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SYSTEMATIC REVIEW

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# Barriers and facilitators to participation in electronic health interventions in older adults with cognitive impairment: an umbrella review

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## Abstract

**Background** Research increasingly supports the role of electronic health technology in improving cognitive function. However, individuals with mild cognitive impairment or dementia often show low compliance with electronic health technology. To understand the barriers and facilitators for this group, this study was conducted.

**Methods** This study used the Joanna Briggs Institute (JBI) umbrella review method, searching relevant English articles in PubMed, Embase, Cochrane, Scopus, MEDLINE, Web of Science, and CINAHL from inception to May 2023. Two researchers independently selected articles based on predefined criteria, assessed study quality using Meta-QAT and A Measurement Tool to Assess Systematic Reviews (AMSTAR), and determined confidence in the evidence using GRADE-CERQual. The Unified Theory of Acceptance and Use of Technology (UTAUT) model was employed to analyze factors related to electronic health technology, and Behavior Change Techniques (BCTs) were used to develop implementation strategies.

**Results** This study included 21 reviews, covering 535 primary studies, identifying 13 factors. The three most impactful factors on engagement were Perceived Behavioral Control, Relative Advantage, and Social Factors. Six implementation strategies were formulated based on BCT: enhancing targeted approaches, adapting to existing contexts, involving care organizations, accommodating family involvement, accessing virtual community resources, and recognizing patient variability.

**Conclusions** This umbrella review underscores the need for a multi-level stakeholder approach and a holistic perspective in developing targeted implementation strategies. Using the UTAUT framework, key influential factors have been identified, offering valuable insights for future interventions and enhancing participation in electronic health interventions.

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**Registration** This study was registered with the PROSPERO (CRD42023429410).
**Keywords** Barriers, Facilitators, Electronic health, Mild cognitive impairment, Dementia, Umbrella review

## Introduction

The world population is transitioning to an aging society and statistics indicate that 5–8% of older adults are living with dementia [1]. Alzheimer's disease (AD) is a commonly encountered degenerative disorder of the central nervous system and the most prevalent form of dementia, accounting for 60–80% of all cases [2]. Mild cognitive impairment serves as a precursor stage of Alzheimer's disease, where individuals exhibit only mild memory decline or mild impairment of other cognitive domains while maintaining basic daily life functioning [3]. Due to the covert nature of mild cognitive impairment onset, approximately 15% of people with mild cognitive impairment progress to dementia within two years, with a significant portion of this population remaining undiagnosed and uninvolved in any preventive interventions [4]. The overall socioeconomic costs of Alzheimer's disease are projected to reach $507.5 billion by 2030 and $1.89 trillion by 2050 [5]. Dementia not only incurs substantial economic burdens but also increases caregiver strain, with 54% of informal caregivers reporting frequent or constant stress or anxiety, while only 8% reported no stress [6]. Dementia is considered one of the most crucial health and social care crises of the 21st century, ranking among the top six chronic diseases causing mortality in individuals aged 65 and above, and inflicting significant negative impacts on patients, families, and society. Consequently, global dementia programs have been designated as a priority in national policies [6].

In this umbrella review, cognitive impairment refers to conditions like mild cognitive impairment and dementia. Mild cognitive impairment is characterized by slight but noticeable and measurable declines in cognitive abilities, including memory and thinking skills, but does not significantly interfere with daily life [3]. On the other hand, dementia is a more severe form of cognitive impairment that involves progressive memory loss and difficulties with thinking skills, drastically affecting a person's ability to perform everyday activities [2]. As of the present, there is currently no effective treatment method internationally that can prevent the occurrence of cognitive impairment or delay disease progression [7]. Although certain medications are widely used for the treatment of cognitive impairment, the lack of high-quality evidence supporting their efficacy, along with concerns regarding their potential side effects, is a source of worry [8]. Non-pharmacological interventions, such as memory training [9], physical activity [10], and computerized cognitive training [11], have been proven to improve cognitive function in individuals with mild cognitive impairment and, to a lesser extent, those with dementia. These interventions have garnered support from governments and non-governmental organizations worldwide [3].

In 2021, the World Health Organization released the "Global Strategy on Digital Health 2020–2025" [12], acknowledging the significant role of digital healthcare within national health systems. Increasing research has provided evidence on the benefits of interventions based on electronic health technologies for people with cognitive impairment [13], highlighting the absolute advantage of non-pharmacological interventions based on electronic health technologies. These technologies included in our umbrella review encompass mobile health (mHealth), telemedicine, wearable devices, and various digital health services accessible through mobile phones, tablets, computers, and other communication devices. They assist individuals with cognitive impairment by enhancing memory, promoting physical activity, and improving social engagement. A randomized controlled study found that interventions based on electronic health technologies were associated with a higher quality of life and improved attention in people with mild cognitive impairment compared to traditional cognitive interventions [14]. Current evidence indicates that electronic health interventions are emerging as viable alternatives to traditional cognitive training, offering potential benefits for individuals with cognitive impairment. These interventions assist them in addressing challenges such as social apathy, social isolation, and prolonged sedentary behavior [15]. Moreover, they enable people with cognitive impairment to maximize their potential and manage their lives to a certain degree of independence [16]. Equally significant, electronic health technologies offer healthcare professionals more efficient and convenient tools to monitor and manage the cognitive and health status of individuals [17]. The pivotal role of affordable and appropriate technologies in cognitive impairment care has been underscored [18].

Despite the advantages of electronic health technologies, there are still significant issues to consider when applying them to individuals with cognitive impairment. Various studies report divergent findings regarding the effectiveness, acceptability, and cost of electronic health interventions in this population. In a scoping review conducted by Fardeau in 2023 [19], it was reported that socially assistive robots can improve negative emotions and social engagement levels in people with dementia; however, apprehensions emerge regarding the potential infantilization of individuals when employing socially assistive robots designed to resemble toys. Conway's review [20] highlights that decreased physical activity levels and sensory impairments in older adults living with dementia barrier the use of electronic health apps. In addition to the inherent decline in subjective/objective cognitive functioning in individuals with cognitive impairment, many studies have reported other factors, such as lack of accessibility, privacy concerns, and limited technological equipment [20–22], which impede the implementation of electronic health interventions.

Identifying the barriers and facilitators for participation in electronic health interventions among individuals with cognitive impairment is a crucial first step in enhancing their participation and compliance and serves as the foundation for developing effective intervention strategies. Given the substantial differences in intervention approaches, types, and durations across different electronic health technologies and the current lack of comprehensive evidence regarding their application in individuals with cognitive impairment, exploring and integrating the barriers and facilitators for participation in electronic health interventions among these populations can provide a fundamental theoretical basis for developing appropriate intervention measures.

Although there is considerable evidence indicating the existence of barriers and facilitators, there is currently a lack of higher-level synthesis of evidence across multiple reviews. This umbrella review, based on multiple high-quality systematic reviews and scoping reviews, provides a higher level of evidence by identifying consistent findings, key factors, and differences within the topic. In this process, we provide more comprehensive and systematic implementation strategies to strengthen the participation of individuals with cognitive impairment in intervention activities based on electronic health technologies. In the first part of this umbrella review, we will synthesize the existing evidence to identify the factors influencing the participation of individuals with cognitive impairment in interventions based on electronic health technologies and map these factors onto the Unified Theory of Acceptance and Use of Technology (UTAUT) model. The UTAUT model is particularly useful in understanding individual-level factors such as perceived ease of use, performance expectancy, and behavioral intention, which are crucial in the early stages of technology adoption. These factors directly influence whether individuals will engage with and continue to use the technology. Given that our focus is on individual participation during the initial implementation phase, UTAUT offers a focused framework that aligns with this goal. Subsequently, we will develop theory-based intervention strategies using a taxonomy composed of Behavior Change Techniques (BCTs) based on the results and recommendations provided by the review. This review aims to identify and integrate evidence regarding (1) barriers and facilitators for the participation of individuals with cognitive impairment in electronic health interventions, and (2) the development of theory-based implementation strategies using the mapping of BCTs to enhance participation in electronic health interventions.

