Zubatiy et al. (2021) [32]	To explore how conversational agents empower older adults with mild cognitive impairment and their care partners	Adults with mild cognitive impairment ($n = 10$) and their care partners ($n = 10$)	Google	(i) Communication (ii) Companionship/connection (iii) Environmental controls (iv) Health management (v) Information retrieval (vi) Media management (vii) Reminders (viii) Safety (ix) Scheduling	Independence aid and participation aid	(i) Cognitive load during setup (ii) Cognitive load during use	Conversational agents proved valuable for empowering individuals with mild cognitive impairment and their care partners. Adequate training and support enabled successful integration into daily activities, with benefits reported in information access, media, and caregiving tasks

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Verbaarschot et al. (2021) [33]	To test whether amyotrophic lateral sclerosis patients can control a visual brain-computer interface speller	Adults with amyotrophic lateral sclerosis ($n = 10$) and healthy adults ($n = 20$)	Generic/nonspecific	(i) Communication (ii) Interface control/device interaction	Independence aid and participation aid	Brain control interfaces	The brain-computer interface speller demonstrated superior performance for amyotrophic lateral sclerosis patients and young healthy participants. It allows for potential applications beyond typing, such as controlling smart home devices. Participants generally rated the system positively
Akturk et al. (2021) [34]	To explore the use of the Dexcom G6 Siri feature in blind patients with diabetes on intensive insulin therapy on glycemic control	Blind adults with diabetes ($n = 7$)	Apple/Siri	(i) Health management (ii) Interface control/device interaction	Independence aid	Upkeep and maintenance	Dexcom G6 with Siri improved glycemic control and reduced severe hypoglycemia. Visually impaired patients accessed real-time glucose levels via voice command. Dexcom app on smartphones offered customizable alerts for hypoglycemia/hyperglycemia
Ding et al. (2023) [35]	To explore the current practice of mainstream smart home technology delivery as assistive technology	Providers working with people with disabilities ($n = 15$)	Generic/nonspecific	(i) Communication (ii) Environmental controls (iii) Interface Control/device interaction (iv) Safety	Independence aid and participation aid	(i) Cognitive load during use (ii) Cost (iii) Lack of educated providers (iv) Limited functionality (v) Privacy (vi) Removal of past assistive features (vii) Upkeep and maintenance	Smart home technology benefits people with disabilities but faces challenges in delivery and maintenance as assistive technology

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Arthanat et al. (2022) [36]	To examine the feasibility of commercially available smart home automation technology intervention for individuals with Alzheimer's disease and related dementia with emphasis on their safety and independence and reduction of care burden	Older adults with Alzheimer's disease and related dementia and their caregivers ($n = 5$ dyads)	Amazon/Alexa	(i) Communication (ii) Environmental controls (iii) Health management (iv) Interface control/device interaction (v) Media management (vi) Reminders (vii) Safety (viii) Scheduling	Independence aid and participation aid	(i) Caregiver hesitance (ii) Cognitive load during setup (iii) Compatibility issues (iv) Internet connection (v) Lack of educated providers (vi) Unique and quickly changing user needs (vii) Upkeep and maintenance	Mainstream home automation tech can enhance safety, activity engagement, and caregiver connectivity for those with Alzheimer's disease and related dementia. Addressing concerns and introducing tech early to optimize benefits, supporting aging-in-place with autonomy
Arnold et al. 2022 [16]	To examine the range and extent of personal voice assistants used for older adults living in the community, their technology readiness level, associated outcomes, and the strength of evidence	Older adults	(i) Amazon/Alexa (ii) Apple/Siri (iii) Development/prototype (iv) Google	(i) Cognitive aid (ii) Communication (iii) Companionship/connection (iv) Health management (v) Information retrieval (vi) Interface control/device interaction (vii) Media management (viii) Reminders (ix) Scheduling	Independence aid and participation aid	(i) Cognitive load during use (ii) Privacy (iii) Speech interpretation	Existing studies on older adults' use of personal voice assistants found convenience and usefulness for tasks like reminders and information searching. However, evidence supporting their efficacy remains limited due to the focus on usability rather than completed effectiveness studies
Cave et al. (2021) [37]	To provide an overview of the literature on the use of automatic speech recognition by users with amyotrophic lateral sclerosis	Adults with amyotrophic lateral sclerosis	(i) Amazon/Alexa (ii) Apple/Siri (iii) Google (iv) Microsoft/Cortana (v) Samsung/Bixby	(i) Communication (ii) Environmental controls (iii) Health management (iv) Interface control/device interaction	Independence aid and participation aid	Speech interpretation	Voice recognition accuracy for dysarthric speech is generally lower than for nondysarthric speech
Schlomann et al. 2021 [6]	To synthesize current research in the context of voice assistant for older adults and propose specific research designs to provide better insights into the adoption and use of voice assistants in advanced age	Older adults with intellectual disabilities	Generic/nonspecific	(i) Communication (ii) Companionship/connection (iii) Health management (iv) Information retrieval (v) Interface control/device interaction (vi) Media management (vii) Reminders	Independence aid and participation aid	(i) Cognitive load during setup (ii) Cognitive load during use (iii) Compatibility issues (iv) Privacy	Authors stress voice assistant studies for older adults, noting benefits like social interaction, well-being support, and independence. Concerns include privacy, dependency, and training needs

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Furini et al. (2021) [38]	To investigate whether conversational interfaces might improve the daily experience of students, professors, and various users within a university campus	Blind adults ($n = 4$) and wheelchair user ($n = 1$)	Amazon/Alexa	(i) Information retrieval (ii) Interface control/device interaction (iii) Navigation	Independence aid	Speech interpretation	Volunteers accomplished ≥2/3 tasks and gave positive ratings for the voice app. User comfort varied, and noise affected Alexa's speech recognition
Salai et al. (2021) [39]	To explore the use of a novel voice-based interaction system that supports users with complex needs by introducing a personalized, human voice command between smart home devices and sensors	Adults with dementia, learning disabilities or autism, older and frail people, and social and healthcare organizations ($n = 79$)	(i) Amazon/Alexa (ii) Development/ prototype (iii) Google	(i) Cognitive aid (ii) Environmental controls (iii) Reminders	Independence aid	(i) Cognitive load during use (ii) Lack of nonverbal control (iii) Speech interpretation	The novel solution supports complex needs, enhances independence, reinforces learning of commands, and provides transparent cause-and-effect explanations for home automation events
Shah et al. (2021) [40]	To develop a functioning brain-computer interface prototype that can be integrated into a smart home to support people with limited motor abilities	Adults with motor and speech impairments ($n = 103$)	(i) Amazon/Alexa (ii) Development/ prototype (iii) Google	(i) Communication (ii) Environmental controls (iii) Interface control/device interaction	Independence aid and participation aid	(i) Brain control interfaces (ii) Lack of nonverbal control	The brain-computer interface for smart speakers got 72.82% overall accuracy. This interface empowers people with limited motor abilities to perform tasks independently, enhancing their daily life autonomy
Chen et al. (2022) [41]	To develop a smart human-environment interactive environment using eye tracking for smart control devices for amyotrophic lateral sclerosis patients	Healthy adults ($n = 34$)	Development/ prototype	(i) Communication (ii) Environmental controls (iii) Interface control/device interaction (iv) Safety	Independence aid and participation aid	(i) Lack of nonverbal control (ii) Privacy	The system achieves an average accuracy of 93.2% in different light conditions and demonstrates positive user experiences across education levels and age groups

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Shukla et al. (2021) [42]	To develop a brain-computer interface system for home appliance control	Adults with motor impairments ($n = 9$) and healthy adults ($n = 14$)	Development/prototype	(i) Environmental controls (ii) Interface control/device interaction (iii) Media management	Independence aid	(i) Brain control interfaces (ii) Cognitive load during use (iii) Lack of nonverbal control	The proposed system achieved improved threshold-free classification accuracies of around 92.44% (healthy) and 89.33% (motor impairment), showing cognitive abilities' influence on performance, not disability type
Kurtoglu et al. (2022) [43]	To develop a system that enables trigger sign detection for device activation and sequential recognition of American sign language	Deaf and hard of hearing adults ($n = 19$)	Development/prototype	Interface control/device interaction	Independence aid	Sign language	The trigger sign detection approach achieved a detection rate of 98.9% for American sign language users
Lea et al. (2022) [44]	To develop a system for nonverbal, sound-based interactions that people with a wide range of speech disorders can use to interact with mobile technology	Adults with speech impairments ($n = 28$)	(i) Apple/Siri (ii) Development/prototype	Interface control/device interaction	Independence aid	(i) Lack of nonverbal control (ii) Speech interpretation	The system achieved an 82% success rate in detecting nonverbal sounds for users with disability. It showed promise in enhancing communication for those with speech impairments and providing accessibility for individuals with limited mobility. Positive feedback was received from users in situations where they could not interact with technology otherwise
Ryu et al. (2022) [45]	To improve augmentative and alternative speech recognition performance of smart speakers by developing a text-to-speech production	Augmentative and alternative communication device users	(i) Development/prototype (ii) Google (iii) Samsung/Bixby	Interface control/device interaction	Independence aid	(i) Lack of nonverbal control (ii) Response time interval	Augmentative and alternative interaction symbols and boards, along with optimized text-to-speech production format, improve speech recognition and enable independent device control and Internet interaction

