

BMJ Open Impact of digital assistive technologies on the quality of life for people with dementia: a scoping review

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ABSTRACT

Background Digital assistive technologies (DATs) have emerged as promising tools to support the daily life of people with dementia (PWD). Current research tends to concentrate either on specific categories of DATs or provide a generic view. Therefore, it is of essence to provide a review of different kinds of DATs and how they contribute to improving quality of life (QOL) for PWD.

Design Scoping review using the framework proposed by Arksey and O'Malley and recommendations from Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews.

Data sources Cochrane, Embase, PubMed, Scopus and Web of Science (January 2013 to May 2023).

Eligibility criteria for selecting studies Completed scientific literature with a primary focus on DATs for PWD, perspectives of caregivers, family members or healthcare workers in relation to a PWD, people living in diverse settings and all severities of dementia.

Data extraction and synthesis Screening and data extraction were conducted, followed by quantitative and qualitative analyses using thematic analysis principles and Digital Therapeutics Alliance categories for DAT grouping.

Results The literature search identified 6083 records, with 1056 duplicates. After screening, 4560 full texts were excluded, yielding 122 studies of different designs. The DATs were categorised into digital therapeutics (n=109), patient monitoring (n=30), digital diagnostics (n=2), care support (n=2) and health system clinical software (n=1). These categories were identified to impact various aspects of QOL: preserving autonomy, engagement, and social interaction, health monitoring and promotion, improving activities of daily living, improving cognition, maintaining dignity, managing behavioural and psychological symptoms of dementia and safety/surveillance.

Conclusions Various DATs offer extensive support, elevating the QOL of PWD. Digital therapeutics are predominantly used for ageing-in-place and independent living through assistance with daily tasks. Future research should focus on less-represented digital health technology categories, such as care support, health & wellness or software solutions. Observing ongoing DAT developments and their long-term effects on QOL remains essential.

INTRODUCTION

Background

In 2023, more than 55 million individuals worldwide are affected by dementia, with

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The study conducted an extensive search across five electronic databases spanning a decade to identify relevant literature on digital assistive technologies (DATs) and their impact on the quality of life (QOL) for people with dementia.
- ⇒ By excluding conference proceedings, book chapters, pilot and feasibility studies, the review might have missed ongoing or planned research that could offer insights into different DATs or QOL impacts.
- ⇒ While the scoping review approach allowed for a broad overview, it did not assess the quality of included studies or intervention effectiveness, potentially introducing bias and limiting in-depth analysis.
- ⇒ The study's emphasis on patient-facing DATs could have introduced bias, highlighting digital therapeutics in the included literature while potentially overlooking other assistive technology categories.

approximately 10 million new cases diagnosed yearly.¹ Dementia encompasses various impairments regarding language, memory, cognition and the ability to perform daily activities.¹ It progressively worsens over time and primarily affects individuals over 65, however can also affect those younger than 65, known as young onset dementia.¹ Globally, dementia currently ranks as the seventh leading cause of death, significantly contributing to disability and dependency among the older population.¹ The changing demographic landscape presents difficulties for caregivers and our healthcare system. As a result, there is a growing focus on using digital assistive technologies (DATs) to address these challenges and help sustain the independence of people with dementia (PWD).²

DAT is an umbrella term covering technologies used for education and rehabilitation, to overcome participation and activity restrictions, and to improve cognitive, sensory and motor abilities. It encompasses any technology that empowers individuals with functional constraints in everyday routines, educational pursuits, occupational

endeavours or recreational engagements.³ DATs offer a valuable means for individuals and caregivers to manage various aspects of their daily routines effectively. They hold great promise for the care and support of PWD, and to alleviate the challenges associated with caregiving, such as maintaining autonomy and dignity.⁴ Here, autonomy can be understood as the principle for self-governance and decision making, where capacity is closely related to consent. However, as PWD progress along their dementia journey, their decision-making capacity may start to be impacted, and therefore maintaining dignity shifts as the greater value. Therefore, both these concepts require a commitment from caregivers in order to provide a quality of care, and hence also form important considerations from rising DATs.