## Methods

This study comprises two parts: The first part involves identifying the barriers and facilitators to the participation of older adults with cognitive impairment in intervention activities based on electronic health technology, while the second part entails developing theory-based implementation strategies to enhance their participation based on the barriers and facilitators identified in the first part. The study has been registered with PROSPERO (CRD42023429410). We followed the umbrella review approach proposed by the Joanna Briggs Institute (JBI) [23] and adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting standards [24].

### Identification of barriers and facilitators to participation in electronic health interventions

#### *Search strategy*

The literature search covered articles published from the inception of the databases up to May 2023. We searched PubMed, Embase, Cochrane, Scopus, MEDLINE, Web of Science, and CINAHL databases. The following search terms (and synonyms) were used: disease (cognitive impairment: mild cognitive impairment/dementia); intervention (electronic health interventions); outcomes (barriers/facilitators); and publication type (systematic or narrative review). (Supplementary Material 1).

#### *Selection criteria*

(1) Type of study: systematic or narrative review covering quantitative, qualitative or mixed methods research.
(2) Type of participant: individuals diagnosed with mild cognitive impairment/dementia.
(3) Type of outcome: barriers and facilitators to participation in any form of electronic health interventions, such as cognitive training programs, home support services (e.g., fall detection), mobile health (mHealth), wearable devices, or various digital health and wellness technologies accessible through communication devices.
(4) Language: studies written in English and peer-reviewed.
(5) Exclusion criteria: a) Studies that solely analyze the effects of electronic health interventions on individuals with mild cognitive impairment or dementia without reporting on barriers or

facilitators; b) Studies that primarily focus on electronic health measures for screening or assessing cognitive functioning in individual with cognitive impairment.

### *Definition of electronic health technology*

The World Health Organization (WHO) defines electronic health as "the use of information and communication technologies (ICT) for health and health-related fields, including healthcare services, health monitoring, health literacy, and health education, knowledge, and research, in a way that is cost-effective and secure" [12]. This concept encompasses mobile health (mHealth), telemedicine, wearable devices, and digital health services accessible through mobile phones, tablets, computers, and other communication devices. The former refers to the use of mobile wireless technologies in the healthcare sector, while the latter involves the utilization of ICT for effective communication, delivery of healthcare services, diagnosis, treatment, and prevention of diseases and injuries, research and evaluation, as well as continuing education for healthcare professionals, to promote individual and community health. In this study, the electronic health interventions covered fall within the scope of the defined electronic health technology concept, as outlined by the WHO.

### *Quality assessment and data extraction*

Two researchers independently screened and extracted data from the literature based on predefined inclusion and exclusion criteria. Disagreements were resolved through discussion, and when necessary, the opinion of a third researcher was sought for consensus. One researcher performed data extraction, including publication details, author information, country, number and types of included studies, types of diseases and interventions discussed, and number of databases. Another researcher cross-checked and verified the extracted information.

As depicted in Fig. 1, the evaluation and data extraction of the included reviews followed a systematic five-step process, utilizing validated tools.

The Meta Quality Appraisal Tool (Meta-QAT) was initially used to assess the methodological quality of the reviews [25]. This tool evaluates relevance, reliability, validity, and applicability across diverse research designs. Additionally, the Meta-QAT incorporates the Assessment of Multiple Systematic Reviews (AMSTAR) tool [26], enhancing its comprehensive assessment capabilities (Supplementary Materials 2 & 3). In the first step of this study, we employed the combined Meta-QAT and AMSTAR tool package to conduct a descriptive evaluation of review quality, with a focus on transparency through the documentation of relevant information, rather than relying on numerical scoring methods. The results of this quality assessment formed the basis for

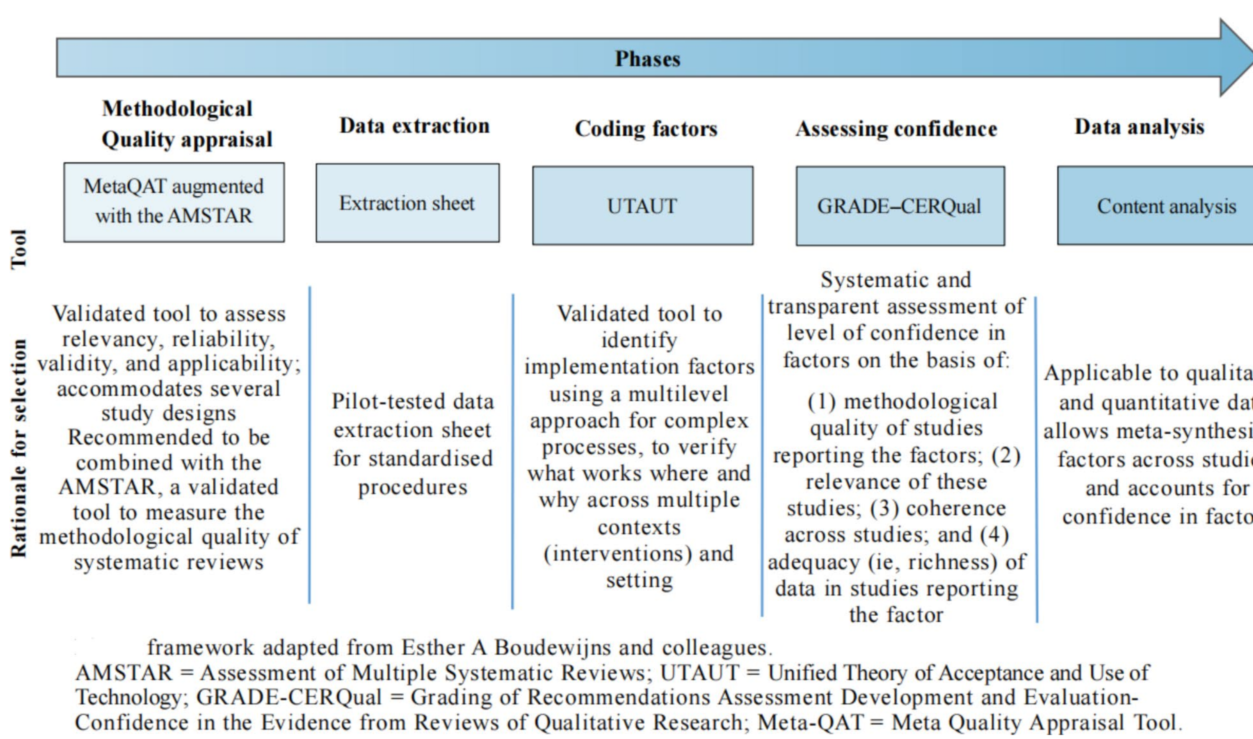


**Fig. 1** Tools applied in each phase of the umbrella review

evaluating evidence credibility. This rigorous approach addressed potential biases from narrative reviews during the meta-synthesis process. In the second step, a standardized data extraction table was used to extract information on review characteristics and factors influencing the implementation of electronic health interventions for cognitive impairment. Findings were recorded comprehensively in the table (Supplementary Material 4). Notably, factors were not categorized strictly as facilitators or barriers, as certain facilitators could also be perceived as barriers and vice versa.

### *Evidence synthesis*

The third step involved encoding barriers and facilitators to implementing electronic health interventions for cognitive impairment using the UTAUT framework. UTAUT integrates multiple theories of information adoption and analyzes organizational and individual behavior during the technology adoption process based on sociological and psychological theories. It focuses on barriers and facilitators in technology adoption and implementation. Empirical studies have shown UTAUT's strong explanatory power (up to 70% for usage behavior), making it the most robust among related models [27]. UTAUT comprises four core concepts: Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions (Supplementary Material 5).