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Velasco-Alvarez et al. (2022) [46, 47]	To control a home automation system through a brain-computer interface that allows the construction of voice commands for people with motor impairments	Healthy adults ($n = 6$)	(i) Development/prototype (ii) Google	(i) Communication (ii) Environmental controls (iii) Information retrieval (iv) Interface control/device interaction (v) Media management (vi) Scheduling	Independence aid and participation aid	(i) Brain control interfaces (ii) Cognitive load during use (iii) Lack of nonverbal control	Brain-computer interface enabled users to access diverse media and environmental controls, along with a texting app. Integrating voice commands with brain-computer interface enhanced device control
Oumard et al. (2022) [48]	To understand whether how and why voice assistants are suitable for blind and visually impaired people and what has to be done for an even better acceptance and benefit	Adults with visual impairments ($n = 146$)	(i) Amazon/Alexa (ii) Apple/Siri (iii) Google	(i) Communication (ii) Dictation (iii) Environmental controls (iv) Information retrieval (v) Interface control/device interaction (vi) Math (vii) Media management (viii) Navigation (ix) Reminders (x) Scheduling	Independence aid and participation aid	(i) Internet connection (ii) Limited functionality (iii) Privacy (iv) Removal of past assistive features (v) Response time interval (vi) Speech interpretation	Voice assistants benefit visually impaired users with tasks like entertainment, Internet access, time, calendars, and notes. They appreciate smart home integration, existing functionalities, and voice commands. Privacy and data security concerns persist, but 86% find the systems helpful, indicating an overall positive outlook with room for improvement
Sciarretta et al. (2021) [1]	To provide an overview of the usability and barriers of smart speakers for people with disabilities	People with disabilities	(i) Amazon/Alexa (ii) Apple/Siri (iii) Generic/nonspecific (iv) Google (v) Microsoft/Cortana (vi) Samsung/Bixby	(i) Cognitive aid (ii) Communication (iii) Dictation (iv) Environmental controls (v) Information retrieval (vi) Interface control/device interaction (vii) Reminders (viii) Scheduling (ix) Spelling	Independence aid and participation aid	(i) Cognitive load during setup (ii) Cognitive load during use (iii) Lack of nonverbal control (iv) Limited functionality (v) Response time interval (vi) Speech interpretation (vii) Unique and quickly changing user needs (viii) Upkeep and maintenance	Voice assistants show promise as inclusive assistive technologies for enhancing quality of life. Acceptance by diverse user groups, nonstigmatizing nature, and accessibility are key strengths. Addressing challenges and adopting an inclusive approach is vital for maximizing their potential in different situations and contexts

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Lewis et al. (2021) [49]	To determine whether Canadians with cognitive disabilities could benefit from voice-activated intelligent personal assistants to access digital services and increase their participation in the digital economy	Adults with cognitive impairments ($n = 24$)	Amazon/Alexa	(i) Environmental controls (ii) Health management (iii) Information retrieval (iv) Instruction (v) Interface control/device interaction (vi) Learning (vii) Math (viii) Media management (ix) Navigation (x) Reminders (xi) Safety (xii) Scheduling	Independence aid	(i) Cognitive load during use (ii) Compatibility issues (iii) Limited functionality (iv) Speech interpretation (v) Response time interval (vi) Unique and quickly changing user needs	Users' opinions on voice assistants were positive, citing increased agency and access to well-being features. Echo Dot proved cost-effective for enhancing the quality of life for vulnerable groups. However, certain complex Alexa Skills, like transportation planning, caused hesitation and confusion due to extensive interactive dialogues
Hugo et al. (2021) [50]	To evaluate the perception of smart home device benefits in 6 different consumer groups, including people with disabilities	Adults with disabilities ($n = 12$)	(i) Amazon/Alexa (ii) Google	(i) Environmental controls (ii) Interface control/device interaction (iii) Safety	Independence aid	(i) Cognitive load during setup (ii) Cost (iii) Lack of skills/apps (iv) Privacy	Persons with disabilities prioritize safety, security, and well-being. Participants did not show a knowledge increase in voice-controlled smart home tech, indicating the need for improved demonstrations. Well-being was their primary benefit, followed by safety and security. Key barriers were cost and consumer privacy concerns

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Uyanik et al. (2022) [51]	To develop a smart home and wheelchair application controlled by a steady-state visual evoked potential-based brain-computer interface system	Healthy adults ($n = 15$)	Development/prototype	(i) Environmental controls (ii) Interface control/device interaction (iii) Navigation	Independence aid	(i) Brain control interfaces (ii) Cost (iii) Lack of nonverbal control	Subjects achieved nearly perfect accuracy in device interaction and wheelchair navigation tasks (>90%). The system controlled a virtual power wheelchair and various household devices with ease. Advantages: low cost, wireless, portable, user-friendly, and high control accuracy without extensive training. Subjects demonstrated increased confidence and competence over time, finding the system easily adaptable and learnable
Corbett et al. (2021) [52]	To investigate the use and usefulness of virtual home assistants among older adults and their support persons	Older adults with chronic health conditions and their caregivers ($n = 10$ dyads)	Amazon/Alexa	(i) Communication (ii) Companionship/connection (iii) Health management (iv) Information retrieval (v) Interface control/device interaction (vi) Media management (vii) Reminders (viii) Safety (ix) Scheduling	Independence aid and participation aid	(i) Cognitive load during setup (ii) Cognitive load during use (iii) Compatibility issues (iv) Lack of educated providers (v) Limited functionality (vi) Unique and quickly changing (vii) User needs (viii) Upkeep and maintenance	Participants found virtual health assistants beneficial for aging in place, but faced challenges in learning and adapting to the technology. They utilized these devices for various activities, valuing features like timers and reminders. These devices were perceived as enhancing security and providing convenience, but more training and periodic assessments were desired to maximize their potential

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Berrett et al. (2022) [53]	To investigate the benefits of personalized augmented assistive technology to support people living with dementia in their daily activities in the home	Older adults with early-to-mild stage dementia ($n = 28$)	(i) Amazon/Alexa (ii) Google	(i) Companionship/ connection (ii) Environmental controls (iii) Health management (iv) Information retrieval (v) Interface control/ device interaction (vi) Media management (vii) Reminders (viii) Scheduling	Independence aid and participation aid	(i) Cognitive load during setup (ii) Cognitive load during use (iii) Privacy (iv) Speech interpretation (v) Unique and quickly changing user needs (vi) Upkeep and maintenance	Participants welcomed the technology, finding it helpful, but it is currently unsuitable for long-term use in dementia. Inclusive development approaches can inform future advancements. Successful deployment at home requires addressing both the person with dementia and their support person's needs
Islam et al. (2022) [54]	To investigate healthcare providers' perspectives on using smart home systems for self-management and care in people with heart failure	Healthcare providers ($n = 9$)	Generic/nonspecific	(i) Communication (ii) Health management (iii) Information retrieval (iv) Reminders (v) Safety	Independence aid and participation aid	(i) Cognitive load during setup (ii) Cognitive load during use (iii) Cost	Participants saw potential in smart home systems for improving self-management of heart failure but had reservations. Benefits included remote monitoring, services, and independent living for patients
Caselgrandi et al. (2021) [55]	To assess patients' satisfaction and engagement in older people with postacute COVID-19 syndrome in the use of a voice assistant	Older adults with postacute COVID-19 syndrome ($n = 50$)	Google	(i) Companionship/ connection (ii) Health management (iii) Information retrieval (iv) Media management	Independence aid and participation aid	N/R	Voice assistant tool rated useful by 96% of participants, showing overall improvement at 6-month follow-up. Empowered participants, enhancing lifestyle, notably in physical activity

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Barbaric et al. (2022) [56]	To evaluate how participants with heart failure interacted with a voice app version of a digital therapeutics	Adults with heart failure ($n = 20$)	Amazon/Alexa	(i) Companionship/connection (ii) Health management (iii) Information retrieval (iv) Media management (v) Reminders	Independence aid and participation aid	(i) Cognitive load during use (ii) Speech interpretation (iii) Upkeep and maintenance	Participants' engagement declined due to app unreliability and adaptation challenges. Older users showed higher engagement, while middle-aged participants found the app more acceptable. Integration into daily routines and convenience for heart failure measurements were observed, but technical limitations and usability issues existed
Kocaballi et al. (2022) [57]	To present the challenges of designing and evaluating conversational agents derived from recent healthcare projects conducted in the last 2 years	Older adults with chronic health conditions	Generic/nonspecific	(i) Health management (ii) Interface control/device interaction	Independence aid	(i) Cognitive load during use (ii) Cost (iii) Internet connection (iv) Privacy (v) Speech interpretation	Common challenges for conversational agents include domain integration, conversational competence, user-system interaction, and evaluation. In healthcare, additional issues arise, like empathy, safety, recruitment of vulnerable populations, and testing in real-world settings
Rohlfing et al. (2021) [58]	To evaluate the ability of common voice recognition systems to transcribe dysphonic voices	Adults with speech impairments ($n = 30$) and healthy adults ($n = 23$)	(i) Amazon/Alexa (ii) Apple/Siri (iii) Google	Interface control/device interaction	Independence aid	Speech interpretation	Voice disorders are linked to lower word recognition. Surprisingly, a faster speech rate improved word recognition. Dysphonia severity consistently affected word recognition, while voice technology accuracy depended on dysphonia perception, not articulation disorders