Recently, technological advancements have paved the way for creating devices and applications that leverage sensory data tailored specifically for PWD. Notably, smart-phones and wearables are now being employed to track physical activities, enabling in-home care assistance⁴ and serving as location trackers for monitoring wandering behaviour.⁵ Moreover, the emergence of artificial intelligence has led to the development of social assistive robots. These robots are designed to provide companionship and engage in therapeutic activities, such as the robotic seal Paro, which serves as an illustrative example.⁶ These technologies extend beyond basic assistance with daily tasks; they also contribute to the preservation of social interactions, memory support, participation in leisure activities, location tracking and health monitoring.^{2,7}

Maintaining a good quality of life (QOL) is essential for PWD and must be considered when assessing the impact of DATs. QOL encompasses physical and mental well-being and extends to social and emotional dimensions (eg, emotional stability, social integration or self-esteem).⁸ Various tools such as questionnaires and self-assessment scales measure the overall perceived QOL; activity-based assessments or cognitive status evaluations serve as diverse means for quantifying QOL.⁹ Consequently, these measures and evaluation instruments should be regarded as guiding tools in determining the QOL experienced by PWD.

While the current literature focuses on specific classes of DATs, often highlighting particular outcomes, there is a lack of a comprehensive overview of the different DATs and their impact on the QOL of PWD. This scoping review aims to fill this gap.

Objectives

The primary aim of this scoping review is to provide an overview of DATs for PWD and the ways in which they influence an individual's QOL. Therefore, the following research question was formulated: 'What is the impact of DATs on the QOL for people with dementia?'

In this scoping review, the opportunities of DATs and their role in enhancing caregiving practices and the QOL of PWD were investigated. Through a compilation of prevailing literature, this review can enhance

the decision-making process by facilitating stakeholders' comprehension of the spectrum of accessible DATs and their efficacy in effectively elevating the QOL as a secondary objective.

METHODS

Search strategy

The methodological framework proposed by Arksey and O'Malley¹⁰ and the recommendations from PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation¹¹ were adopted to conduct this scoping review. A protocol for the scoping review was published on 13 December 2023¹² and the study was preregistered on the Open Science Framework Registry on 5 May 2023 (<https://osf.io/zcnx8/>).

Search terms were derived from a preliminary search and analysed by comparing the words found in titles, abstracts and keywords, following a 'patient/population, intervention, outcome' (PIO) concept. Additionally, to enhance the accuracy and comprehensiveness of the search results, all authors were involved in a consensus process, and an additional expert was consulted to validate the identified terms and suggest any additional relevant keywords. A comprehensive search was performed on 17 May 2023 across five electronic databases: Cochrane, Embase, PubMed, Scopus and Web of Science, to locate published literature surrounding the research question. To focus on recent technological advancements, only articles published between 1 January 2013 and 17 May 2023 were considered, allowing for a more up-to-date review. The search terms using the PIO table and full electronic search strategy can be seen in online supplemental file 1.

Inclusion and exclusion criteria

The articles were screened following specific inclusion and exclusion criteria, established by all authors and consolidated by an additional expert. Table 1 shows the eligibility criteria to ensure the relevance of the included studies to the research question.

Screening, data extraction and analysis

The search results were extracted and uploaded onto a literature review software, Rayyan (www.rayyan.ai) for screening. From May to June 2023, CS and RV screened all eligible articles' titles and abstracts to determine their suitability for a full-text review according to the inclusion and exclusion criteria. Potential discrepancies were discussed between the authors and resolved through discussion and consensus. CS piloted the data extraction using five articles; checked and consulted by RV. An example of the data extraction form is described in online supplemental file 2. A full-text review of the final sample of included studies was conducted by CS and further consolidated by RV. A critical appraisal of individual sources of evidence was not done for this scoping review as it is beyond the scope of this article.

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
▶ Scientific literature (completed) ▶ Articles that have a primary focus on DATs for PWD ▶ Articles discussing perspectives of caregivers, family members or healthcare workers in relation to a PWD ▶ Articles about people living in diverse settings including communities, hospitals or nursing homes and all severities of dementia. We will not use age as a criterion	▶ Articles not in English or German ▶ Articles that discuss dementia negligibly or with other comorbidities/health conditions ▶ Articles that mention DATs briefly or as an insignificant part of a review ▶ Pilot or feasibility studies that only report the implementation of an intervention ▶ Book chapters, commentaries, conference proceedings, editorials, interviews, opinion pieces, proposals, reports, protocols, short news ▶ Non-human studies

DATs, digital assistive technologies; PWD, people with dementia.

