Research in Social and Administrative Pharmacy 22 (2026) 901–907

Contents lists available at ScienceDirect

Research in Social and Administrative Pharmacy

journal homepage: www.elsevier.com/locate/rsap

Assistive technologies for medication self-management in people with disabilities: A systematic scoping review and evidence map

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ARTICLE INFO

Keywords:
Self-help devices
Persons with disabilities
Vision disorders
Hearing loss
Intellectual disability
Self-management
Pharmaceutical preparations

ABSTRACT

Background: Medication self-management poses significant challenges for persons with disabilities. Although self-help devices and assistive technologies (ATs) have the potential to enhance autonomy and safety, the evidence supporting their effectiveness is fragmented.
Objective: To systematically map scientific literature on ATs that support medication use among individuals with vision disorders, hearing loss, or intellectual disabilities.
Methods: A systematic scoping review was conducted in accordance with the JBI and PRISMA-ScR guidelines. Six databases were searched for studies published since 2000 that evaluated ATs designed to support medication management in specified populations. Data were extracted in duplicate to classify the technologies, study designs, and outcomes.
Results: Of the 1147 identified records, 80 studies were included. Most of these studies addressed visual impairment (n = 41; 51.2%) and focused on electronic devices. The evidence base consisted primarily of small-scale observational studies. Only 23 studies (28.7%) evaluated outcomes, primarily user satisfaction or device performance. Only three studies assessed clinical outcomes such as medication errors or hospitalizations, and only ten (12.5%) reported cost analyses.
Conclusions: There is a critical gap between the technological innovation of ATs and their clinical validation. Despite the existence of numerous prototypes, there is a lack of robust evidence on the effectiveness, safety, and cost-effectiveness of ATs. Future research should use rigorous methods, such as randomized controlled trials and economic evaluations, to prove the clinical value of ATs in improving medication safety and accessibility for people with disabilities.

1. Introduction

Safe and effective medication management is essential for patient safety and healthcare quality.[1] Nevertheless, medication errors, poor adherence, and self-management difficulties are major global challenges that contribute to preventable morbidity, hospitalizations, and increased healthcare expenditures.[2] These barriers are exacerbated for people with disabilities, especially those with visual, hearing, or intellectual impairments. These individuals face persistent obstacles when it comes to accessing, understanding, and using therapeutic information.[3,4] Consequently, this population is at a higher risk for adverse events related to medication and poor health outcomes.

Medication management requires precisely interpreting complex information, such as dosing instructions, labels, package inserts, and professional counseling.[5] Comprehension of these elements may be impaired when sensory or communication abilities are compromised.

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https://doi.org/10.1016/j.sapharm.2026.05.006
Received 7 November 2025; Received in revised form 25 April 2026; Accepted 11 May 2026
Available online 20 May 2026

Individuals with visual impairments often have difficulty identifying medications and doses due to a lack of tactile or accessible labeling.[6] People with hearing impairments may misinterpret verbal instructions. People with intellectual disabilities may have difficulty understanding instructions, which can lead to a greater reliance on caregivers.[7] Together, these limitations compromise medication safety, adherence, and autonomy.

Assistive technologies (ATs) have emerged as a strategy to address these inequities. The World Health Organization defines ATs as: any product, device, equipment, service, or system designed to maintain or improve an individual's functioning and independence, thereby promoting well-being[8.] In pharmacotherapy, ATs include talking devices, automated dispensers, mobile applications with visual or auditory reminders, adapted packaging with Braille or tactile markings, pictogram-based instructions, and specialized medication support services.[8]

Despite their potential, there is limited and fragmented evidence on the effectiveness, safety, usability, and cost-effectiveness of ATs. Most studies are preliminary, with small sample sizes and heterogeneous designs. These studies tend to emphasize user satisfaction or technical performance rather than clinical or economic outcomes.[9,10] Moreover, reviews on medication adherence or education tend to use generalized approaches that overlook the specific needs of people with disabilities. This limits their applicability to inclusive clinical practices and equitable pharmaceutical policies[8,9,11].

Thus, the objective of this systematic scoping review was to map the scientific literature on ATs that support medication management for individuals with visual, hearing, or intellectual disabilities, and to identify evidence gaps regarding their effectiveness, safety, and cost-effectiveness that hinder their implementation in pharmacy practice.