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Stellin et al. (2022) [59]	To develop a hand gesture dataset to recognize the gestures of sign language and convert it into verbal language	Deaf and hard of hearing adults	Development/ prototype	(i) Dictation (ii) Interface control/device interaction	Independence aid	(i) Lack of nonverbal control (ii) Limited functionality (iii) Sign language	The system achieves 99.13% accuracy in recognizing and translating sign language gestures into speech, promising significant assistance to speech-impaired individuals, enhancing communication, and providing them with a virtual voice
Velasco-Álvarez et al. (2022) [46, 47]	To create a system to facilitate communication between a brain-computer interface and devices in the environment using voice commands	Adults with amyotrophic lateral sclerosis ($n = 3$) and healthy adults ($n = 12$)	(i) Development/ prototype (ii) Google	(i) Communication (ii) Environmental controls (iii) Interface control/device interaction (iv) Media management	Independence aid and participation aid	(i) Brain control interfaces (ii) Cognitive load during use (iii) Compatibility issues (iv) Response time interval	Amyotrophic lateral sclerosis participants found the brain-computer interface system easy to use and rated mental demand and effort between 50 and 60 (out of 100). The system's uniqueness lies in its user-friendliness and customizable menus for controlling devices, making it valuable to the field
Maleki et al. (2021) [60]	To review all the papers on brain-computer interface-based smart home systems published in the last 6 years	Adults with motor and speech impairments	(i) Development/ prototype (ii) Generic/ nonspecific	(i) Communication (ii) Environmental controls (iii) Interface control/device interaction (iv) Media management (v) Navigation	Independence aid and participation aid	(i) Brain control interfaces (ii) Cognitive load during use (iii) Cost (iv) Lack of nonverbal control (v) Limited functionality (vi) Upkeep and maintenance	Promising results in brain-computer interface system accuracy. These systems are practical for interaction with smart home devices but lack user-friendliness. User comfort was identified as a major issue
Akram et al. (2022) [61]	To present a brain-computer interface paradigm for controlling home appliances	Healthy adults ($n = 10$)	Development/ prototype	(i) Communication (ii) Environmental controls (iii) Interface control/device interaction (iv) Media management	Independence aid and participation aid	Brain control interfaces	Satisfactory control of appliances and phone calls. Enhanced freedom, more devices to control, and dialing phone numbers for improved quality of life, especially for individuals with disabilities

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Velasco-Álvarez et al. (2021) [62]	To create a communication bridge between a brain-computer interface speller platform and the messaging services of WhatsApp, Telegram, e-mail, and SMS through the use of a virtual assistant running in a smartphone	Healthy adults ($n = 12$)	Google	(i) Communication (ii) Interface control/device interaction	Independence aid and participation aid	(i) Brain control interfaces (ii) Cognitive load during use (iii) Lack of nonverbal control (iv) Response time interval (v) Upkeep and maintenance	Brain-computer interface-based spelling system showed promising results with healthy subjects, achieving 86.14% accuracy and positive usability feedback. However, for subjects with motor impairment, accuracy is generally lower (67-68%) due to difficulty in gaze control, requiring improvements for real-world implementation
Wang et al. (2021) [63]	To develop a prototype smart home gesture-based control facility that can control various home appliances	Adults with speech impairments	Development/ prototype	(i) Environmental controls (ii) Interface control/device interaction	Independence aid	Lack of nonverbal control	Gesture-based smart home control system enables easy appliance operation with hand movements, aiding people with disabilities, eliminates multiple controllers, integrates well with smart speakers, and promotes user-friendliness
Adams et al. (2021) [64]	To develop an automatic speech recognition model for use between the smart assistant and the user with improved accuracy for atypical speech	Adults with speech impairments	(i) Development/ prototype (ii) Google	Interface control/device interaction	Independence aid	Speech interpretation	Automatic speech recognition models show promise in learning atypical speech patterns, highlighting the significance of accessible technology for those with speech impairments

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Vieira et al. 2022 [14]	To explore how interactions between people with disability and voice assistant technology have an impact on the individual and collective well-being	Adults with visual and motor impairments ($n = 25$) and their family members ($n = 23$)	Google	(i) Environmental controls (ii) Information retrieval (iii) Interface control/device interaction (iv) Media management (v) Reminders (vi) Scheduling	Independence aid	(i) Cognitive load during setup (ii) Cognitive load during use (iii) Internet connection (iv) Limited functionality (v) Privacy (vi) Sign language (vii) Speech interpretation (viii) Upkeep and maintenance	Voice assistant technology enhances independence, daily activities, and reduces disparities for people with disabilities. Challenges include integration with smart home tech, performance improvements, and disability-focused features. Consider socioeconomic barriers for wider access. Positive impact on well-being and quality of life
Glasser et al. (2021) [65]	To examine deaf and hard of hearing users' experience and attitude towards personal assistants, as well as potential interactions with such devices	Deaf and hard of hearing adults ($n = 86$)	Generic/nonspecific	(i) Communication (ii) Environmental controls (iii) Information retrieval (iv) Interface control/device interaction (v) Media management (vi) Notes (vii) Reminders	Independence aid and participation aid	(i) Lack of nonverbal control (ii) Privacy (iii) Sign language (iv) Speech interpretation	Over 60% of participants expressed interest in personal assistant devices that understand sign language and show sign language videos/animations on screen. They preferred text output but were interested in unique applications like receiving alerts about sounds and requesting sign language interpretation
Rajasekhar et al. (2022) [66]	To explore a device that interprets and recognizes American sign language to control smart home components	Adults who use sign language	Development/prototype	(i) Environmental controls (ii) Interface control/device interaction	Independence aid	Sign language	The device is capable of recognizing 4 signs (lights on, play, stop, and idle) with 89.4% accuracy. It can also initiate corresponding actuation commands with the same accuracy level

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Caselgrandi et al. (2021) [55]	To assess patients' satisfaction and engagement in older people with postacute COVID-19 syndrome in the use of a voice assistant	Older adults with postacute COVID-19 syndrome ($n = 50$)	Google	(i) Companionship/connection (ii) Health management (iii) Information retrieval (iv) Media management	Independence aid and participation aid	N/R	Voice assistant tool rated useful by 96% of participants, showing overall improvement at 6-month follow-up. Empowered participants, enhancing lifestyle, notably in physical activity
Barbaric et al. (2022) [56]	To evaluate how participants with heart failure interacted with a voice app version of a digital therapeutics	Adults with heart failure ($n = 20$)	Amazon/Alexa	(i) Companionship/connection (ii) Health management (iii) Information retrieval (iv) Media management (v) Reminders	Independence aid and participation aid	(i) Cognitive load during use (ii) Speech interpretation (iii) Upkeep and maintenance	Participants' engagement declined due to app unreliability and adaptation challenges. Older users showed higher engagement, while middle-aged participants found the app more acceptable. Integration into daily routines and convenience for heart failure measurements were observed, but technical limitations and usability issues existed
Kocaballi et al. (2022) [57]	To present the challenges of designing and evaluating conversational agents derived from recent healthcare projects conducted in the last 2 years	Older adults with chronic health conditions	Generic/nonspecific	(i) Health management (ii) Interface control/device interaction	Independence aid	(i) Cognitive load during use (ii) Cost (iii) Internet connection (iv) Privacy (v) Speech interpretation	Common challenges for conversational agents include domain integration, conversational competence, user-system interaction, and evaluation. In healthcare, additional issues arise, like empathy, safety, recruitment of vulnerable populations, and testing in real-world settings

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Rohlfing et al. (2021) [58]	To evaluate the ability of common voice recognition systems to transcribe dysphonic voices	Adults with speech impairments ($n = 30$) and healthy adults ($n = 23$)	(i) Amazon/Alexa (ii) Apple/Siri (iii) Google	Interface control/device interaction	Independence aid	Speech interpretation	Voice disorders are linked to lower word recognition. Surprisingly, a faster speech rate improved word recognition. Dysphonia severity consistently affected word recognition, while voice technology accuracy depended on dysphonia perception, not articulation disorders
Stellin et al. (2022) [59]	To develop a hand gesture dataset to recognize the gestures of sign language and convert it into verbal language	Deaf and hard of hearing adults	Development/ prototype	(i) Dictation (ii) Interface control/device interaction	Independence aid	(i) Lack of nonverbal control (ii) Limited functionality (iii) Sign language	The system achieves 99.13% accuracy in recognizing and translating sign language gestures into speech, promising significant assistance to speech-impaired individuals, enhancing communication, and providing them with a virtual voice
Velasco-Álvarez et al. (2022a,b) [46, 47]	To create a system to facilitate communication between a brain-computer interface and devices in the environment using voice commands	Adults with amyotrophic lateral sclerosis ($n = 3$) and healthy adults ($n = 12$)	(i) Development/ prototype (ii) Google	(i) Communication (ii) Environmental controls (iii) Interface control/device interaction (iv) Media management	Independence aid and participation aid	(i) Brain control interfaces (ii) Cognitive load during use (iii) Compatibility issues (iv) Response time interval	Amyotrophic lateral sclerosis participants found the brain-computer interface system easy to use and rated mental demand and effort between 50 and 60 (out of 100). The system's uniqueness lies in its user-friendliness and customizable menus for controlling devices, making it valuable to the field