A narrative synthesis accompanied by frequency analysis was performed of the included literature to present findings on (1) author locations, (2) study approach, (3) type of article (4) study locations, (5) digital health technology (DHT) categories (see Coding strategy), (6) target population and (7) instruments measuring QOL. The QOL measures were initially evaluated according to the protocol.¹² Based on a pilot of the extraction of the articles, it became obvious that there was rarely one distinct 'QOL instrument' used throughout all articles. However, these metrics were discovered to be excessively diverse and unsuitable to be reported consistently, leading to their omission. Instead, indirect outcomes, which also influence the QOL, were additionally recorded (eg, activity instruments, cognitive status, rating of the individual's QOL, etc⁹). Furthermore, the protocol outlined the analysis of the type of DATs and sensory distribution channels.¹² During the extraction of the articles, it became evident that the type of DATs and sensory distribution channels would not provide consistent reporting across the studies, and were instead replaced with DHT categories. Several studies discussed different DATs employing distinct sensory distribution channels, making it impossible to provide a uniform report, resulting in their exclusion.

Coding strategy

The codes for QOL measures/outcomes were generated by CS and RV based on thematic analysis.¹³ The Flanagan Quality of Life Scale served as the basis for the code, which forms the general ideas about concepts for evaluating the QOL.¹⁴ In addition, QOL scales such as QOL-AD and DQOL were explored to identify relevant concepts for

PWD.¹⁵ Physical, social and environmental concepts were also included to have a broader impact on QOL than just health-related QOL.¹⁶ Ethical considerations were integrated into the coding strategy by drawing on principles of biomedical ethics (ie, dimensions such as autonomy and dignity).¹⁷ Furthermore, it should be noted that the priorities of these principles may shift as an individual's dementia progresses. For instance, autonomy might be more important for individuals with mild dementia, while maintaining dignity becomes paramount for those with severe dementia. This consideration enabled providing a holistic overview of QOL dimensions across all stages of dementia, aligning with the evolving ethical dimensions of care. CS applied the codes to the articles using the ATLAS application (www.atlasti.com), and uncertainties were resolved by RV.

All the included studies were initially categorised using an inductively created classification scheme. However, it became apparent that this method was inadequate for representation purposes. Subsequently, the classification scheme was deductively realigned with the Digital Therapeutics (DTx) Alliance categories, and all the studies were reclassified accordingly.

The DTx Alliance introduced eight (industry-facing and admin-facing, healthcare provider and patient-facing) DHT categories: non-health system software/digital health solutions, health system operational software, health system clinical software, health & wellness, patient monitoring, care support, digital diagnostics and digital therapeutics.¹⁸ To apply these categories to the included studies, some of the definitions were adapted (see [table 2](#) for an adapted version of the definitions):

- ▶ Initially, the patient monitoring category exclusively monitored specific patient health data. However, in the context of this scoping review, location data were included as well to be able to classify studies that discuss tracking devices.
- ▶ Only studies explicitly mentioning self-management or similar concepts were assigned to the care support category. Otherwise, nearly all papers would qualify for this category, as they predominantly aim to assist patients in various ways.
- ▶ The criteria for the digital therapeutics category have been refined and a broader range of digital technologies was encompassed that generate and deliver medical interventions, while the initial definition pertained to 'health software designed to treat or alleviate a specific disease or medical condition by generating and delivering a medical intervention'.¹⁸ It is important to note that not all of them qualify as medical devices or products, and may not be subject to regulation based on the adapted definition for the purpose of this scoping review.

Patient and public involvement

Patients and/or public were not involved in this research.