2. Methods

A systematic scoping review was conducted in accordance with the Joanna Briggs Institute (JBI) recommendations for scoping reviews[12] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines.[13] The completed PRISMA-ScR checklist is provided in the Supplementary Material.

2.1. Literature selection

Six databases (PubMed, Scopus, SciELO, Web of Science, Directory of Open Access Journals, and Epistemonikos) were searched. The full search strategy is provided in the Supplementary Material.

Eligible studies were defined based on the concept of interest (assistive technologies for medication use) and the target population (adults with specified impairments). Studies addressing assistive technologies designed to support medication use among adults (≥18 years) with visual, auditory, combined sensory (visual and auditory), or cognitive impairments were included, as these conditions directly affect key domains of medication use, including access, comprehension, and safe administration.[14,15] Sensory impairments limit the reception of visual and auditory health information, such as prescription labels and verbal counseling,[16,17] whereas cognitive impairment affects information processing, memory, and decision-making related to medication use.[15] This classification is consistent with established frameworks that recognize vision and hearing as core sensory modalities and cognition as central to medication management and health information processing [14–17].

For the purpose of this review, medication use was operationally defined as patient-level activities related to the management of pharmacological treatments in real-world settings, including access and acquisition, comprehension of medication-related information, preparation and administration, adherence, and monitoring of therapeutic outcomes and safety.[18,19] This definition aligns with conceptual models of medication self-management as a multidimensional process involving cognitive, behavioral, and organizational tasks performed in daily life. Studies published from Jan 1, 2000, onwards, in English, Portuguese, or Spanish, were included.

Studies were excluded if they did not address assistive technologies related to medication use, or if they evaluated interventions focused exclusively on pharmacy design, environmental accessibility, or healthcare logistics, as these do not directly target individual-level medication self-management processes. This distinction follows frameworks differentiating environmental or system-level barriers from individual functional limitations in disability and health.[14] Studies involving non-disabled or simulated populations were excluded to ensure applicability to real-world clinical contexts. Studies addressing mental impairments related to psychosocial or psychiatric conditions were excluded due to their conceptual and clinical heterogeneity and the distinct mechanisms underlying medication use behaviors in these populations. In contrast, sensory and cognitive impairments are more consistently associated with functional limitations in communication, cognition, and information processing, whereas psychosocial conditions often involve dynamic and context-dependent factors such as motivation, stigma, and social vulnerability, requiring different analytical approaches [14–20]. Eligibility regarding study design was assessed during full-text screening. Studies not employing experimental, observational, descriptive, or systematic review designs were excluded at this stage.

These eligibility criteria were defined a priori to ensure transparency, reproducibility, and conceptual coherence between the review objectives, the technologies evaluated, and the target population.

2.2. Study selection

Title and abstract screening and full-text assessment were conducted independently by two pairs of reviewers. Disagreements at any stage were resolved by a third reviewer. Inter-reviewer agreement was assessed using Cohen's kappa statistic.

2.3. Data extraction and synthesis

Two pairs of trained reviewers independently extracted the data, and disagreements were resolved by a third reviewer. Extracted data included publication year, study design, sample characteristics, type of disability, technology description, estimated cost, and reported outcomes. Studies addressing more than one type of disability or functional loss were classified as involving sensory impairments.

Based on the Technology-Related Assistance for Individuals with Disabilities Act of 1988,[21] Cooper et al. (2023),[11] and the Minnesota Assistive Technology Framework,[22] assistive technologies were categorized as devices, packaging or informational adaptations, and services. These frameworks were selected for their conceptual clarity and widespread use, enabling consistent classification across heterogeneous studies.

The reported AT applications and outcomes were summarized by frequency. A Sankey diagram was created to depict the relationship between technology type and evaluated outcome. An evidence map combining types of assistive technology and types of disability was created. This map presents studies with circle sizes proportional to their participant distribution quartile. Both figures were created using R/RStudio (Posit, Boston, MA) using the ggalluvial[23] and ggplot2 packages.

In line with the purpose of scoping reviews, which is to comprehensively identify and map available evidence, no formal assessment of methodological quality or risk of bias was performed. The review protocol was prospectively registered on the Open Science Framework (OSF) platform (DOI: 10.17605/OSF.IO/439EZ).