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Maleki et al. (2021) [60]	To review all the papers on brain-computer interface-based smart home systems published in the last 6 years	Adults with motor and speech impairments	(i) Development/prototype (ii) Generic/nonspecific	(i) Communication (ii) Environmental controls (iii) Interface control/device interaction (iv) Media management (v) Navigation	Independence aid and participation aid	(i) Brain control interfaces (ii) Cognitive load during use (iii) Cost (iv) Lack of nonverbal control (v) Limited functionality (vi) Upkeep and maintenance	Promising results in brain-computer interface system accuracy. These systems are practical for interaction with smart home devices but lack user-friendliness. User comfort was identified as a major issue
Akram et al. (2022) [61]	To present a brain-computer interface paradigm for controlling home appliances	Healthy adults ($n = 10$)	Development/prototype	(i) Communication (ii) Environmental controls (iii) Interface control/device interaction (iv) Media management	Independence aid and participation aid	Brain control interfaces	Satisfactory control of appliances and phone calls. Enhanced freedom, more devices to control, and dialing phone numbers for improved quality of life, especially for individuals with disabilities
Velasco-Álvarez et al. (2021) [62]	To create a communication bridge between a brain-computer interface speller platform and the messaging services of WhatsApp, Telegram, e-mail, and SMS through the use of a virtual assistant running in a smartphone	Healthy adults ($n = 12$)	Google	(i) Communication (ii) Interface control/device interaction	Independence aid and participation aid	(i) Brain control interfaces (ii) Cognitive load during use (iii) Lack of nonverbal control (iv) Response time interval (v) Upkeep and maintenance	Brain-computer interface-based spelling system showed promising results with healthy subjects, achieving 86.14% accuracy and positive usability feedback. However, for subjects with motor impairment, accuracy is generally lower (67-68%) due to difficulty in gaze control, requiring improvements for real-world implementation
Wang et al. (2021) [63]	To develop a prototype smart home gesture-based control facility that can control various home appliances	Adults with speech impairments	Development/prototype	(i) Environmental controls (ii) Interface control/device interaction	Independence aid	Lack of nonverbal control	Gesture-based smart home control system enables easy appliance operation with hand movements, aiding people with disabilities, eliminates multiple controllers, integrates well with smart speakers, and promotes user-friendliness

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Adams et al. (2021) [64]	To develop an automatic speech recognition model for use between the smart assistant and the user with improved accuracy for atypical speech	Adults with speech impairments	(i) Development/ prototype (ii) Google	Interface control/device interaction	Independence aid	Speech interpretation	Automatic speech recognition models show promise in learning atypical speech patterns, highlighting the significance of accessible technology for those with speech impairments
Vieira et al. 2022 [14]	To explore how interactions between people with disability and voice assistant technology have an impact on the individual and collective well-being	Adults with visual and motor impairments ($n = 25$) and their family members ($n = 23$)	Google	(i) Environmental controls (ii) Information retrieval (iii) Interface control/device interaction (iv) Media management (v) Reminders (vi) Scheduling	Independence aid	(i) Cognitive load during setup (ii) Cognitive load during use (iii) Internet connection (iv) Limited functionality (v) Privacy (vi) Sign language (vii) Speech interpretation (viii) Upkeep and maintenance	Voice assistant technology enhances independence, daily activities, and reduces disparities for people with disabilities. Challenges include integration with smart home tech, performance improvements, and disability-focused features. Consider socioeconomic barriers for wider access. Positive impact on well-being and quality of life
Glasser et al. (2021) [65]	To examine deaf and hard of hearing users' experience and attitude towards personal assistants, as well as potential interactions with such devices	Deaf and hard of hearing adults ($n = 86$)	Generic/nonspecific	(i) Communication (ii) Environmental controls (iii) Information retrieval (iv) Interface control/device interaction (v) Media management (vi) Notes (vii) Reminders	Independence aid and participation aid	(i) Lack of nonverbal control (ii) Privacy (iii) Sign language (iv) Speech Interpretation	Over 60% of participants expressed interest in personal assistant devices that understand sign language and show sign language videos/ animations on screen. They preferred text output but were interested in unique applications like receiving alerts about sounds and requesting sign language interpretation

Table 6: Continued.

Author (year)	Study aim	Type of study participants	Technology	Tasks	Utilization	Barriers	Findings
Rajasekhar et al. (2022) [66]	To explore a device that interprets and recognizes American sign language to control smart home components	Adults who use sign language	Development/ prototype	(i) Environmental controls (ii) Interface control/device interaction	Independence aid	Sign language	The device is capable of recognizing 4 signs (lights on, play, stop, and idle) with 89.4% accuracy. It can also initiate corresponding actuation commands with the same accuracy level

Table 7: Data extraction categories.

Data extraction category	Gray or peer	Selection options/reporting methods
Study type	Peer-reviewed	(i) Commentary/letter (ii) Development study (iii) Review-scoping (iv) Review-mapping (v) Review-literature/narrative (vi) Review-rapid (vii) Conference paper
Reporter type	Gray	(i) Advocate (ii) Developer/device company (iii) Disabled person (iv) Family/caregiver (v) General public (vi) News (vii) Researcher (viii) Service/medical provider
Disability	Both	(i) General/nonspecific (ii) Hearing (iii) Vision (iv) Chronic health/medical (v) Nonverbal (vi) Speech (vii) Mobility/dexterity (viii) Neurodiverse
Neurodiversity	Both	(i) General/nonspecific (ii) ADHD (iii) Autism (iv) Cognitive impairment (v) Dementia (vi) Dyslexia (vii) General (viii) Intellectual disability (ix) Learning disability (x) Mental health
Focus	Both	(i) Utilize existing devices (ii) Utilize existing add-on devices (iii) Utilize existing skill or app (iv) Develop solutions (v) Identify a barrier
Device brand	Both	(i) Amazon/Alexa (ii) Apple/Siri (iii) Google (iv) Microsoft/Cortana (v) Samsung/Bixby (vi) Generic/unspecified (vii) Development/prototype
Device type	Both	(i) Smart speaker (ii) Smartphone (iii) Smart speaker w/ screen (iv) Smart watch (v) Tablet (vi) Unspecified

Table 7: Continued.

Data extraction category	Gray or peer	Selection options/reporting methods
Setting	Both	(i) Home (ii) Community (iii) Work (iv) Education (v) Nonspecific
Utilization purpose	Both	(i) Independence (ii) Participation
Tasks	Both	(i) Companionship (ii) Communication (iii) Dictation (iv) Environment control (v) Information retrieval (vi) Reading (vii) Media management (viii) Safety (ix) Navigation (x) Health management (xi) Spelling (xii) Math (xiii) Scheduling (xiv) Reminders (xv) Cognitive aid (xvi) Interface control (xvii) Learning
Utilization barriers	Both	(i) Sign language (ii) Speech interpretation (iii) Brain control interfaces (iv) Setup's cognitive load (v) Lack of voice control (vi) Lack of nonverbal control (vii) Limited functionality (viii) Lack of skills/apps (ix) Features removed (x) Privacy
Additional barrier details	Both	Text response
Facilitators	Peer-reviewed	Text response
Intervention details	Peer-reviewed	Text response
Location if available	Both	Text response
Results	Peer-reviewed	Text response
Other findings	Both	Text response
Sample size	Peer-reviewed	Text response
Study aims	Peer-reviewed	Text response
Bibliometric data	Both	Automatically collected

in asking Amazon to integrate these technologies permanently such as this post:

[Specific skill available for download] seems like a great app for people with non-standard speech to control an @amazon [Alexa device]. But the user has to talk to the app, not the device. Why has not Amazon put something like this into Alexa so disabled people can just use their voices like everyone else? (@jennyhunterdc, 2021)

Similarly, multiple posts and duplicate posts from user shares were found advertising Google and Apple's recruitment efforts to improve speech interpretation in this population.

Meet Relate: Google's new beta app that is serving as a voice assistant to people with speech impairments, and helping make tech more inclusive to users with neurological conditions. (@talgroupusa, 2021)

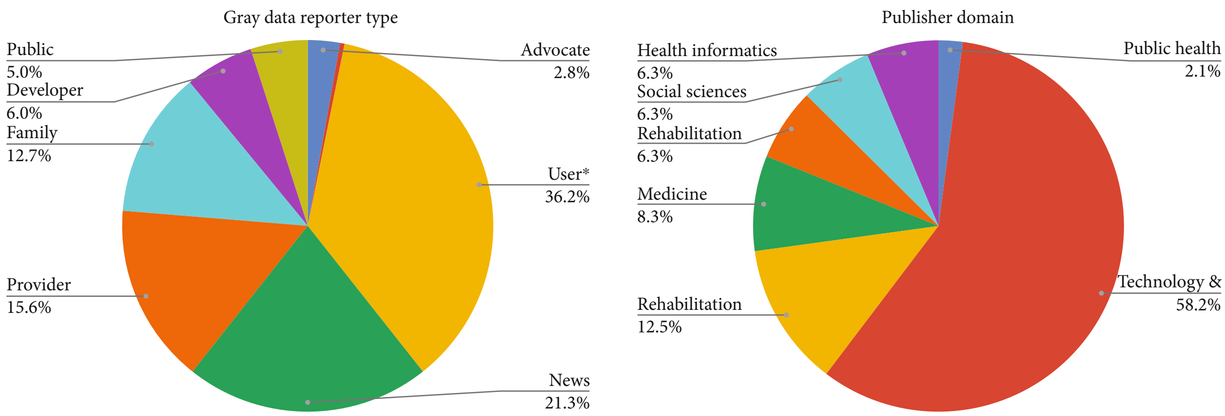

Figure 3: Reporter type and publisher domain. *User refers to users with disabilities.