In the fourth step, the GRADE-CERQual tool [28] was used to assess the quality of evidence. This tool is applicable in various research fields, including international development and environmental studies [29]. It evaluates evidence quality in four domains: methodological limitations, relevance, coherence, and adequacy. Each domain was scored from 1 (substantial concerns) to 4 (no concerns to very minor concerns) for each included review. Coherence is not scored because it is assessed in the relevance section of the content analysis (fifth step). Methodological limitations and relevance scores were based on the categories of the combined Meta-QAT and AMSTAR tool. Adequacy scores were assigned based on the data sources (Supplementary Material 8).

In the fifth step, a meta-synthesis of factors from the reviews was conducted using content analysis, following the Dixon-Woods and Krippendorff methods. Dixon-Woods' integrative approach was employed to harmonize qualitative and quantitative findings, allowing us to identify overarching themes across diverse studies [30] and Krippendorff's content analysis provided a structured approach to ensure reliability and consistency in the coding process [31]. Confidence in factors was determined by multiplying the quality score of reviews mentioning a specific factor (step four) by the number of comments referring to that factor (Supplementary Material 9). Each review was considered once per UTAUT construct to provide insights into the diversity of reported factors, even if multiple implementation factors were coded within the same UTAUT construct (e.g., age and family composition assigned to "other individual attributes"). Furthermore, the overall confidence in the implementation factors was calculated by summing the scores across the three domains. Thus, higher scores reflected higher levels of adequacy, relevance, quality, frequency, or combinations of these factors in the reviews. A matrix was created to address evidence duplication when multiple systematic reviews included the same primary studies, summarizing key studies and outlining duplicate findings [32](Supplementary Material 10).

### Develop a theoretically grounded implementation strategy

In the second part, implementation strategies were formulated to facilitate participation in electronic health interventions for individuals with cognitive impairment. The identified barriers and facilitators from the first part were combined with BCTs to develop specific strategies. BCTs, derived from various behavior change theories, represent observable and effective components of interventions for promoting behavior change [33] (Supplementary Material 6). Combining insights from Part 1 reviews with provider feedback ensured the robustness and relevance of the intervention strategies informed by BCTs for older individuals with cognitive impairment. A thematic analysis was conducted to identify key themes related to barriers and facilitators in electronic health interventions for individuals with cognitive impairment. Following **Braun and Clarke's (2006)** [34], guidelines, we systematically coded the data and refined these into cohesive themes, ensuring consistency and relevance to the research questions.

## Results

A total of 2,317 reviews were retrieved, out of which 226 were selected for full-text reading, and ultimately, 21 reviews were included (Fig. 2). This study encompassed 8 systematic reviews [35–42], 12 scoping reviews [19–22, 43–50], and 1 meta-ethnography [51]. The number of studies included in each review ranged from 1 to 135, and the databases covered varied from 3 to 10. Detailed information about the included reviews can be found in Supplementary Material 4.

### Quality appraisal

The relevance, reliability, validity, and applicability of 21 systematic reviews (Supplementary Material 3) were assessed using the combined tools of Meta-QAT and AMSTAR. As shown in Fig. 3, among these reviews, 15 articles (71%) were highly relevant, while 6 articles (29%) had moderate relevance. No reviews were classified as having low relevance. The included articles varied

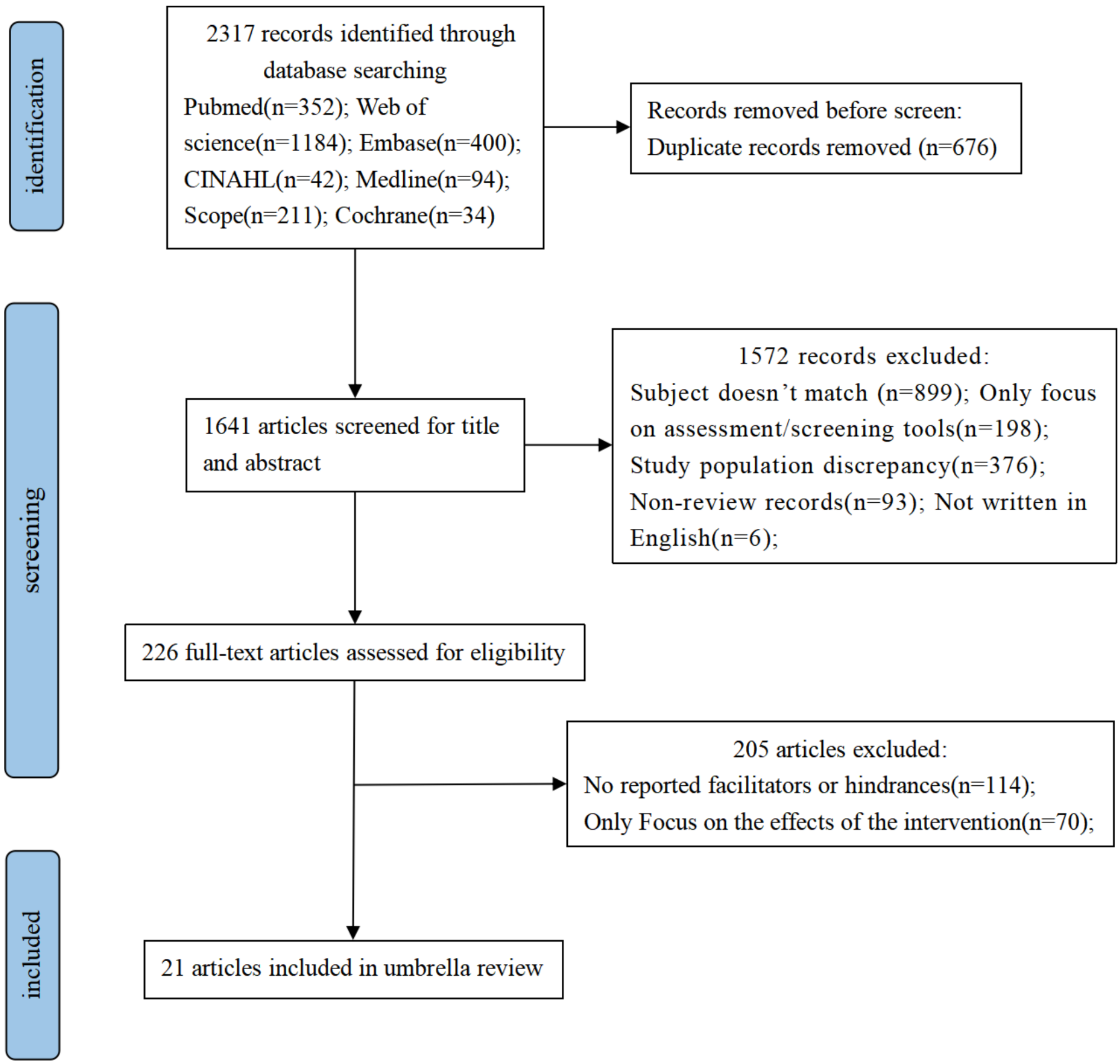


**Fig. 2** Study flowchart

in terms of their reliability: 8 articles (38%) were highly reliable, 8 articles (38%) had moderate reliability, and 5 articles (24%) had lower reliability. The main reasons for low or moderate reliability scores were unclear reporting methods, lack of specific data or unclear sources. In terms of validity evaluation, 5 articles (24%) demonstrated a high level of validity, 15 (71%) articles showed moderate validity, and 1 article (5%) had lower validity. This was primarily due to the lack of reporting bias risks, methodological flaws (such as lack of duplicate data extraction and quality assessment of included studies), or unclear reporting of analytical methods, resulting in lower validity scores. Notably, 20 articles (95%) received a high applicability score, while 1 (5%) received a medium grade. There was minimal overlap among the main studies included in the literature (Supplementary Material 10).

**Barriers or facilitators associated with participation in electronic health interventions as identified by the UTAUT framework**.