3. Results

A total of 1147 records were retrieved from the bibliographic

database searches. After screening and eligibility stages, 80 studies were included in the final analysis (Fig. S1). All the included studies are listed in Table S1 of the Supplementary Material. Inter-rater reliability yielded a Cohen's kappa coefficient of 0.81. Most of the studies were published between 2016 and 2025 (83.7%), with the majority conducted in Europe (37.5%) and Asia (36.2%). Visual impairment was the focus of 41 studies (51.2%), followed by intellectual disability in 19 studies (23.8%) and hearing impairment in 14 studies (17.5%). Six studies (7.5%) addressed several sensory disabilities, referring to a partial or total loss of more than one sensory function (Table 1).

In terms of study design, observational and qualitative or mixed-methods studies were predominant across all types of disability and technology. Randomized controlled trials were rare and were limited to the evaluation of devices for visual or intellectual disabilities. Most studies involved small samples, typically falling within the first and second quartiles (Q1–Q2) of sample size distribution. Larger studies (Q3–Q4) were uncommon. Table 2 provides a detailed description of studies evaluating assistive technologies, organized by type of disability. Table 2 also summarizes key characteristics of the studies, including author, year, country, AT classification, study design, sample size, and primary outcomes assessed.

Studies conducted in adult populations also encompassed older age groups; however, results were often reported in aggregated form, sometimes combining age strata, precluding the estimation of sex- and age-specific proportions. Most studies included patients (n = 44), while others involved multiple stakeholders, including pharmacists, caregivers, and, less frequently, pharmacy students or physicians. Health conditions were unspecified in 71 of studies, although polypharmacy was commonly addressed. Among specified conditions, hypertension was reported in three studies; diabetes, asthma, and glaucoma in two each; and Alzheimer's disease and depression in one study each.

The classification of ATs revealed that devices were the most

Table 1
Characteristics of the included studies (n = 80).

Category	N (%)
Continent	
Europe	30(37.5)
Asia	29(36.2)
North America	16(20.0)
Oceania	3 (3.8)
Africa	1 (1.2)
Type of disability	
Visual	41 (51.2)
Intellectual	19 (23.8)
Hearing	14 (17.5)
Visual plus hearing (sensory)	8 (10.0)
Type of Assistive Technology	
Device	37 (46.2)
Classification by Code	18 (22.5)
Adaptations	12 (15.0)
Services	10 (12.5)
Others/Combined	3 (3.8)
Publication Period	
2001-2010	4 (5.0)
2011-2015	9 (11.2)
2016-2020	23 (28.7)
2021-2025	44 (55.0)
Assessment of Outcomes	23 (28.7)
Main Outcomes Assessed	
Satisfaction or performance	21 (26.2)
Reduction of errors	1 (1.4)
Hospitalization rate	1 (1.4)
Cost Assessed	
Cost Assessment	10 (12.5)
Type of Costs Described	
Low Cost	7 (30.4)
Free	1 (4.3)
High Cost	1 (4.3)
Others	1 (4.3)

Table 2
Description of studies evaluating assistive technologies for medication management, organized by type of disability.