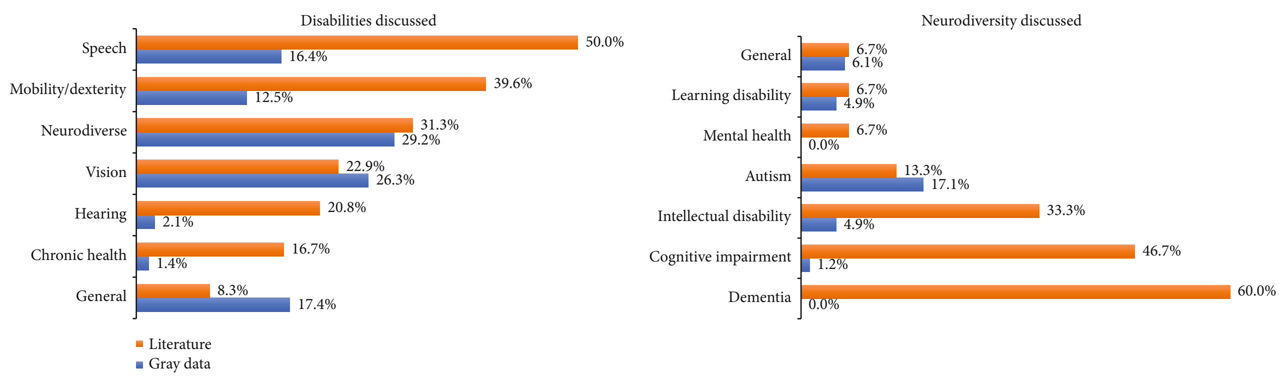

Figure 4: Disabilities and neurodiversity discussed in the literature.

Speech interpretation can be improved by creating more inclusive speech recognition training models and providing software updates to existing devices. Sign language and gesture-based control most likely would require developing new hardware, a much more time, and resource-costly solution, which may explain the slow turnaround based on research-reported user demand.

4.3.2. Assistive Features Removed. While device improvements and innovative ideas were seen across gray data and the literature, degradation of existing devices and services was also unfortunately reported. This usually involved software updates deleting previously included assistive features from devices after a company abandons the support of certain features. The most frequently reported case of this occurred with Apple in 2021 affecting Siri's ability to provide blind users access to voicemails, emails, and phone calls.

Hello. Looking for some help from fellow Redditors. I have a (visually impaired) family member that uses Siri to dictate unread emails throughout the day. After updating to iOS 15, Siri is unable to do this anymore. Prior to iOS 15, saying "Hey Siri, check unread emails" would result in Siri reading the unread emails. I checked the Accessibility settings, but I do not see any possible solutions. Any recommendations? If not, is it possible to downgrade to iOS 14? Thank you. (u/brian_jkwo, 2021)

This exposes a potential risk and trade-off to using mainstream devices as assistive technology as an alternative to dedicated assistive devices, which appears to be becoming a more widespread practice. As stated by the Institute of Medicine Committee on Disability in America [23], companies may lack sufficient motivation to include specific accessibility features in their products unless there is a promising market and significant additional revenues at stake. Even when accessibility features have the potential to increase revenue, they must compete with other product features for limited engineering and marketing resources; therefore, accessibility features might be relegated to a lower priority.

Overall, the barriers identified in this rapid review highlight the importance of adapting voice assistance technology to meet the diverse needs of people with disabilities. For instance, the speech interpretation challenges currently presented by voice assistants can be addressed by developing more inclusive voice recognition training models. Additionally, integrating sign language or gesture-based interactions can improve accessibility for people who are deaf or hard of hearing.

Furthermore, efforts to avoid the removal of assistive features through software updates are crucial to maintaining the functionality of these devices for users with disabilities. However, achieving this level of personalization may require significant resources and investments in research and development. Nonetheless, it is imperative that technology

TABLE 8: Reported tasks by disability.

Task	Task total (%)		General		Neurodiverse		Vision		Hearing		Chronic health		Mobility & dexterity		Speech	
	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray
Cognitive aid	2.4%	1.1%	—	1.2%	5.3%	2.4%	4.5%	2%	8.3%	—	2.2%	—	2.1%	2%	2.3%	—
Communication	10.6%	8.7%	13.3%	7.2%	8.5%	4.8%	9.1%	15.8%	8.3%	—	8.7%	27.3%	16%	12%	13.6%	4%
Companionship	3.8%	2.7%	—	9.6%	5.3%	1.2%	4.5%	—	2.8%	—	10.9%	—	3.2%	2%	1.1%	—
Dictation	1.9%	6.3%	—	4.8%	1.1%	8.4%	3%	3%	5.6%	—	—	18.2%	1.1%	12%	3.4%	2%
Environment control	11.5%	12%	20%	14.5%	9.6%	6%	7.6%	6.9%	11.1%	—	—	9.1%	13.8%	32%	15.9%	12%
Health management	7.2%	1.6%	13.3%	3.6%	8.5%	1.2%	6.1%	3%	2.8%	—	17.4%	9.1%	5.3%	4%	3.4%	—
Information retrieval	8.7%	7.6%	—	10.8%	9.6%	3.6%	10.6%	11.9%	8.3%	—	13%	9.1%	7.4%	8%	4.5%	2%
Instruction	1%	—	—	—	2.1%	—	1.5%	—	2.8%	—	—	—	—	—	1.1%	—
Interface control	19.7%	22.1%	26.7%	14.5%	11.7%	7.2%	15.2%	16.8%	25%	100%	10.9%	—	20.2%	20%	26.1%	74%
Learning	1%	0.3%	—	1.2%	2.1%	—	1.5%	—	—	—	2.2%	—	1.1%	—	2.3%	—
Math	1%	0.5%	—	1.2%	1.1%	1.2%	1.5%	—	—	—	—	—	—	—	1.1%	—
Media management	9.1%	7.4%	—	9.6%	7.4%	8.4%	9.1%	9.9%	5.6%	—	10.9%	9.1%	9.6%	2%	8%	4%
Navigation	2.4%	1.9%	—	1.2%	1.1%	1.2%	3%	3%	—	—	—	—	3.2%	2%	3.4%	2%
Notes	0.5%	—	—	—	—	—	—	—	2.8%	—	—	—	—	—	—	—
Reading	—	8.2%	—	3.6%	—	9.6%	—	20.8%	—	—	—	9.1%	—	4%	—	—
Reminders	7.7%	12.5%	6.7%	8.4%	10.6%	44.6%	9.1%	3%	8.3%	—	10.9%	9.1%	6.4%	—	4.5%	—
Safety	5.3%	0.3%	20%	1.2%	6.4%	—	4.5%	—	—	—	6.5%	—	4.3%	—	3.4%	—
Scheduling	5.8%	2.5%	—	4.8%	8.5%	4.8%	7.6%	2%	5.6%	—	6.5%	—	5.3%	—	4.5%	—
Spelling	0.5%	4.4%	—	2.4%	1.1%	16.9%	1.5%	—	2.8%	—	—	—	1.1%	—	1.1%	—
Total count (n)	208	367	15	83	94	101	66	99	36	4	46	11	94	50	88	50

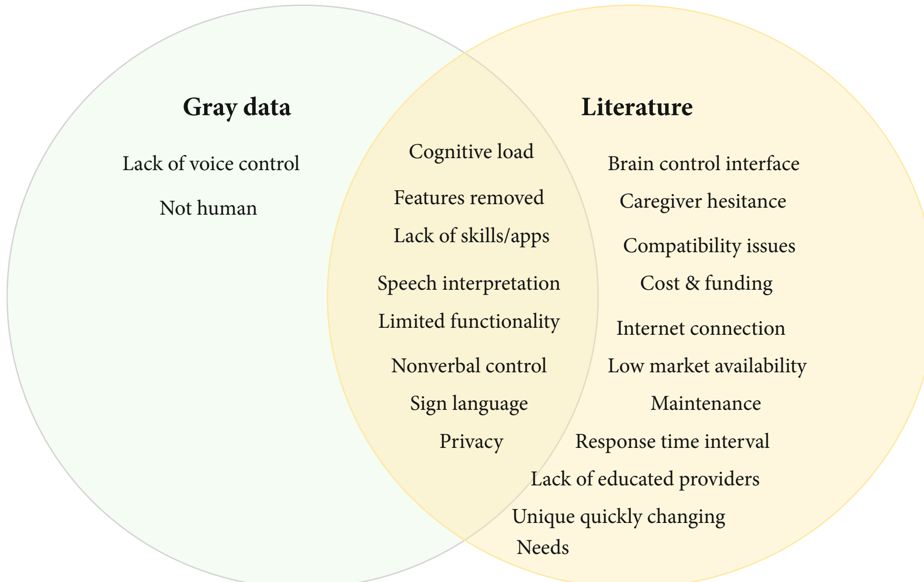

Figure 5: Barriers discussed.

companies prioritize the inclusion of accessibility features to ensure equitable access to voice assistance technology for people with disabilities.