We found significant variations in the factors influencing the successful implementation of electronic health interventions for individuals with cognitive impairment. These variations are dependent on the technology utilized and the specific implementation details. A comprehensive list of factors for each UTAUT framework

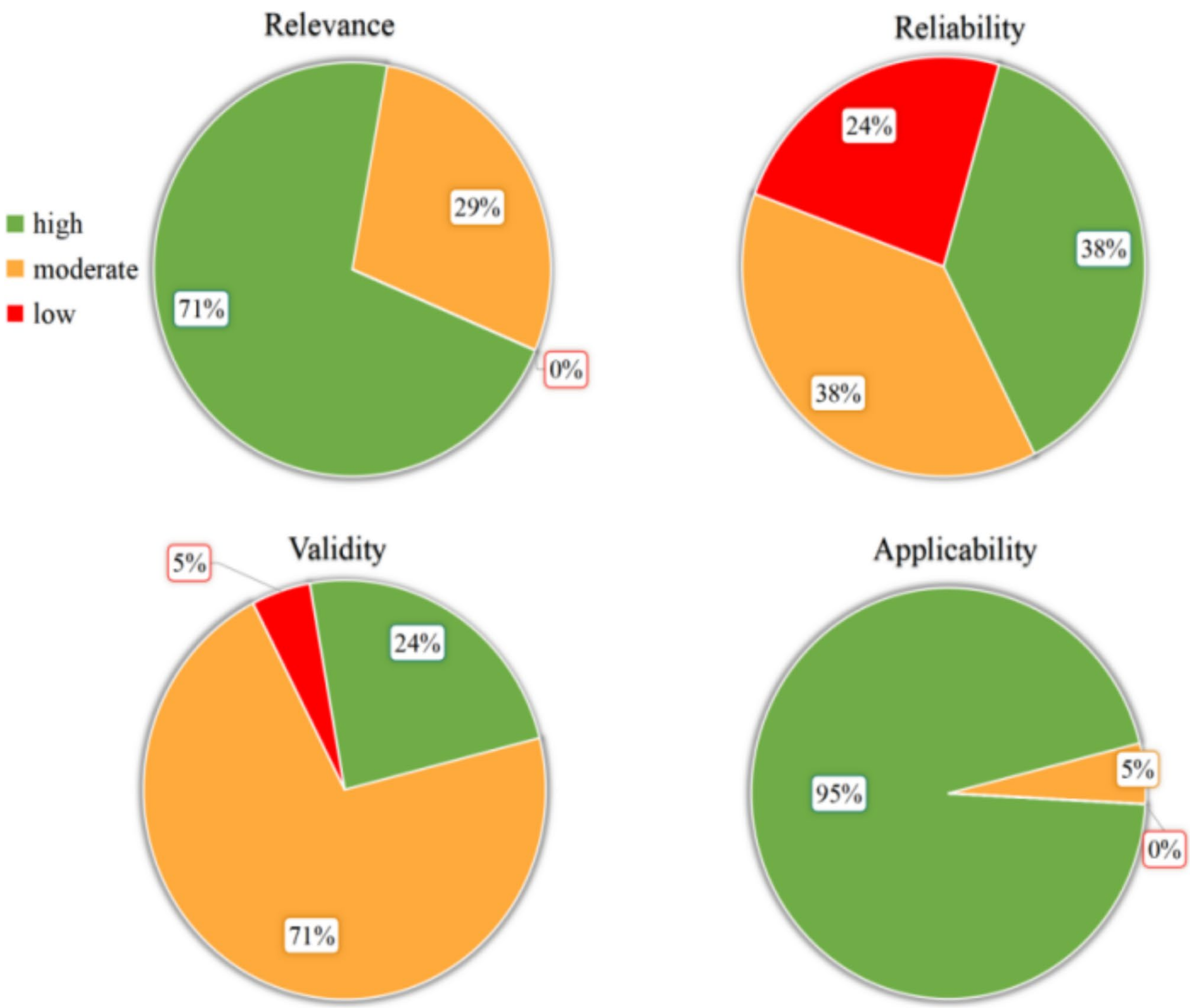


**Fig. 3** Quality evaluation results

construct is presented in Supplementary Material 7. A total of 13 factors influencing the participation of individuals with cognitive impairment in electronic health interventions were extracted from 21 literature reviews using UTAUT framework. (refer to Fig. 4). We focused our discussion on the three most influential factors affecting implementation, namely Perceived Behavioral Control, Relative Advantage, and Social Factor, which accounted for 37.8% of the total score in the content analysis (Supplementary Materials 8 & 8).

The factor with the strongest support was Perceived Behavioral Control. Within the framework of UTAUT, we categorized the specific factors into four aspects: Physical factors, Electronic technology literacy and knowledge, Social and cultural factors, and Personal attitude and willingness. The reviews primarily highlighted physical factors that barrier the use of electronic health technologies by individuals with cognitive impairment, such as subjective or objective cognitive decline, reduced physical functioning, and visual, auditory, and language impairments. Therefore, it is important to prioritize interface accessibility in technology design. For individuals with MCI, who generally retain a higher degree of cognitive function than those with dementia, a simplified user interface with clear guidance may be sufficient to support participation in the technology [36]. However, individuals with dementia typically require more extensive support due to more pronounced cognitive decline. This may include additional help features, intuitive navigation, and ongoing caregiver assistance to facilitate learning and usage [42]. The most frequently mentioned social and cultural factor was the economic and cost aspect of technology. Therefore, affordable and portable electronic health technologies are more likely to be favored by individuals with cognitive impairment. Additionally, the reviews emphasized that personal attitudes