Author, Year (Country)	Assistive Technology Classification	Study Design (Participants)	Outcomes Analyzed
Visual Impairment			
Németh et al., 2007 (Hungary)	Device – Text-to-speech/ Talking system	Two-phase system evaluation (n = 48)	Performance/ Satisfaction
Lertwiriyaprapa et al., 2015 (Thailand)	Device – Electronic packing device	Retrospective case–control study (n = 75)	Performance/ Satisfaction
Spektor et al., 2015, (USA)	Device – Text-to-speech/ Talking system	Retrospective case–control study (n = 84)	Hospitalization rate
Spina et al., 2025, (USA)	Device – Mobile application	Prospective crossover study (n = 41)	Performance/ Satisfaction
Connors et al., 2020, (USA)	Packaging adaptation – Packing device	Repeated-measures study (n = 54)	Performance/ Satisfaction
Shetty et al., 2021 (India)	Information adaptation – Language	Observational survey (n = 100)	Error reduction
Meshram et al., 2022 (India)	Device – Electronic packing device	Performance evaluation (n = 30)	Performance/ Satisfaction
Connors et al., 2022, (USA)	Packaging adaptation – Packing device	Repeated-measures study (n = 54)	Performance/ Satisfaction
Meshram et al., 2023 (India)	Device – Mobile application	Experimental analysis (n = 30)	Performance/ Satisfaction
Merenda et al., 2025 (France)	Device – Talking device + Organizer box	Delphi questionnaire	Medication management
Allemann et al., 2015 (Switzerland)	Device – Electronic packing device	14-day trial and focus group (n = 6)	Performance/ Satisfaction
Wong et al., 2020 (Singapore)	Information adaptation – Language	Prototype testing with user feedback (n = 9)	Performance/ Satisfaction
Dagnachew et al., 2021 (Ethiopia)	Information adaptation – Language	Qualitative phenomenological study (n = 19)	Access to medication information
Alanazi et al., 2025 (Saudi Arabia)	Device – Software	Semi-structured interviews (n = 9)	Information management and access
Hearing Impairment			
Wolters et al., 2015 (UK)	Device – Reminder system	Experimental study with reminders/ distractors (n = 44)	Performance/ Satisfaction
Hyoguchi et al., 2016 (Japan)	Hybrid – Information service + Language	Comparative questionnaire (n = 59)	Performance/ Satisfaction
Jacob et al., 2017 (Malaysia)	Device – Mobile application	Focus groups (n = 10)	Performance/ Satisfaction
Dagnachew et al., 2021 (Ethiopia)	Information adaptation – Language	Qualitative phenomenological study (n = 19)	Access to medication information
Lim et al., 2025 (Canada)	Service – Medication reminder system	Focus group discussions (n = 19)	Performance/ Satisfaction
Intellectual Disability			
Strydom et al., 2001 (UK)	Service – Information service	Randomized controlled trial (n = 54)	Performance/ Satisfaction
Thomas et al., 2014 (USA)	Device – Reminder system	Longitudinal monitoring (n = 2802)	Performance/ Satisfaction

(*continued on next page*)

Table 2 (*continued*)

Author, Year (Country)	Assistive Technology Classification	Study Design (Participants)	Outcomes Analyzed
Sheehan et al., 2017 (UK)	Service – Information service	Mixed-methods assessment (n = 6)	Performance/ Satisfaction
Zhang et al., 2023 (USA)	Service – Information service	Clinical trial (n = 412)	Emergency visits/ Hospitalizations
Chaparro et al., 2021 (Spain)	Device – Medication reminder system	Use-case study (n = 36)	Performance/ Satisfaction
Allemann et al., 2015 (Switzerland)	Device – Electronic packing device	14-day trial and focus group (n = 6)	Performance/ Satisfaction
Alanazi et al., 2025, (Saudi Arabia)	Device – Software	Semi-structured interviews (n = 9)	Information management and access
Chen et al., 2025 (USA)	Service – Information service	Randomized controlled trial (n = 412)	Cost savings

prevalent category (38.8%), including mobile applications, reminder systems, and electronic dispensers. Interventions delivered by health professionals accounted for 22.5% of the total, while informational adaptations (17.5%) and packaging adaptations (6.2%) were less common. Furthermore, 18 studies (22.5%) described interventions that combined two or more technology subtypes and were categorized as mixed approaches.

The most frequently reported ATs across all three disability types were electronic devices for dose monitoring, package opening and identification, alarms, and software with speech or image systems, as well as mobile applications. Other ATs described included adaptations of informational materials and medication packaging with varied textures, colors, shapes, adhesive markers, elastic bands, and Braille labeling.

Services targeting medication use among individuals with disabilities addressed key stages of the medication use process and can be grouped into three categories. Information and communication strategies included educational materials (e.g., leaflets), training initiatives, and adapted approaches (plain language, written communication, lip reading, clear verbal interaction, and sign language interpretation) [24–30]. Assistive formats and resources comprised Braille materials, audio instructions, and tactile or differentiated labeling.[30] Care coordination and follow-up included multidisciplinary interventions, individualized counseling, group discussions, and longitudinal monitoring via telephone or email [31–35].