4.4. Alignment between Academic Articles and Gray Data. Alignment between the research and community discussion provided an interesting opportunity to compare if the research lines up with use. Overall, the frequency of tasks discussed between the two groups aligned much more closely than of barriers discussed. This, however, could be due to the limited number of media posts about barriers to use. That said, alignment was not perfect for tasks and was most closely aligned for articles and posts discussing speech-related disabilities. Four out of the top five most discussed tasks matched between the groups. The disability focus with the lowest task alignment was within the neurodiverse community. Initially, it appeared that both the literature and gray data had a similar distribution of neurodiverse-focused articles and posts at 31.3% and 29.2%, respectively.

However, after a closer analysis breaking down neurodiversity by subtype, a nearly inverse relationship between the subtypes discussed emerged, which may be a possible explanation for the misalignment of focuses. Within the literature, the majority of articles (60%) focused on device use among people with dementia, followed by cognitive impairment (46.7%) which greatly overlapped with dementia across articles, and intellectual disability (33.3%).

Conversely, the gray data posts contained no discussion on dementia, and very little on cognitive and intellectual disabilities (1.2 and 4.9%, respectively). This may be due to these groups being less prevalent on social media due to age and access to the Internet, though more information is needed. Individuals with autism were similarly represented in both groups at 17.1% for gray data and 13.3% for literature articles. When looking at the alignment of tasks for individuals with intellectual disabilities, which was discussed in both groups, alignment was 3 out of 5 topics, a much closer result than the original 1 of 5. The two autism groups did not align; however, the literature focused more on autism presenting with intellectual effects, whereas the posts appeared to be more focused on autism without intellectual effects, which could explain this difference in use.

What is overwhelmingly apparent is that the literature greatly lacks any information on how individuals with attention-deficit/hyperactivity disorder (ADHD) utilize voice assistants, despite their presence making up 47.6% of neurodiverse posts. Similarly, dyslexia also appears to be a neglected area of focus covered by only 6.7% of neurodiverse articles compared to 28% of related media posts. While the lack of media posts from individuals with cognitive and intellectual disabilities may be explained by a lack of access to or participation in social media, the reason for the lack of research on ADHD and dyslexia is unclear. More research and attention to these populations are needed to determine how these tools can be utilized to improve independence among individuals with disabilities affecting executive function and learning.

Across both groups, areas such as mental health and learning disabilities lacked much discussion, and while hearing-related articles made up 20.8% of literature articles, very little discussion occurred on social media at only 2.1%. The omission of the term "deaf" in the data search for social media posts might have contributed to the limited representation of relevant publications within this domain.

Overall, though many of the uses for voice assistance technology among the disability community seem to mirror what would be expected among nondisabled individuals, more comparative research would be needed to say definitively. It would appear that the disability community has found a unique way to utilize voice assistants to perform ordinary activities of daily life.

Table 9: Reported barriers by disability.

Barrier	Barrier total (%)		General		Neurodiverse		Vision		Hearing		Chronic health		Mobility & dexterity		Speech	
	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray	Lit	Gray
Features removed	1.3%	8.1%	4.5%	—	1.7%	—	4.4%	25.9%	—	—	—	—	1.4%	5.9%	—	—
Brain control interfaces	5.8%	—	—	—	—	—	—	—	—	—	—	—	13.0%	—	14.3%	—
Caregiver hesitance	0.6%	—	—	—	1.7%	—	—	—	—	—	—	—	—	—	—	—
Setup's cognitive load	7.8%	7.1%	9.1%	—	13.6%	20%	8.9%	7.4%	7.4%	—	8.7%	—	5.8%	11.8%	1.6%	3.8%
Use's cognitive load	13.0%	—	13.6%	—	16.9%	—	11.1%	—	7.4%	—	21.7%	—	15.9%	—	12.7%	—
Compatibility issues	3.2%	—	—	—	5.1%	—	2.2%	—	—	—	4.3%	—	2.9%	—	3.2%	—
Cost	5.2%	—	18.2%	—	3.4%	—	4.4%	—	—	—	8.7%	—	5.8%	—	3.2%	—
Internet connection	3.2%	—	9.1%	—	3.4%	—	4.4%	—	—	—	4.3%	—	2.9%	—	—	—
Educated providers	1.9%	—	4.5%	—	3.4%	—	2.2%	—	—	—	4.3%	—	1.4%	—	—	—
Nonverbal control	10.4%	2.0%	4.5%	—	5.1%	—	2.2%	—	22.2%	33.3%	—	—	13.0%	—	20.6%	3.8%
Lack of skills/apps	0.6%	1.0%	4.5%	—	—	—	—	3.7%	—	—	—	—	—	5.9%	—	—
Lack of voice control	—	12.1%	—	16.7%	—	5.0%	—	22.2%	—	—	—	—	—	11.8%	—	3.8%
Limited functionality	6.5%	25.3%	9.1%	33.3%	6.8%	30.0%	11.1%	33.3%	7.4%	—	4.3%	—	7.2%	29.4%	6.3%	7.7%
Low market availability	0.6%	—	—	—	—	—	2.2%	—	—	—	—	—	—	—	—	—
Not human	—	1.0%	—	—	—	5.0%	—	—	—	—	—	—	—	—	—	—
Privacy	7.8%	9.1%	13.6%	33.3%	6.8%	20.0%	13.3%	—	11.1%	—	8.7%	—	7.2%	5.9%	1.6%	—
Response time interval	4.5%	—	—	—	3.4%	—	4.4%	—	3.7%	—	—	—	4.3%	—	9.5%	—
Sign language	3.9%	2.0%	—	—	1.7%	—	2.2%	3.7%	18.5%	66.7%	—	—	1.4%	—	3.2%	—
Speech interpretation	12.3%	32.3%	4.5%	16.7%	10.2%	20.0%	15.6%	3.7%	14.8%	—	17.4%	—	8.7%	29.4%	15.9%	80.8%
Unique evolving needs	4.5%	—	—	—	10.2%	—	2.2%	—	3.7%	—	4.3%	—	1.4%	—	3.2%	—
Maintenance	6.5%	—	4.5%	—	6.8%	—	8.9%	—	3.7%	—	13.0%	—	7.2%	—	4.8%	—
Total count (*n*)	154	99	22	21	59	20	45	27	27	3	23	—	69	17	63	26

4.5. Use of Voice Assistants in Research. One notable finding is the disparity in the distribution of academic literature across different journals. Surprisingly, only a few articles were published in health and rehabilitation journals, with the majority of cited journals focusing on technology and engineering. Many of the technology and engineering-related articles focused more heavily on problem-solving and innovative approaches to solve existing technology limitations, rather than the current use of these devices. This suggests a need for more research that comes from a rehabilitation perspective to better understand how individuals are actively using these devices.

While no formal quality assessment of the available research was done, the overall type of research (qualitative, quantitative, or mixed methods) along with the publication method (journal vs. conference) was recorded. Of academic articles, 29.8% were strictly qualitative in nature, suggesting a comprehensive exploration of thematic data to capture the nuance and complexity of voice assistant utilization within this population. This is complemented by a sizable amount of quantitative data. Notably, 39.6% of articles were published at only a conference level, many of which have yet to lead to peer-reviewed publications. This, however, could be due to several factors including the focus of this review being recent literature possibly outpacing the publication process.

4.6. Limitations. Limitations of the study include the rapidly evolving nature of voice assistance technology and the dynamic needs of individuals with disabilities, which might have changed since the data collection period. Additionally, the use of gray data from social media may not be fully representative of the entire disability community, as access and usage of such platforms may vary among individuals.

5. Conclusion

This rapid review focused on how people with disabilities are utilizing voice assistance technology for independence, aiming to fill a critical research gap in this rapidly evolving field. The findings provide valuable insights into how disabled people utilize these devices to support their independence and community participation. The results demonstrated that voice assistants have a wide range of potential uses for individuals with disabilities. These devices play a significant role in facilitating independent living by enabling environmental control and reminders, supporting leisure activities through media management and information retrieval, and alleviating social isolation by serving as a means of communication. By providing voice-controlled interfaces and automating various tasks, these devices empower people with disabilities to perform activities independently.

However, the review also identified several barriers that may hinder the full utilization of voice assistants by individuals with disabilities. These include limited functionality, speech interpretation difficulties, lack of nonverbal control, data privacy concerns, cognitive load during setup and use, and removal of assistive features. Some of these barriers, for example, cognitive load and privacy concerns, could be alleviated through provider and user training. Training resources that target common pain points by curating intuitive cognitive load reduction strategies, include tutorials for custom command creation, and provide straightforward routine maintenance guides for targeted audiences (users vs. caregiver vs. provider) could lead to more successful implementation and fewer instances of abandonment.

Moreover, the research highlighted some disparities between the focus of academic literature and community discussions. While both sources mentioned similar usage patterns and benefits of voice assistants, there were differences in the emphasis on specific disability subtypes. Notably, there was a lack of research on how individuals with ADHD and dyslexia utilize these devices, despite being highly discussed topics within the community.

In conclusion, voice assistants have the potential to be powerful tools for enhancing the lives of individuals with disabilities and enabling independence. However, more research and innovation are necessary to fully harness their benefits and overcome the barriers that may limit their use, especially for community engagement. By adopting an inclusive approach and actively involving individuals with disabilities in the development and design process, we can ensure that these technologies truly serve and empower the disability community.