Table 2 The eight DHT categories with their adapted definitions and examples

Industry and admin-facing			Healthcare providers-facing		Patient-facing			
DHT category	Non-health system software/DH solutions	Health system operational software	Health system clinical software	Health & wellness	Patient monitoring	Care support	Digital diagnostics	Digital therapeutics
Overview	Health Information Technology (HIT) and digital health (DH) solutions are designed for stakeholders outside of the hospital and health system settings, such as pharma, medtech, insurances, employers and pharmacies.	Enterprise HIT is aimed at delivering benefits and facilitating support for non-clinical functions (ie, operational and financial aspects).	Enterprise HIT and DH solutions are designed to offer clinicians assistance in effectively managing their patient populations. Divided into four subcategories: clinical documentation & image archiving, communication support, clinical decisions support and telehealth. ¹⁴¹	DH solutions are not specific to any particular disease and primarily focus on capturing and storing general health information while encouraging and facilitating a healthy lifestyle, and do not deliver any medical interventions.	Digital solutions to monitor specific (health or location) data that can be interpreted by a physician to assist in decision making for a medical procedure, or inform a caregiver or family member.	Digital solutions are created to assist patients in improving their self-management of a specific disease or medical condition. May offer recommendations or information but they do not deliver medical treatments.	Verified digital tools and software that provide a diagnosis or prognosis for a particular disease or medical condition.	Any digital technologies that address or mitigate a disease by generating and implementing a medical intervention.
Examples	Accounting Software, documentation tool for compliance.	Software for patient bed management, data & analytics platforms.	Platform for electronic medical records and clinical communications.	Motivational tools, health diaries.	Tracking devices detecting falls, GPS, wearables.	Static care support (medication tracker application), responsive care support.	Apps for dementia screening, algorithm returning a measure of Alzheimer's disease severity.	Robots, Apps, multimedia systems, Augmented Reality/Virtual Reality.

Source: DTx Alliance (<https://dtxalliance.org>).^{18 141}
DH, digital health; DHT, digital health technology; HIT, health information technology.