Visual impairment was the most frequently studied condition. A substantial number of publications focused on device development and packaging adaptations. Intellectual disability was the second most represented condition, with technologies distributed across three main categories. Studies addressing hearing impairment primarily focused on service-based or informational adaptations.

Twenty-three studies (28.7%) evaluated outcomes related to ATs, with user satisfaction and performance being the most common. The majority were pilot studies with a focus group design. Only five studies included samples of 100 or more participants. The most frequently analyzed outcomes were user satisfaction and the effectiveness of the intervention in improving access to medication, as well as knowledge and comprehension of it. Only three studies evaluated clinical outcomes such as emergency visit and hospitalization rates and reduction in medication errors in individuals with cognitive and visual disabilities. Two randomized controlled trials evaluated educational interventions. One study examined 412 Medicaid beneficiaries with intellectual disabilities and hypertension. The intervention group, which received educational text or email messages, demonstrated reduced hospitalizations over a two-year period (see Fig. 1).

Fig. 2 illustrates the relationship between AT categories and evaluated outcomes. Devices (n = 47) were the most frequently investigated category, followed by packaging/adaptation (n = 31) and services (n = 20). Satisfaction/performance (n = 59) was the most common outcome and was assessed across all AT types, particularly devices. Clinical/adherence outcomes (n = 29) were the second most frequent and were observed across all categories. In contrast, cost-effectiveness analyses (n = 3) were rarely conducted and were limited to studies evaluating devices and services. Overall, only 23 studies (28.7%) reported cost-related data.

4. Discussion

This systematic scoping review mapped the scientific literature on ATs for medication management among people with disabilities, identifying 80 eligible studies. Despite a marked increase in publications over the past decade, the findings confirm that the evidence remains fragmented, methodologically limited, and insufficient to support clinical translation or effective policy development.

The primary finding is the pronounced imbalance in the focus of research. Most studies addressed visual impairment, primarily investigating electronic devices and packaging adaptations[30,36–41]. This suggests a preference for addressing more tangible, technology-solvable barriers, such as label reading. More complex challenges associated with hearing and intellectual disabilities, however, remain under-explored. Barriers related to communication and cognition, which often require multimodal or service-based interventions, are notably underrepresented. This highlights a persistent gap in developing equitable solutions across disability profiles.[11,42,43]

Although assistive technologies were categorized according to their form (devices, services, informational and packaging adaptations), their functional role within the medication use process provides additional insight for clinical practice. Across studies, devices such as electronic reminders and dispensing systems primarily supported adherence and dose monitoring, while informational adaptations addressed comprehension barriers. Packaging adaptations were mainly related to medication identification and handling, particularly among individuals with visual impairment. Service-based interventions often addressed multiple steps, including education, access, and follow-up. These findings suggest that assistive technologies may support single or multiple stages of medication self-management, highlighting their potential integration into pharmaceutical care processes.

Another key finding of the evidence map is the issue of methodological fragility. The predominance of small-scale, observational, or qualitative studies, many of which are focused on prototype testing, indicates that the field remains largely confined to assessments of feasibility and acceptability.[11] While these studies are essential for early development, the scarcity of randomized controlled trials (RCTs) and longitudinal designs prevents the reliable evaluation of clinical effectiveness.[44] Consequently, outcome measurement is limited. Most studies assess satisfaction or task performance rather than clinically meaningful outcomes, such as adherence rates, medication error reduction, hospitalizations, and quality of life improvements.[9] The absence of a link between interventions and tangible health outcomes is a significant obstacle to adopting ATs in healthcare systems.[32]

Economic evaluations were also limited. Cost analyses were rare and mostly descriptive. For instance, Allemann et al.[45] estimated the price of prepackaged multidose dispensing devices to be between CHF 10 and 20, whereas Lertwiriyaprapa and Fakkheow (2015)[46] reported that mass production reduced the cost of these devices from USD 100 to 30. Zhang et al. evaluated educational text and phone-based interventions as low-cost alternatives, but they did not specify monetary values.[34] Importantly, few studies conducted cost-effectiveness analyses. Without these evaluations, policymakers and healthcare managers lack the evidence necessary to make informed decisions about funding and reimbursement.[47] Regardless of its potential, innovation cannot be scaled