Data Availability

The data that support the findings of this study are available from the corresponding author, MG, upon reasonable request.

Conflicts of Interest

The authors have no conflicts of interest to declare.

Acknowledgments

This work was supported by the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) (HHS-2021-ACL-NIDILRR-REGE-0029).

References

[1] E. Sciarretta and L. Alimenti, "Smart speakers for inclusion: how can intelligent virtual assistants really assist everybody?," in *Human-Computer Interaction. theory, Methods and Tools: Thematic Area, HCI 2021, Held as Part of the 23rd HCI International Conference, HCII 2021, Virtual Event, July 24–29, 2021, Proceedings, Part I*, vol. 12762, Springer International Publishing, 2021.

[2] M. B. Hoy, "Alexa, Siri, Cortana, and more: an introduction to voice assistants," *Medical Reference Services Quarterly*, vol. 37, no. 1, pp. 81–88, 2018.

[3] G. Terzopoulos and M. Satratzemi, "Voice assistants and smart speakers in everyday life and in education," *Informatics in Education*, vol. 19, no. 3, pp. 473–490, 2020.

[4] Y. Mohammad, "10+ voice assistant statistics: the key data and numbers," 2023, Online Dasher. https://www.onlinedasher.com/voice-assistant-statistics/#:~:text=46.9%25%20of%

20US%20adults%20used,to%20157.1%20million%20in%202026.

[5] F. Masina, V. Orso, P. Pluchino et al., “Investigating the accessibility of voice assistants with impaired users: mixed methods study,” *Journal of Medical Internet Research*, vol. 22, no. 9, article e18431, 2020.

[6] A. Schlomann, H.-W. Wahl, P. Zentel et al., “Potential and pitfalls of digital voice assistants in older adults with and without intellectual disabilities: relevance of participatory design elements and ecologically valid field studies,” *Frontiers in Psychology*, vol. 12, article 684012, 2021.

[7] G. E. Lancioni, N. N. Singh, M. F. O’Reilly et al., “People with intellectual and visual disabilities access basic leisure and communication using a smartphone’s Google Assistant and voice recording devices,” *Disability and Rehabilitation. Assistive Technology*, vol. 17, no. 8, pp. 957–964, 2020.

[8] K. J. Edwards, R. B. Jones, D. Shenton et al., “The use of smart speakers in care home residents: implementation study,” *Journal of Medical Internet Research*, vol. 23, no. 12, article e26767, 2021.

[9] E. Smith, P. Sumner, C. Hedge, and G. Powell, “Smart-speaker technology and intellectual disabilities: Agency and well-being,” *Disability and Rehabilitation: Assistive Technology*, vol. 18, no. 4, pp. 432–442, 2020.

[10] G. V. Balasubramanian, P. Beaney, and R. Chambers, “Digital personal assistants are smart ways for assistive technology to aid the health and well-being of patients and carers,” *BMC Geriatrics*, vol. 21, no. 1, p. 643, 2021.

[11] C. Bérubé, T. Schachner, R. Keller et al., “Voice-based conversational agents for the prevention and management of chronic and mental health conditions: systematic literature review,” *Journal of Medical Internet Research*, vol. 23, no. 3, article e25933, 2021.

[12] T. Wallace and J. Morris, “Identifying barriers to usability: smart speaker testing by military veterans with mild brain injury and PTSD,” in *Breaking Down Barriers*, pp. 113–122, Springer international publishing, 2018.

[13] A. Pradhan, K. Mehta, and L. Findlater, ““Accessibility came by accident”: use of voice-controlled intelligent personal assistants by people with disabilities,” in *CHI '18: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pp. 1–13, Montreal, QC, Canada, 2018.

[14] A. D. Vieira, H. Leite, and A. V. L. Volochtchuk, “The impact of voice assistant home devices on people with disabilities: a longitudinal study,” *Technological Forecasting and Social Change*, vol. 184, article 121961, 2022.

[15] R. Jamwal, H. K. Jarman, E. Roseingrave, J. Douglas, and D. Winkler, “Smart home and communication technology for people with disability: a scoping review,” *Assistive Technology*, vol. 17, no. 6, pp. 624–644, 2022.

[16] A. Arnold, S. Kolody, A. Comeau, and A. Miguel Cruz, “What does the literature say about the use of personal voice assistants in older adults? A scoping review,” *Disability and Rehabilitation: Assistive Technology*, vol. 19, no. 1, pp. 100–111, 2022.

[17] R. Tavares, H. Sousa, and J. Ribeiro, “O uso de smart speakers na incapacidade: uma scoping review,” *New Trends in Qualitative Research*, vol. 8, pp. 392–403, 2021.

[18] P. Darda, V. Nerlekar, U. Bairagi, M. Pendse, and M. Sharma, “Usage of voice assistant in time of COVID 19 as a touchless Interface,” *Academy of Strategic Management Journal*, vol. 20, no. 6S, pp. 1–13, 2021.

[19] P. Moons, E. Goossens, and D. R. Thompson, “Rapid reviews: the pros and cons of an accelerated review process,” *European Journal of Cardiovascular Nursing*, vol. 20, no. 5, pp. 515–519, 2021.

[20] S. Walia, “COVID-19 accelerates the paradigm shift from touch to talk,” 2020, https://rain.agency/raindrops/covid-19-accelerates-paradigm-shift-touch-talk.

[21] A. Booth, A. Sutton, and D. Papaioannou, *Systematic approaches to a successful literature review*, SAGE Publications, 2016.

[22] M. J. Page, J. E. McKenzie, P. M. Bossuyt et al., “statement: an updated guideline for reporting systematic reviews,” *BMJ*, vol. 2021, no. 372, 2020.

[23] Institute of Medicine (US) Committee on Disability in America, “Assistive and mainstream technologies for people with disabilities,” in *The Future of Disability in America*, M. J. Field and A. M. Jette, Eds., National Academies Press, Washington (DC), 2007, https://www.ncbi.nlm.nih.gov/books/NBK11418/.

[24] G. E. Lancioni, M. F. O’Reilly, J. Sigafoos et al., “Tying the Delivery of Activity Step Instructions to Step Performance: Evaluating a Basic Technology System with People with Special Needs,” *Advances in Neurodevelopmental Disorders*, vol. 5, pp. 488–497, 2021.

[25] T. M. Driesse, X. Liang, R. Roth, and J. A. Batsis, “Older Adults' Experience and Response to Voice Assistant Systems [Poster abstract],” in *AGS 2022 Annual Meeting*, Orlando, FL, United States, 2022.

[26] R. Turrisi, A. Braccia, M. Emanuele et al., “EasyCall Corpus: A Dysarthric Speech Dataset,” in *Proceedings of Interspeech 2021*, pp. 41–45, ISCA, 2021.

[27] A. Omata, S. Ishikawa, M. Kobayashi, and S. Kiriyama, “Collaborative Development of Outing Assistants for People with Dementia: A Case Study on a Co-design Approach,” in *Asian CHI Symposium 2021*, pp. 21–24, Yokohama, Japon, 2021.

[28] V. Mande, A. Glasser, B. Dingman, and M. Huenerfauth, “Deaf Users’ Preferences Among Wake-Up Approaches during Sign-Language Interaction with Personal Assistant Devices,” in *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, pp. 1–6, Yokohama, Japon, 2021.

[29] A. Jaddoh, F. Loizides, and O. Rana, “Interaction between people with dysarthria and speech recognition systems: A review,” *Assistive Technology*, vol. 35, no. 4, pp. 330–338, 2023.

[30] S. Gordon, F. Telford-Sharp, W. Crowe, and S. Champion, “Effectiveness of a co-designed technology package on perceptions of safety in community-dwelling older adults,” *Australasian Journal on Ageing*, vol. 41, no. 3, pp. e257–e265, 2022.

[31] O. OliveiraDe, M. Carvalho Gonçalves, R. W. de Bettio, and A. Pimenta Freire, “A qualitative study on the needs of visually impaired users in Brazil for smart home interactive technologies,” *Behaviour & Information Technology*, vol. 42, no. 10, pp. 1496–1524, 2023.

[32] T. Zubatiy, K. L. Vickers, N. Mathur, and E. D. Mynatt, “Empowering Dyads of Older Adults With Mild Cognitive Impairment And Their Care Partners Using Conversational Agents,” in *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pp. 1–15, Yokohama, Japon, 2021.

[33] C. Verbaarschot, D. Tump, A. Lutu et al., “A visual brain-computer interface as communication aid for patients with amyotrophic lateral sclerosis,” *Clinical Neurophysiology:*

Official Journal of the International Federation of Clinical Neurophysiology, vol. 132, no. 10, pp. 2404–2415, 2021.

[34] H. K. Akturk, J. K. Snell-Bergeon, and V. N. Shah, "Continuous Glucose Monitor with Siri Integration Improves Glycemic Control in Legally Blind Patients with Diabetes," *Diabetes Technology & Therapeutics*, vol. 23, no. 1, pp. 81–83, 2021.

[35] D. Ding, L. Morris, K. Messina, and A. Fairman, "Providing mainstream smart home technology as assistive technology for persons with disabilities: A qualitative study with professionals," *Disability and Rehabilitation. Assistive Technology*, vol. 18, no. 7, pp. 1192–1199, 2023.