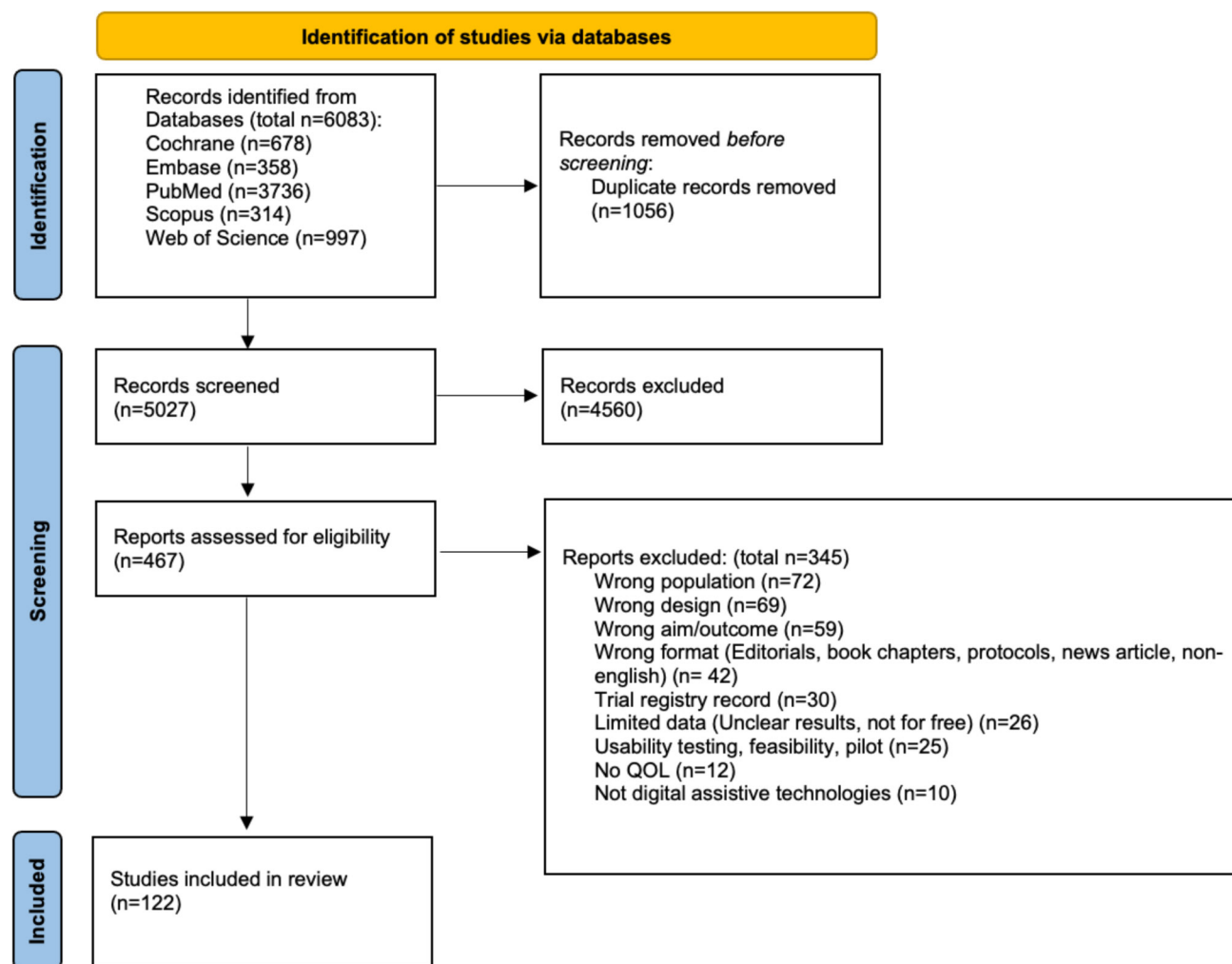


Figure 1 PRISMA flow chart. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; QOL, quality of life.

RESULTS

Search findings

The search identified 6083 records from the electronic databases. A total of 1056 duplicates were identified and removed, leaving 5027 articles and trial records to be screened. Title and abstract screening led to the exclusion of 4560 records, resulting in 467 full texts that needed to be assessed for eligibility. Of these, 122 studies were included (see online supplemental file 3) and 345 were excluded for the following reasons: 72 did not focus only on PWD or their results could not be separated (wrong population), 69 had the wrong design and 59 pursued wrong aims or outcomes, 42 were the wrong publication type or language (ie, editorials, book chapters, protocols, news articles, non-English), 30 were only trial registry records, 26 could not be accessed, 25 were either pilot, feasibility or usability studies which only tested the viability of intervention, 12 did not deal with QOL and 10 did not include DATs. These are reported in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart in [figure 1](#).

Characteristics of included studies

Scientific literature from 1 January 2013 to 17 May 2023 was included to capture the most recent findings. [Figure 2](#) represents the number of articles published for each year in the date range included for this scoping review.

The authors' location was collected for each study, ensuring unique country attribution per study while capturing all countries affiliated with each author. There were 180 entries recorded. The countries with the highest number of entries were the UK (n=38, 21.1%), Australia (n=17, 9.4%), the USA (n=14, 7.8%), Canada, China and Norway (n=11, 6.1% each). Notably, European countries showed significant numbers of contributions, including Germany and the Netherlands (n=8, 4.4% each). Sweden and Italy (n=6, 3.3% each) and France (n=4, 2.2%). From the Asian and Oceania continent, contributions were made by Japan (n=6, 3.3%), Taiwan and South Korea (n=5, 2.8% each), New Zealand and Singapore (n=3, 1.7% each), Pakistan and Qatar (n=2, 1.1% each) and India, Indonesia and Malaysia (n=1, 0.6% each). From the African continent, there were only contributions from South Africa (n=4, 2.2%). Some countries, such as

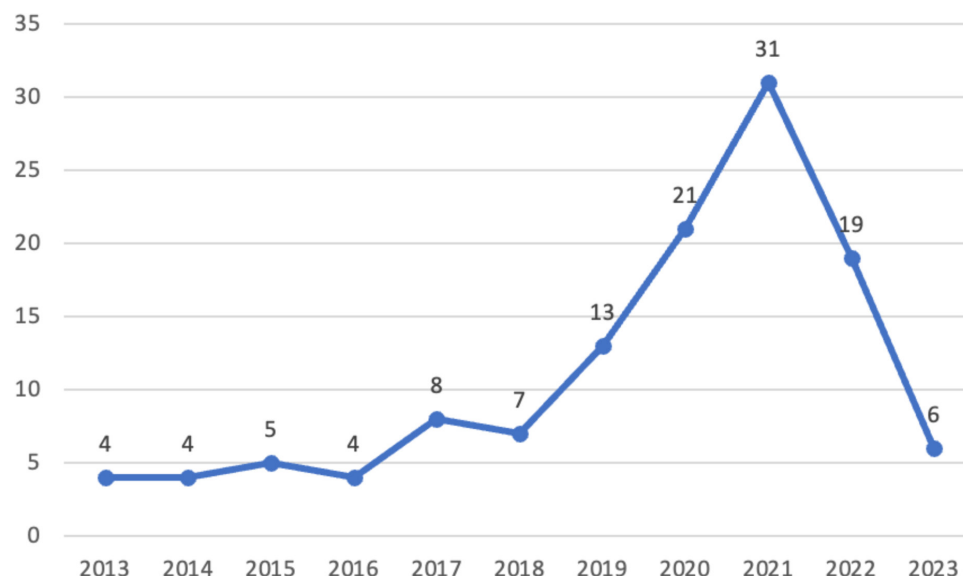


Figure 2 The graph displays the trend of the number of studies published per year.