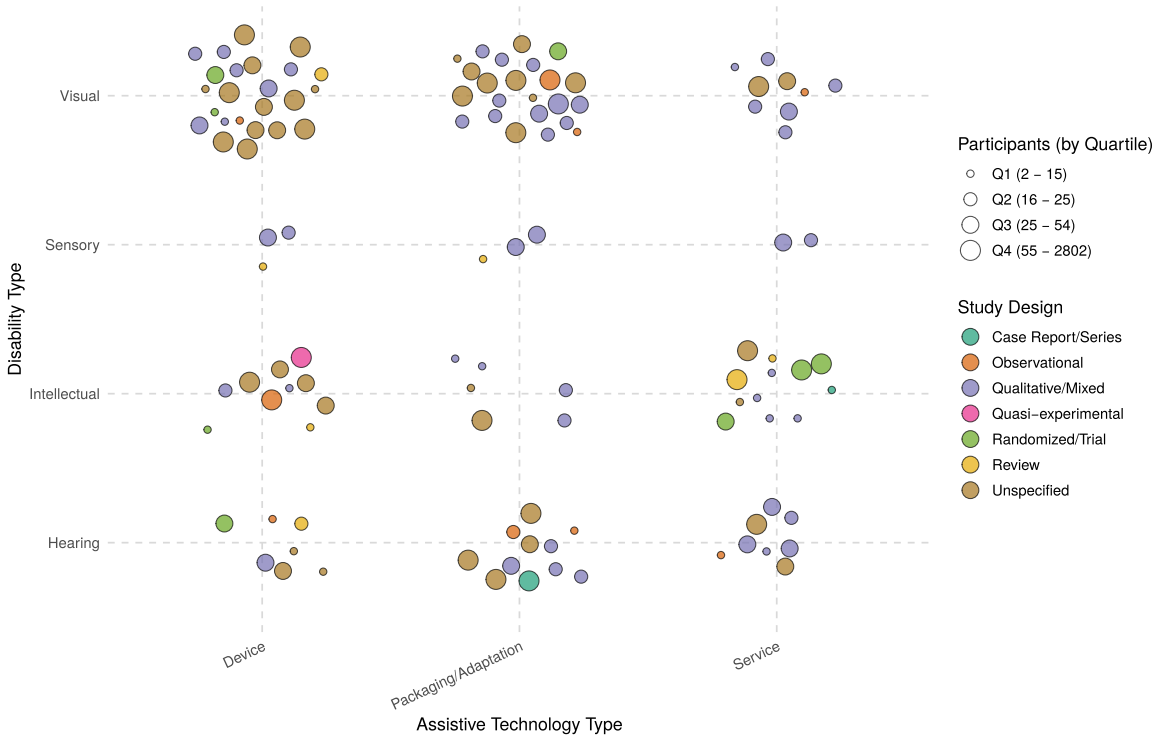

Fig. 1. Distribution of studies by type of assistive technology, type of disability, study design, and sample size (grouped by quartile).