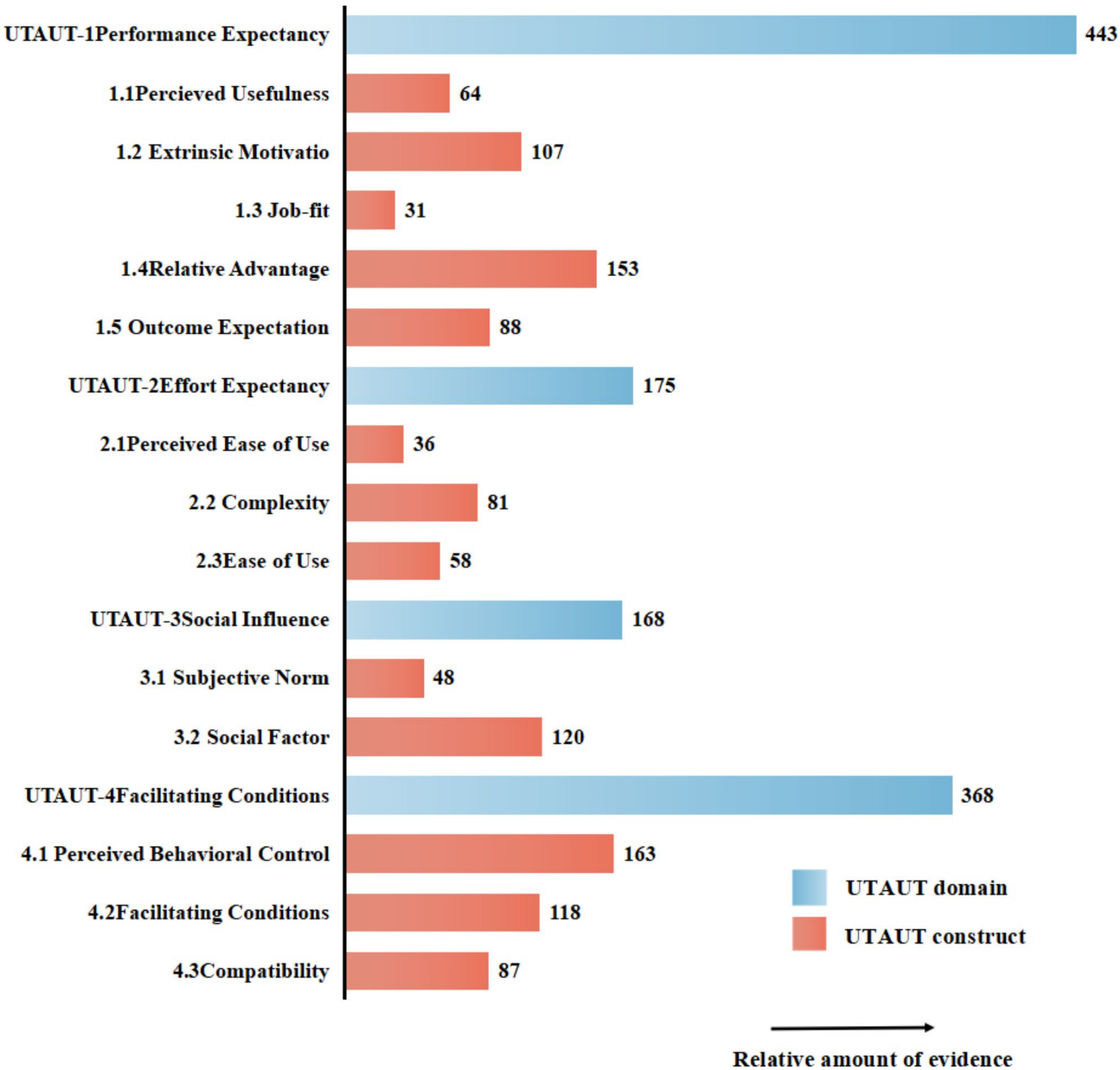


**Fig. 4** Overview of influencing factors

and willingness to use technology impact the implementation of electronic health interventions. A positive initial experience with the technology can encourage individuals with cognitive impairment to continue using it.

The second most supported factor was relative advantage, which can be further categorized into four specific aspects: Enhancing individual well-being and health, Improving resource utilization and efficiency, Economic cost-related disadvantages, Privacy and personal rights-related disadvantages. Electronic health technologies offer benefits in improving negative emotions, enhancing the quality of life, and strengthening social abilities, thereby promoting individual well-being and health. Moreover, they contribute to resource conservation by reducing healthcare utilization, which encourages patient participation in electronic health intervention activities. However, it is important to acknowledge that these technologies also have certain disadvantages. For instance, high economic costs and concerns related to privacy and personal information breaches may impede patient participation.

The third supported factor is the social factor, which can be further divided into four components: Social Support and Personnel Training, Social Policies and Regulations, Resources and Equipment, and Social and Cultural Factors. Most literature reviews mention that support from family members and caregivers can facilitate the use of this technology among individuals with cognitive impairment. This support is particularly crucial for individuals with dementia, who, due to more severe cognitive challenges, may require additional caregiver assistance to effectively engage with electronic health technologies [35]. In contrast, individuals with MCI may be able to use these technologies more independently, though still benefiting from caregiver support. However, some literature reviews also report that the current social policies and regulations regarding electronic health technologies are not comprehensive, lacking necessary constraints such as relevant laws and reimbursement policies, which barrier the application of these technologies. The lack of adequate equipment, including wearable devices, and the high cost of electronic health technologies—coupled with limited reimbursement—also impede the implementation of these technologies. Furthermore, social and cultural factors, such as concerns about technology replacing humans, lack of organizational sustainability in managing these technologies, and increased caregiver burden, have also been identified as potential barriers to the development of electronic health technologies. Additional factors supported by ample evidence are described in Supplementary Material 9.

### Develop implementation strategies to promote participation in electronic health interventions for people with mild cognitive impairment or dementia

The intervention-mapping technique was utilized to identify a range of BCTs targeting the barriers and facilitators found within the UTAUT framework. These techniques aim to encourage the participation of individuals with cognitive impairment in electronic health interventions. (Fig. 5; Table 1, Supplementary material 6)

#### *Personalized interventions: enhancing targeted approaches*

Tailoring electronic health interventions to individual needs and preferences can enhance participation for individuals with cognitive impairment. For individuals with dementia, who experience more severe cognitive challenges, this often requires simpler interfaces and greater caregiver involvement to facilitate effective use. In contrast, individuals with MCI may be able to navigate more complex interfaces with less support, provided that the design is user-friendly. Collaborative goal-setting, regular monitoring with standardized assessment tools, and timely feedback are crucial aspects of these interventions. Questionnaires or interviews can gather valuable information on individuals' attitudes, beliefs, and confidence in technology use, enabling personalized interventions. Addressing visual or hearing impairments can involve prominent icons or buttons, larger fonts, and artificial voice broadcasting. Additionally, timely reminders can support individuals who struggle with adherence to intervention activities.

#### *Environmental considerations: adapting to existing contexts*

Creating a comfortable and quiet intervention environment can promote patient participation. Conducting a comprehensive assessment of the physical environment is crucial to identify and address potential barriers