Brazil, Cyprus, Czech Republic, Denmark, Greece, Malta, Portugal, Spain and Switzerland, had limited representation, with only 1–2 (0.6%, 1.1%, respectively) contributions each (figure 3).

A variety of study designs were used in the included studies (figure 4), comprising of 56 (46%) reviews, 16 (13%) randomised controlled trials (RCTs), 15 (12%) case studies, 13 (11%) intervention studies, 8 (6%) pilot or feasibility studies, 5 (4%) interviews/surveys, 5 (4%) trials, 2 (2%) cohort studies and 2 (2%) observation studies.

In total, there were 36 (30%) quantitative studies, 52 (43%) qualitative studies and 34 (28%) that adopted a mixed-methods approach.

The study locations were diverse with 73 different study locations identified. The highest number of studies was carried out in the UK (n=15, 20.5%), followed by Australia (n=9, 12.3%), the USA (n=7, 9.6%), Sweden (n=6, 8.2%) and Norway (n=5, 6.8%). Other locations included Canada, Italy and the Netherlands (n=4, 5.5% each), Denmark and France (n=3, 4.1% each) and Japan and Taiwan (n=2, 2.7% each).

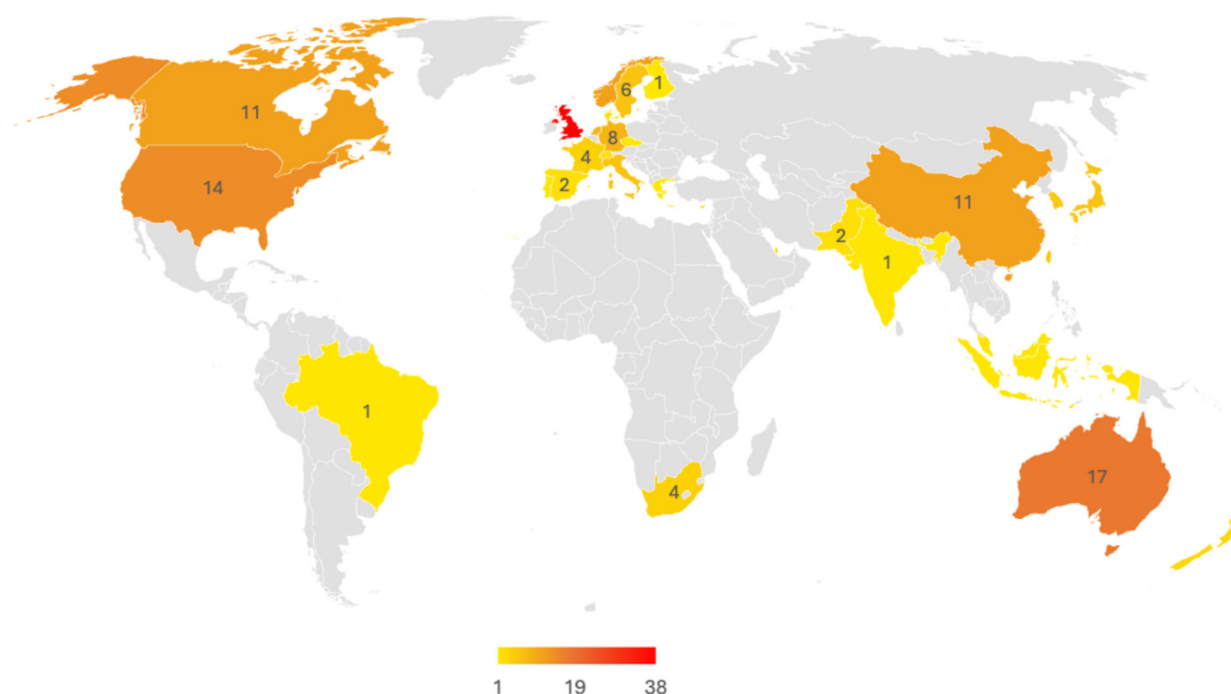


Figure 3 Distribution of the authors' locations. The countries are coloured based on the number of country attribution, while encompassing all countries associated with each author.