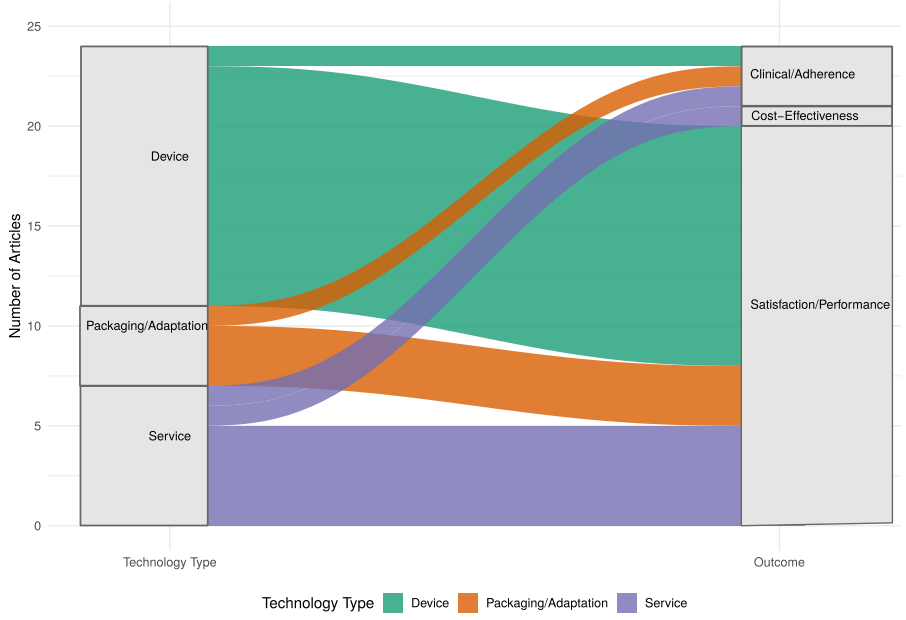

Fig. 2. Flow between assistive technology type and primary outcomes evaluated in the included studies.

sustainably without a clear understanding of its budgetary impact and value compared to standard care.

On the other hand, technologies such as mobile applications, electronic reminders, and adapted packaging appear to be the most scalable within routine pharmacy workflows, as they require minimal structural changes and can be integrated into dispensing and counseling processes. However, important barriers remain, including gaps in the implementation of accessibility standards within health systems and regulatory frameworks, as well as limited reimbursement mechanisms. Pharmacists play a central role in medication management and are directly involved in patient education, adherence support, and monitoring, positioning them as key stakeholders in the implementation, adaptation, and evaluation of assistive technologies. The limited number of studies assessing clinical and economic outcomes highlights a critical gap, reinforcing the need for future research to inform policy decisions and sustainable implementation.

Furthermore, integrating artificial intelligence (AI) into AT could be a paradigm shift for improving accessibility and autonomy for people with disabilities. AI-driven systems, such as adaptive interfaces, speech recognition tools, and conversational agents, can improve communication, facilitate diagnosis, and provide better adherence support, thereby reducing health disparities. However, there are still ethical and

operational challenges. Algorithmic bias, data privacy issues, and the lack of inclusivity in AI model development may inadvertently perpetuate inequities and compromise patient confidentiality.[48] Addressing these challenges is essential for the equitable deployment of AI-enabled ATs.

The findings point to a necessary future research agenda based on four main areas: (i) conduct pragmatic RCTs and evaluate the effectiveness of promising ATs under real-world conditions using validated clinical and adherence outcomes; (ii) focus on underrepresented populations and direct research and innovation efforts toward individuals with hearing and intellectual disabilities, who may benefit most from service-based or multimodal interventions; (iii) integrate economic evaluations by incorporating cost-effectiveness analyses from the initial design phases to inform future technology adoption and funding decisions; and (iv) standardize outcome measures and develop and adopt a core outcome set for AT research in medication management to enable comparability and synthesis across studies. When recommending ATs, healthcare professionals should acknowledge the limited evidence base and prioritize shared decision-making. This involves collaborating with patients to select and adapt tools that best align with their functional abilities and preferences.

This review has some limitations. As a scoping review, methodological quality and risk of bias were not assessed, precluding judgments on study validity. Additionally, although the search strategy was broad, gray literature (e.g., technical reports, conference proceedings) may not have been fully captured, potentially underestimating technologies in early development. Nevertheless, the inclusion of gray literature in evidence syntheses remains debated, with limited evidence of significant influence on review outcomes.[49]

5. Conclusion

ATs have the potential to reduce health disparities and improve medication safety for people with disabilities. However, this review shows that the enthusiasm for technological innovation has surpassed the generation of substantial evidence regarding its effectiveness, safety, and cost-efficiency. In order to translate this potential into real patient benefits, research must shift toward greater methodological rigor, clinically relevant outcomes, and a strong commitment to equity in the design and evaluation of assistive solutions for all disability groups.

CRediT authorship contribution statement

Alice Ramos-Silva: Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Beatriz Dias Cruz:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Fernando Fernandez-Llimos:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Thais Gouvea:** Writing – review & editing, Data curation. **Valcieny Sandes:** Writing – review & editing, Data curation. **Graziela Medeiros:** Writing – review & editing, Data curation. **Patricia Portela:** Writing – review & editing, Data curation. **Aline Guerra:** Writing – review & editing, Data curation. **Elisangela Costa Lima:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

Funding

No external funding.

Declarations of interest

No conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sapharm.2026.05.006.

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