[36] S. Arthanat, J. Wilcox, and D. LaRoche, "Smart home automation technology to support caring of individuals with Alzheimer's disease and related dementia: An early intervention framework," in *Disability and rehabilitation: assistive technology*, pp. 1–11, Taylor & Francis, 2022.

[37] R. Cave and S. Bloch, "The use of speech recognition technology by people living with amyotrophic lateral sclerosis: A scoping review," *Disability and Rehabilitation. Assistive Technology*, vol. 18, no. 7, pp. 1043–1055, 2023.

[38] M. Furini, S. Mirri, M. Montangero, M. Pecorelli, and C. Prandi, "On using Conversational Interfaces to Improve the Accessibility of a University Campus," in *2021 IEEE 18th Annual Consumer Communications & Networking Conference (CCNC)*, Las Vegas, NV, USA, 2021.

[39] A.-M. Salai, G. Cook, and L. E. Holmquist, "IntraVox: A Personalized Human Voice to Support Users with Complex Needs in Smart Homes," in *Human-Computer Interaction – INTERACT 2021*, C. Ardito, R. Lanzilotti, A. Malizia, H. Petrie, A. Piccinno, G. Desolda, and K. Inkpen, Eds., vol. 12932, pp. 223–244, Springer International Publishing, 2021.

[40] S. J. Shah, A. A. Albishri, and Y. Lee, "Deep Learning Framework For Internet Of Things For People With Disabilities," in *2021 IEEE International Conference on Big Data (Big Data)*, pp. 3609–3614, Orlando, FL, USA, 2021.

[41] X. Chen, Z. Fu, Z. Song et al., "An IoT and Wearables-Based Smart Home for ALS Patients," *IEEE Internet of Things Journal*, vol. 9, no. 21, pp. 20945–20956, 2022.

[42] P. K. Shukla, R. K. Chaurasiya, S. Verma, and G. R. Sinha, "A Thresholding-Free State Detection Approach for Home Appliance Control Using P300-Based BCI," *IEEE Sensors Journal*, vol. 21, no. 15, pp. 16927–16936, 2021.

[43] E. Kurtoglu, A. C. Gurbuz, E. A. Malaia, D. Griffin, C. Crawford, and S. Z. Gurbuz, "ASL Trigger Recognition in Mixed Activity/Signing Sequences for RF Sensor-Based User Interfaces," *IEEE Transactions on Human-Machine Systems*, vol. 52, no. 4, pp. 699–712, 2022.

[44] C. Lea, Z. Huang, D. Jain et al., "Nonverbal Sound Detection for Disordered Speech," in *ICASSP 2022 - 2022 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, pp. 7397–7401, Singapore, 2022.

[45] S. H. Ryu, K. H. Hong, S. Chae, and S. J. Yeon, "Augmentative and Alternative Interaction Service with AI Speakers to Access Home IoT Devices and Internet Services for People with Multiple Disabilities," in *Computers Helping People with Special Needs. ICCHP-AAATE 2022*, K. Miesenberger, G. Kouroupetroglou, K. Mavrou, R. Manduchi, M. Covarrubias Rodriguez, and P. Penáz, Eds., vol. 13341 of Lecture Notes in Computer Science, Springer, Cham, 2022.

[46] F. Velasco-Álvarez, Á. Fernández-Rodríguez, and R. Ron-Angevin, "Home Automation System Controlled Through Brain Activity," in *Computers Helping People with Special Needs. ICCHP-AAATE 2022*, K. Miesenberger, G. Kouroupetroglou, K. Mavrou, R. Manduchi, M. Covarrubias Rodriguez, and P. Penáz, Eds., vol. 13342 of Lecture Notes in Computer Science, Springer, Cham, 2022.

[47] F. Velasco-Álvarez, Á. Fernández-Rodríguez, and R. Ron-Angevin, "Brain-computer interface (BCI)-generated speech to control domotic devices," *Neurocomputing*, vol. 509, pp. 121–136, 2022.

[48] C. Oumard, J. Kreimeier, and T. Götzelmann, "Pardon? An Overview of the Current State and Requirements of Voice User Interfaces for Blind and Visually Impaired Users," in *Computers Helping People with Special Needs. ICCHP-AAATE 2022*, K. Miesenberger, G. Kouroupetroglou, K. Mavrou, R. Manduchi, M. Covarrubias Rodriguez, and P. Penáz, Eds., vol. 13341 of Lecture Notes in Computer Science, Springer, Cham, 2022.

[49] L. Lewis and A. Vellino, "Helping Persons with Cognitive Disabilities using Voice-Activated Personal Assistants," in *2021 8th International Conference on ICT & Accessibility (ICTA)*, Tunis, Tunisia, 2021.

[50] N. Hugo, T. Israr, W. Boonsuk, Y. Ben Miloud, J. Cloward, and P. P. Liu, "Usability Study of Voice-Activated Smart Home Technology," in *Cross Reality and Data Science in Engineering. REV 2020. Advances in Intelligent Systems and Computing*, M. Auer and D. May, Eds., vol. 1231, Springer, Cham, 2021.

[51] C. Uyanik, M. Khan, R. Das, J. Hansen, and S. Puthusserypady, "Brainy Home: A Virtual Smart Home and Wheelchair Control Application Powered by Brain Computer Interface," in *In Proceedings of the 15th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2022) - BIODEVICES*, pp. 134–141, SciTePress, 2022.

[52] C. Corbett, E. Combs, P. Wright et al., "Virtual Home Assistant Use and Perceptions of Usefulness by Older Adults and Support Person Dyads," *International Journal of Environmental Research and Public Health*, vol. 18, no. 3, 2021.

[53] J. Berrett, A. de Kruiff, S. Pedell, and A. Reilly, "Augmented assistive technology: The importance of tailoring technology solutions for people living with dementia at home," *International Journal of Human-Computer Studies*, vol. 165, article 102852, 2022.

[54] S. M. S. Islam, A. Halooq, J. Dening et al., "Healthcare providers' perspectives on using smart home systems to improve self-management and care in people with heart failure: A qualitative study," *International Journal of Medical Informatics*, vol. 167, article 104837, 2022.

[55] A. Caselgrandi, J. Milic, F. Motta et al., "Voice assistance to develop a participatory research and action to improve health trajectories of people with PACS," *Antiviral Therapy*, vol. 26, 1-supplement, pp. 13-14, 2021.

[56] A. Barbaric, C. Munteanu, H. Ross, and J. A. Cafazzo, "A Voice App Desig for Heart Failure Self-management: Proof-of-Concept Implementation Study," *JMIR Formative Research*, vol. 6, no. 12, article e40021, 2022.

[57] A. B. Kocaballi, E. Sezgin, L. Clark et al., "Design and Evaluation Challenges of Conversational Agents in Health Care and Well-being: Selective Review Study," *Journal of Medical Internet Research*, vol. 24, no. 11, article e38525, 2022.

[58] M. L. Rohlfing, D. P. Buckley, J. Piraquive, C. E. Stepp, and L. F. Tracy, "Hey Siri: How Effective are Common Voice Recognition Systems at Recognizing Dysphonic Voices?," *The Laryngoscope*, vol. 131, no. 7, pp. 1599–1607, 2021.

[59] R. Stellin, P. Rukmani, L. J. Anbarasi, and S. Narayanan, "HandGCNN model for gesture recognition based voice assistance," *Multimedia Tools and Applications*, vol. 81, no. 29, pp. 42353–42369, 2022.

[60] M. Maleki, N. Manshouri, and T. Kayikcioglu, "Brain-computer Interface Systems for Smart Homes—A Review Study," *Recent Advances in Electrical & Electronic Engineering*, vol. 14, no. 2, pp. 144–155, 2021.

[61] F. Akram, A. Alwakeel, M. Alwakeel, M. Hijji, and U. Masud, "A Symbols Based BCI Paradigm for Intelligent Home Control Using P300 Event-Related Potentials," *Sensors*, vol. 22, no. 24, 2022.

[62] F. Velasco-Álvarez, Á. Fernández-Rodríguez, F.-J. Vizcaíno-Martín, A. Díaz-Estrella, and R. Ron-Angevin, "Brain–Computer Interface (BCI) Control of a Virtual Assistant in a Smartphone to Manage Messaging Applications," *Sensors*, vol. 21, no. 11, 2021.

[63] R.-J. Wang, S.-C. Lai, J.-Y. Jhuang, M.-C. Ho, and Y.-C. Shiau, "Development of Smart Home Gesture-based Control System," *Sensors and Materials*, vol. 33, no. 10, p. 3459, 2021.

[64] D. W. Adams and C. Merkel, "Expanding smart assistant accessibility through dysarthria speech-trained transformer networks," *Applications of Machine Learning*, vol. 11843, pp. 156–165, 2021.

[65] A. Glasser, V. Mande, and M. Huenerfauth, "Understanding deaf and hard-of-hearing users' interest in sign-language interaction with personal-assistant devices," in *Proceedings of the 18th International Web for All Conference*, New York, 2021.

[66] N. Rajasekhar and S. Panday, "SiBo-The Sign Bot, Connected World for Disabled," in *2022 IEEE Women in Technology Conference (WINTECHCON)*, Bangalore, India, 2022.