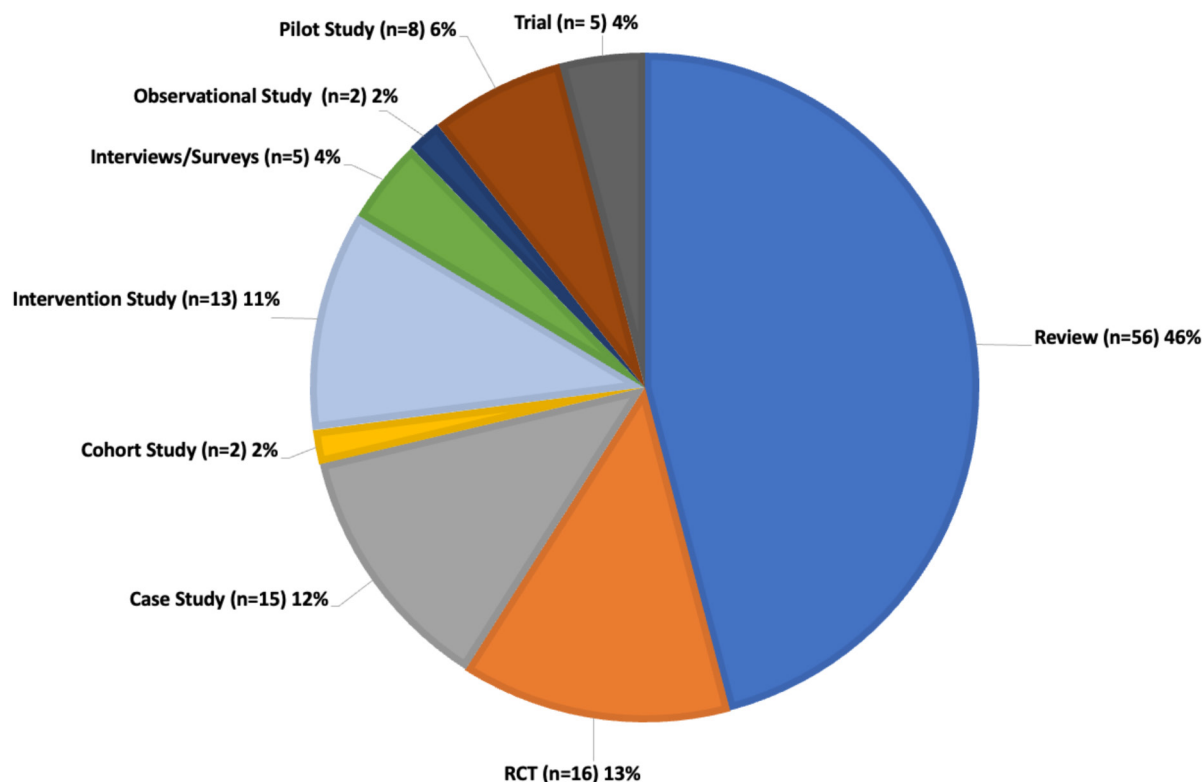


Figure 4 The distribution of the study designs. RCT, randomised controlled trial.

There was one study (1.4%) each from China, Cyprus, Germany, Ghana, Greece, Korea, New Zealand, Singapore and Spain. Within these locations, different study settings were used; home-based (n=25, 33.8%), residential care (n=10, 13.5%), long-term care and nursing homes (n=9, 12.2% each), daycare centres (n=7, 9.5%), community-based and hospital (n=4,

5.4% each), other care facilities or memory clinics (n=3, 4.1% each) and a laboratory setting (n=1, 1.4%).

Diverse target groups of the included studies were identified, as presented in [table 3](#). As indicated in the review process and as part of the exclusion criteria, only research articles that could separate results for PWD from other comorbidities or conditions were included.