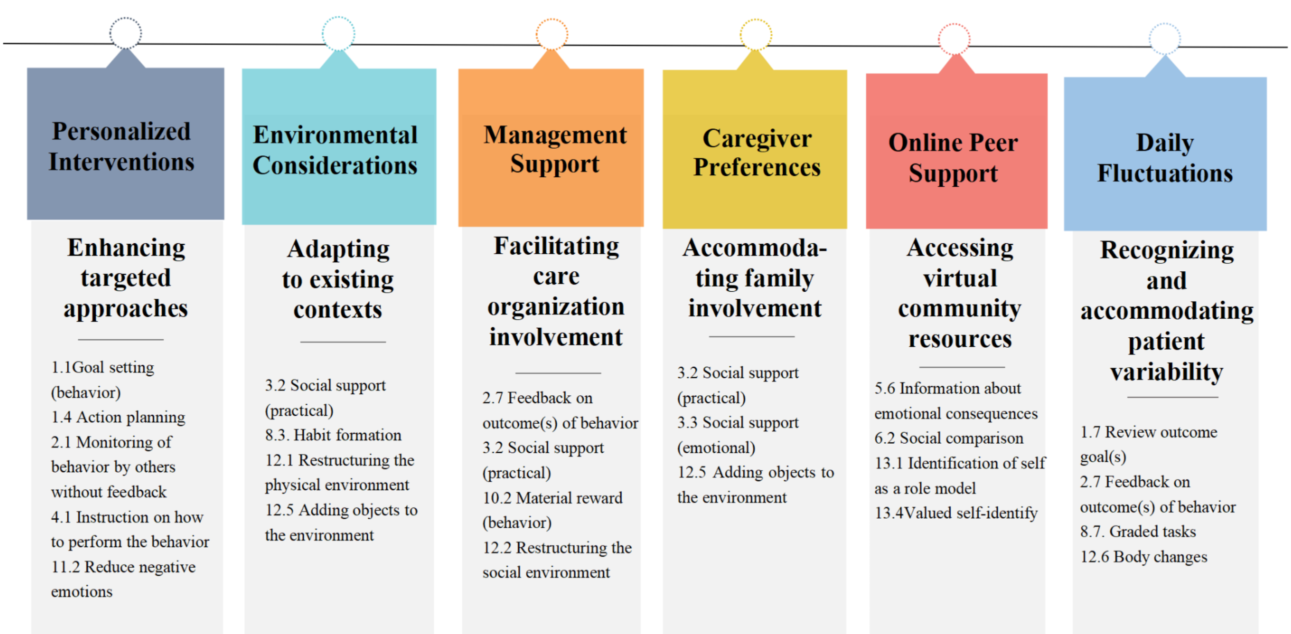


**Fig. 5** Implementation strategies based on BCTs

**Table 1** Implementation strategies

| Strategy | Details | Relevant BCTs | Themes | References |
|---|---|---|---|---|
| 1. **Collaborative goal-setting and progress monitoring** | Engage participants in goal-setting discussions, jointly identifying specific cognitive domains or functional tasks to address. Use standardized assessment tools to establish baseline performance and monitor progress over time. Provide regular feedback to participants, discussing their achievements, areas for improvement, and adjustments to goals as needed. | 1.1Goal setting (behavior)<br>1.4 Action planning<br>2.1 Monitoring of behavior by others without feedback<br>4.1 Instruction on how to perform the behavior<br>11.2 Reduce negative emotions | **Personalized Interventions: Enhancing targeted approaches** | Conway et al. (2023)<br>Md Fadzil et al. (2022)<br>Elbaz et al. (2021)<br>Yi et al. (2021)<br>Koh et al. (2021)<br>Engelsma et al. (2021)<br>Sohn et al. (2021)<br>Lee et al. (2021)<br>Zhu et al. (2023)<br>Salehi et al. (2022)<br>Brown et al. (2020)<br>Lee-Cheong et al. (2022)<br>Dowson et al. (2021)<br>Yi et al. (2021)<br>Sekhon et al. (2021)<br>Hung et al. (201)<br>Nkodo et al. (2022) |
| 2. **Personalized intervention content** | Tailor the content of e-health interventions to each participant's specific needs and preferences. This may include selecting exercises or activities that align with their cognitive strengths and interests. Personalization enhances engagement and motivation, increasing the likelihood of sustained participation. | | | |
| 3. **Visual Aids and Memory Support** | Replace hard-to-remember names and phone numbers with visual aids. Use photos of the corresponding contacts in the intervention platform or on smartphones or tablets. Associating faces with contacts can enhance recognition and reduce reliance on memory recall, addressing cognitive decline-related challenges. | | | |
| 4. **Assessing Motivation and Digital Literacy Readiness** | Prior to intervention implementation, conduct assessments to understand participants' motivation levels and digital literacy readiness. Use validated questionnaires or interviews to gather information about their attitudes, beliefs, and confidence in using technology. Tailor the interventions and provide additional support based on individual needs and preferences. | | | |
| 1. **Environmental assessment** | Conduct a comprehensive assessment of the physical environment where e-health interventions will take place. Identify potential barriers, such as excessive noise, poor lighting, or uncomfortable seating arrangements. Modify the environment to optimize usability and minimize distractions, ensuring a calm and comfortable space for participants. | 3.2 Social support (practical)<br>8.3. Habit formation<br>12.1 Restructuring the physical environment<br>12.5 Adding objects to the environment | **Environmental Considerations: Adapting to existing contexts** | Conway et al. (2023)<br>Elbaz et al. (2021)<br>Yi et al. (2021)<br>Koh et al. (2021)<br>Engelsma et al. (2021)<br>Sohn et al. (2021)<br>Löbe et al. (2022)<br>Scerri et al. (2021)<br>Zhu et al. (2023)<br>Kruse et al. (2022)<br>Lee-Cheong et al. (2022)<br>Amiri et al. (2022)<br>Dowson et al. (2021)<br>Yi et al. (2021)<br>Sekhon et al. (2021)<br>Nkodo et al. (2022) |
| 2. **Pre-training and Equipment Provision** | Offer pre-training sessions to users and caregivers on how to effectively use the cognitive rehabilitation technology. Provide guidance on navigation, utilizing different features, and maximizing the benefits of the technology. Ensure that necessary equipment, such as smartphones, tablets, or assistive devices, is provided to users who may not have access to such resources. | | | |
| 3. **Support for Everyday Tasks** | Expand the functionality of cognitive rehabilitation technology to support everyday tasks such as online shopping, trip planning, or simplified Internet access. Provide features that enhance the user's ability to independently manage daily activities, increasing their sense of control and autonomy. | | | |
| 4. **Affordable and Accessible Technology** | Ensure that the technology devices chosen are affordable so that patients and their families can afford them. This can include choosing relatively inexpensive devices such as smartphones, tablets or smartwatches to deliver eHealth services. Ensure that patients have easy access to the technology devices they need. This may include setting up loaner programs or mechanisms for renting devices so that patients can borrow or rent devices when they need them without incurring excessive costs. In addition, partnerships with community resources or charitable organizations could be explored to obtain donations or subsidies for technology equipment. | | | |
| 5. **Inclusive Technology Development** | Encourage technology companies and developers to engage a diverse range of people with dementia and caregivers in all stages of technology development. Include individuals from different cultural and socioeconomic backgrounds, and urban and rural settings, to ensure that the technology meets the diverse needs and preferences of the target population. | | | |

**Table 1** (continued)

| Strategy | Details | Relevant BCTs | Themes | References |
|---|---|---|---|---|
| 1. **Involvement of Caregivers in Technology Development** | Involve caregivers in the early stages of developing complex health technologies for people with dementia. Seek their input, experiences, and feedback to ensure that the technologies meet their needs and are user-friendly. Incorporate their perspectives in the design and functionality of the technologies. | 2.7 Feedback on outcome(s) of behavior<br>3.2 Social support (practical)<br>10.2 Material reward (behavior)<br>12.2 Restructuring the social environment | **Management Support: Facilitating care organization involvement** | Md Fadzil et al. (2022)<br>Elbaz et al. (2021)<br>Koh et al. (2021)<br>Sohn et al. (2021)<br>Löbe et al. (2022)<br>Scerri et al. (2021)<br>Zhu et al. (2023)<br>Kruse et al. (2022)<br>Brown et al. (2020)<br>Lee-Cheong et al. (2022)<br>Amiri et al. (2022)<br>Dowson et al. (2021)<br>Yi et al. (2021)<br>Sekhon et al. (2021)<br>Hung et al. (2019)<br>Nkodo et al. (2022) |
| 2. **Tailoring Complex Health Technologies to Caregiver Abilities** | Recognize that caregivers may have different levels of knowledge and skills. Ensure that complex health technologies can be flexibly tailored to accommodate the abilities of all caregivers. Provide user-friendly interfaces, clear instructions, and comprehensive training programs to support caregivers in effectively utilizing the technologies | | | |
| 3. **Multidisciplinary collaboration** | Foster collaboration among different care organization disciplines involved in the participants' care, such as physicians, nurses, psychologists, and occupational therapists. Encourage regular interdisciplinary meetings to share insights, discuss progress, and optimize care plans based on e-health intervention outcomes. | | | |
| 4. **Reinforcement and rewards** | Implement a system of reinforcement and rewards to motivate participation and effort. This can include verbal praise, virtual badges or points, or small incentives tied to achieving specific goals. Regularly acknowledge and celebrate participants' progress to reinforce their engagement. | | | |
| 1. **Recognizing Benefits to Family Caregivers** | Highlight and emphasize the potential benefits to family caregivers when people with dementia use technology. This includes improved caregiver well-being, reduced symptoms of distress, depression, and anxiety, and increased knowledge and skills related to dementia care. Raise awareness of these benefits to motivate family caregivers to engage in technology use. | 3.2 Social support (practical)<br>3.3 Social support (emotional)<br>12.5 Adding objects to the environment | **Caregiver Preferences: Accommodating family involvement** | Koh et al. (2022)<br>Conway et al. (2023)<br>Elbaz et al. (2021)<br>Md Fadzil et al. (2022)<br>Sohn et al. (2021)<br>Scerri et al. (2021)<br>Brown et al. (2020) |
| 2. **Supportive Caregiver or Companion** | Encourage the involvement of a supportive caregiver or companion in the use of technology, particularly for physical activity applications. This person can provide motivation, assistance, and companionship, promoting engagement and adherence to the activities. Consider involving younger caregivers (e.g., children or grandchildren) in supporting older patients during telemedicine consultations, ensuring successful interactions. | | | |
| 3. **Research on Online Training Programs** | Conduct research to enhance the quality of online training programs for families of people with dementia. Investigate caregiver change mechanisms and develop evidence-based approaches to optimize the effectiveness of online training. Explore innovative methods, such as interactive modules, virtual support groups, and personalized feedback, to enhance the training experience and outcomes. | | | |

**Table 1** (continued)

| Strategy | Details | Relevant BCTs | Themes | References |
|---|---|---|---|---|
| 1. **Virtual peer support platforms** | Provide access to dedicated online platforms or forums where participants can connect with peers who have similar experiences with mild cognitive impairment or AD. These platforms should allow for secure and private communication, enabling participants to share challenges, seek advice, and offer support to one another. | 5.6 Information about emotional consequences<br>6.2 Social comparison<br>13.1 Identification of self as a role model<br>13.4 Valued self-identify | **Online Peer Support: Accessing virtual community resources** | Conway et al. (2023)<br>Md Fadzil et al. (2022)<br>Zhu et al. (2023)<br>Dowson et al. (2021)<br>Fardeau et al. (2023) |
| 2. **Virtual social events and activities** | Organize virtual social events or activities for participants to foster a sense of community and camaraderie. This may include virtual game nights, virtual art or music sessions, or themed discussions to create opportunities for socialization and mutual support. | | | |
| 3. **Expert-led Q&A sessions** | Arrange virtual Q&A sessions with experts in the field of MCI and Alzheimer's disease to address participants' questions and concerns. These sessions can cover topics related to e-health interventions, cognitive health, and strategies for managing mild cognitive impairment and Alzheimer's disease, providing valuable information and reassurance. | | | |
| 4. **Peer mentorship programs** | Implement a peer mentorship program where participants who have successfully completed the e-health interventions can provide guidance and support to new participants. This fosters a sense of empowerment, resilience, and motivation as participants learn from their peers who have overcome similar challenges. | | | |
| 1. **Proactive monitoring and check-ins** | Implement proactive monitoring systems that collect data on participants' daily fluctuations and engagement levels. Regularly check in with participants through remote assessments, surveys, or brief virtual meetings to identify any changes or challenges they may be experiencing. Adjust the interventions accordingly to accommodate their needs. | 1.7 Review outcome goal(s)<br>2.7 Feedback on outcome(s) of behavior<br>8.7. Graded tasks<br>12.6 Body changes | **Daily Fluctuations: Recognizing and accommodating patient variability** | Conway et al. (2023)<br>Engelsma et al. (2021)<br>Sohn et al. (2021)<br>Scerri et al. (2021)<br>Salehi et al. (2022)<br>Lee-Cheong et al. (2022)<br>Dowson et al. (2021)<br>Yi et al. (2021) |
| 2. **Objective Tracking for Decision-Making** | Design e-health interventions to adapt in real-time based on participants' performance and fluctuations. Utilize algorithms or adaptive algorithms that can adjust the difficulty level, pacing, or content of the interventions to match participants' capabilities and immediate needs, ensuring optimal engagement and challenge. | | | |

like noise and lighting. Caregiver support is essential for patient participation, necessitating training on electronic health technologies and ensuring sufficient equipment resources. Affordability and accessibility of devices impact individuals' willingness to participate; considering reasonably priced options like affordable smartphones and tablets, and implementing strategies such as rental services, can improve accessibility.

#### *Management support: facilitating care organization involvement*

Caregivers play a pivotal role as operators and facilitators of electronic health technology interventions for individuals with cognitive impairment. Their attitudes greatly influence the success of these interventions. Involving caregivers in the early stages of developing complex healthcare technologies for cognitive impairment individuals is vital. Gathering their input, experiences, and feedback while considering their varying technological proficiency is important. Regular interdisciplinary meetings among nursing administrators, doctors, nurses, psychologists, and occupational therapists foster collaboration, enabling insights sharing, progress discussion, and optimization of intervention plans within the nursing organization.

#### *Family Caregiver preferences: accommodating family involvement*

Meaningful participation in technology-based activities has significant implications for the quality of life of individuals with cognitive impairment and the well-being of their primary family caregivers. Encouraging family caregivers to join older adults living with cognitive impairment during technology interventions, such as involving younger caregivers (e.g., children or grandchildren) in remote medical consultations, enhances successful interaction. Furthermore, promoting the development of suitable online training programs enables remote education and training opportunities for family caregivers.

#### *Online peer support: accessing virtual community resources*

Enhancing peer support can be achieved through virtual communities, online platforms, or forums that facilitate patient connections. Regular online activities like virtual concerts or Q&A sessions organized by interventionists can foster participation. Peer mentoring programs can also be implemented, where individuals who have completed interventions offer guidance to new participants, empowering them and promoting participation.

#### *Daily fluctuations: recognizing and accommodating patient variability*

Nursing personnel can employ assistive technologies to track patient progress objectively, enabling timely adjustments in intervention difficulty, pace, or content to align with participants' abilities and immediate needs. This approach ensures optimal participation by providing an appropriate level of cognitive challenge that matches participants' capabilities, promoting continued participation and progress. Utilizing data from assistive technologies, nursing personnel can effectively monitor individuals' conditions and make necessary adaptations to interventions.

## Discussion

In the first part of this umbrella review, we synthesized evidence from 21 reviews, covering 535 studies, to identify and assess the barriers and facilitators influencing the participation of individuals with cognitive impairment in electronic health interventions. We also evaluated the confidence in the evidence related to these factors. Our findings indicate that a range of factors synergistically influences the participation of individuals with cognitive impairment in interventions based on electronic health technologies. This highlights the need for targeted implementation strategies to enhance the involvement of older adults with cognitive impairment in such interventions. In the second part of this study, we employed an intervention mapping approach, utilizing BCTs, to develop six implementation strategies building upon the results from the first part, aiming to improve the participation of older adults with cognitive impairment in interventions based on electronic health technologies.

The results of this umbrella review indicate that Perceived Behavioral Control, Relative Advantage, and Social Factors are the top three influential factors in ranking confidence levels. Conway's study [20], indicated that the participation of individuals with cognitive impairment in interventions based on electronic health technologies is dependent on their confidence and beliefs regarding the usefulness and value of electronic health technology in their daily lives. If they perceive electronic health technology as convenient or beneficial, they are more likely to participate. Our umbrella review reported positive emotional responses (feeling pleasant, safe, relaxed, calm, and enjoyable) [19, 35, 36] as well as negative emotional responses (lack of self-efficacy, privacy concerns, and lack of trust in using new technology) [44, 46, 47] among individuals with cognitive impairment when using electronic health technologies. These findings suggest that interveners need to enhance participants' perceived behavioral control of electronic health technologies, improve their electronic health literacy and beliefs, and highlight the benefits that electronic health technologies bring, creating a pleasant and comfortable initial experience. Social Factors were also frequently mentioned, with a broad scope, primarily referring to social and governmental support. Several reviews reported that the lack of electronic devices and unstable wireless networks were the main implementation barriers [52, 53]. Providing a comfortable intervention environment and convenient intervention devices by governments and organizations can enhance the participation of individuals with cognitive impairment. Furthermore, other social factors were mentioned in some reviews, such as concerns about infantilization when using toy-like social robots, which may harm or barrier personal growth [19]; issues of data ownership, data protection/privacy [21, 47]; and the lack of laws, regulations, and reimbursement policies [37, 47]. Finally, we found that negative attitudes towards technology use by peers, family members, and caregivers of individuals with cognitive impairment also influence their willingness to engage in electronic health interventions [21, 47, 51]. This finding aligns with Rozental's study [54], which found that such concerns about technology have negative psychological impacts on users.

In this umbrella review, we present six implementation strategies aimed at promoting the participation of older adults with cognitive impairment interventions based on electronic health technology. The active involvement of caregivers, intervention providers, and technical designers is essential for implementing these strategies play critical roles in management support, environmental adjustments, and customizing interventions to address patient-specific needs, which are fundamental to successful implementation. For each topic, we also discuss relevant advancements in BCTs, which provide a scientific foundation and a clear framework for developing specific intervention strategies [55].

The availability of technology influences the user experience, which in turn affects their motivation to continue using it [56]. Therefore, we advocate for targeted intervention approaches. The Best Practice Guidelines for Dementia Patients' Interaction with Technology, published by the INDUCT and DISTINCT networks, emphasize the need to develop technology specifically tailored to the visual, auditory, and cognitive abilities of individuals with cognitive impairment [57]. Consequently, it is essential to assess individual preferences, capabilities, and needs (such as occupational requirements, as well as physical, cognitive, and sensory abilities) before initiating interventions. Furthermore, it is important to involve cognitive impairment of varying severity cognitive impairment and care providers (including those from different cultural and socioeconomic backgrounds, urban and rural environments, etc.) at various stages. When considering compliance with computer-based cognitive rehabilitation programs among cognitive impairment individuals, it is crucial to account for socio-demographic factors (age, gender, education level), cognitive factors (memory, attention, executive functions), and psychological factors (motivation, expectations, prior computer usage) [58]. The physical environment of the intervention plays a significant role in whether participants are willing to continue their involvement. Therefore, we recommend adapting to existing environments and assessing the suitability of the physical environment prior to the intervention, including factors such as lighting, noise, and potential barriers [59]. Moreover, intervention technologies are best designed to align with the daily lives of individuals with cognitive impairment, for example, by providing online shopping and travel planning capabilities, thereby increasing their control over the surrounding environment [60]. Additionally, certain safety alert features are highly relevant to individuals' daily lives, such as fall detection, GPS tracking, and emergency assistance [61]. Due to impairments in memory, attention, and executive functions, individuals with cognitive impairment often lack a clear understanding of their environment. In such cases, the provision of appropriate companionship and supervision by healthcare professionals, caregivers, and peers can greatly enhance their participation in electronic health interventions [62]. However, this approach also places certain demands on caregivers and family members, requiring them to be proficient in the use of these technologies. Therefore, it is necessary to provide intervention technology training for them in advance [63]. Two of the reviews [64, 65] highlight the significant benefits of peer support for individuals with cognitive impairment, as it promotes their fulfilment of responsibilities and rights, self-management, and participation in social activities. Peers can share experiences, information, and coping strategies in these domains, extending beyond the support that healthcare and social care professionals, friends, and family can provide [64, 65]. Lastly, monitoring participants' physical condition and emotional fluctuations is crucial. Those who are implementing interventions can use this information to swiftly modify the complexity, speed, or subject matter of the intervention to ensure maximum participation by providing an appropriate level of cognitive challenge that aligns with the participants' abilities and immediate needs [66–68].

While we have summarized the evidence and identified the top three factors in terms of confidence level, it is important to note that the degree of trust in supporting a specific factor should not be interpreted as a prioritization of its relative importance or as an indication of the sequence of interventions or implementation [69, 70]. High levels of confidence in the evidence merely indicate the relative certainty of the impact of that factor on the participation of individuals with cognitive impairment in electronic health interventions. We believe that all factors included in the study results should be appropriately addressed or at least considered in the development of implementation strategies. Conversely, the absence of a factor does not necessarily imply its insignificance but may simply indicate a lack of available evidence. It is worth noting that the presentation of evidence in the reviews depends on the methods used and the perspectives of researchers, interveners and intervention recipients. Through the UTAUT framework, we identified several gaps in the current research on the implementation of electronic health technologies for individuals with cognitive impairment. For example, most studies focus primarily on the advantages of the technology and external facilitating conditions, with limited attention to factors like participant role identification or the impact of social status/identity. Individuals from lower socioeconomic backgrounds, rural areas, or marginalized communities may face greater barriers to access due to the high costs of these technologies and the lack of reimbursement options. This could lead to inequalities in healthcare access, with only wealthier populations benefiting from such interventions. These issues should form the basis for further investigation. Unfortunately, due to the variability in types of electronic health technologies and their diverse implementation contexts, specific average cost data is not always available in the reviewed studies. Future research should aim to address these gaps by examining the costs of different technologies and their equity implications.

## Strengths and limitations

Given the increasing global trend of population ageing and the growing pressure and burden dementia imposes on society and families, conducting implementation research is essential for improving health outcomes [71]. To the best of our knowledge, this umbrella review represents the first comprehensive and balanced examination of the evidence pertaining to critical factors for the successful implementation of electronic health interventions for cognitive impairment. However, bridging the research-practice gap requires more than just evidence [72]. Therefore, we have developed six new evidence-based implementation strategies. These strategies provide a practical overview of the factors influencing the implementation of electronic health interventions and demonstrate the level of evidence supporting these factors, along with examples of how they impact implementation.

Despite the strengths of this study, there are notable limitations. First, our review primarily relied on the UTAUT model, which focuses on individual-level factors such as user acceptance and behavioral intention. While this framework is highly valuable for understanding early-stage engagement with technology, it does not address broader systemic or contextual barriers—such as organizational support or environmental influences—that may affect the success of electronic health interventions at a larger scale. Furthermore, while our study adhered to rigorous design and execution standards, following PRISMA reporting guidelines [73], the exclusion of grey literature data is another limitation. The challenges of retrieving data from non-academic sources have been emphasized [74].

## Recommendations for Future Research and Design

We believe that the UTAUT is a valuable framework for understanding the individual-level factors influencing participation in electronic health interventions, however we must acknowledge that it primarily focuses on user acceptance and does not fully capture the broader organizational and contextual factors essential for successful implementation. These multi-level factors are more comprehensively addressed by other models, such as the Consolidated Framework for Implementation Research (CFIR) [75] and Normalization Process Theory (NPT) [76]. Future research could attempt to combine UTAUT with models like CFIR or NPT to better capture all factors influencing both adoption and implementation success, particularly in healthcare environments with complex multi-level influences.

It is challenging to create an intervention that satisfies all barriers and facilitators simultaneously, particularly when trying to balance cost, functionality, and ease of use. For example, while offering multiple functionalities in an intervention can increase its effectiveness, this often comes with higher costs and complexity, which may limit accessibility for individuals in low-resource settings. Additionally, if training is required for both users and caregivers, this increases the workload on caregivers, which could be a barrier for families and healthcare systems already under strain. Future research should explore the development of modular interventions that allow for flexibility in design, so that essential features can be prioritized while optional functionalities can be added as resources and needs evolve. In addition, focusing on user-centered design will ensure that interventions are simple and intuitive, reducing the need for extensive training and increasing accessibility. Furthermore, supporting caregivers with training resources and ongoing digital assistance can help reduce their workload while maintaining high-quality care for the individual with cognitive impairment. Finally, cost-effectiveness analysis should be integrated into the development of e-health interventions to ensure that the cost does not outweigh the benefits, particularly for marginalized populations.

## Conclusion

The evidence presented in this umbrella review highlights the importance of a multi-stakeholder approach and a holistic perspective in promoting the participation of individuals with cognitive impairment in electronic health interventions. By employing an UTAUT framework, we not only identified the 13 factors shaping the construction of future intervention measures but also revealed unexplored areas within this research domain. The data generated from this umbrella review is expected to inform the development of customized implementation strategies based on intervention mapping approaches, thus facilitating the participation of older adults with cognitive impairment in electronic health interventions.

## Supplementary Information

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Supplementary Material 1

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### Author contributions

C.Z. completed the literature search, content analysis, and additional materials and drafted the manuscript.Y.A. completed the graphics and tables, revised, and finalized the manuscript.C.Z. and S.W. worked together on data extraction, quality assessment, and content analysis.Y.Y. completed the review of all the data in this article.A.Z. completed the collation of all the references in this article.Y.W. and H.H. provided administrative, technical, or material support.All authors read and approved the final manuscript.

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### Data availability

All data generated or analysed during this study are included in this published article [and its supplementary information files].

## Declarations

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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