Table 3 The different target groups of the included studies sorted by the number of studies

Target population of the included studies	Number of studies (%)	References
PWD	72 (59)	8 21–27 45–59 66–77 84–105 115 116 120–123 126–132 137 142
PWD and caregivers	31 (25.4)	19 28–39 60–63 78–80 106–108 114 117 118 124 133 138 143
PWD and MCI patients	4 (3.3)	20 40 41 119
PWD and healthy adults	4 (3.3)	81 109 134 135
PWD, caregiver and stakeholders	3 (2.5)	42 64 110
Diverse stakeholders	2 (1.6)	82 83
PWD with chronic pain	1 (0.8)	111
PWD, MCI patients and cognitive impairments	1 (0.8)	112
PWD, MCI patients and caregivers	1 (0.8)	43
PWD, MCI patients and healthy adults	1 (0.8)	65
PWD and psychiatric disorders	1 (0.8)	113
PWD and Parkinson's disease patients	1 (0.8)	136

The frequency of each class is indicated (as the number of studies), along with the corresponding references.
MCI, mild cognitive impairment; PWD, people with dementia.

Table 4 The different classes of DATs

DHT category	Number of assigned DATs (%)	References
Non-health system software/DH solutions	0	–
Health system operational software	0	–
Health system clinical software	1 (0.7)	114
Health & wellness	0	–
Patient monitoring	30 (20.8)	19–33 35–44 46 88 90 137 138
Care support	2 (1.4)	30 45
Digital diagnostics	2 (1.4)	30 46
Digital therapeutics	109 (75.7)	8 21–23 25–31 33 35 37 40 41 44–75 77–113 115–124 126–136 138 142 143
Total	144	

The frequency of each category is indicated, along with the corresponding references. DATs, digital assistive technologies; DH, digital health; DHT, digital health technology.

Characteristics of DATs

Categories of DATs

The DATs of the 122 included studies underwent classification into the DHT categories provided by the DTx Alliance.¹⁸ Some studies discussed different DATs and therefore were assigned to multiple categories due to their varying applicability (see [table 4](#)).

Qualitative aspects of QOL

Positive impact of DATs on QOL dimensions

Through qualitative analysis of the included studies, recurring themes were identified that reflect the different aspects of how DATs influence QOL for PWD: preserving autonomy, engagement and social interaction, health monitoring and promotion, improving activities of daily living (ADL), improving cognition, maintaining dignity, managing behavioural and psychological symptoms of dementia (BPSD) and safety/surveillance (online supplemental file 4). These concepts can influence each other, and it is possible for a single DAT to simultaneously have multiple effects. In the following sections, these impacts will be discussed in more detail based on the analysis of the included studies.

Preserving autonomy

Autonomy can be understood as an individual's ability to be involved in decision making, consent, receiving treatment or intervention (ie, to choose and act independently without coercion).¹⁷ Within healthcare, the preservation of autonomy has emerged as a significant topic, most importantly known as the principle of respect for autonomy. DATs can be seen as a useful tool for promoting autonomy and, therefore, positively contributing to PWD's lives. The use of DATs is intended to increase the capacity of an individual to participate in decision making^{19 20} and promote independent living, and enable ageing-in-place.²¹

From 50 of the included studies, the following were used to promote autonomy: patient monitoring,^{19–44} care support^{30 45} and digital therapeutics.^{8 21–23 25–31 33 35 37 40 41 44–65}

Engagement and social interaction

The topic of engagement and social interaction was highlighted in 64 studies. They differentiated between cases where DATs increased social interaction^{23 31 40 54–56 58 64 66–83} and fostered higher engagement (ie, in therapy settings).^{8 20 23 31 44 45 53 55 61 63–65 68 69 71–73 77 79 82 84–113}

Sixty-two of the included studies demonstrated that digital therapeutics play a significant role in promoting social interaction and engagement,^{8 23 31 40 44 45 53–56 58 61 63–75 77–113} including other DATs from the patient monitoring⁴⁰ and care support categories.^{30 45}

Health monitoring and promotion

Health monitoring refers to monitoring bodily functions and reporting their states or imbalances. Ten studies reported using DATs to monitor and promote health for PWD.^{21 23 30 32 37 40 41 46 56 114} This was achieved, for example, through social assistive robots⁵⁶ and wearables,³² including wristwatches that measure movement, skin temperature and pulses.³⁷

Improving ADL

DATs support PWD in maintaining or regaining their ability to perform ADL such as meal preparation, managing medication or communication. Forty-five of the included studies highlight this field's broad spectrum of possibilities, for instance, they range from the implementation of interventions from the patient monitoring category,^{20 24 26 29 31 33 34 40 43} care support,^{30 45} to digital therapeutics.^{8 22 25 26 28–31 33 35 37 40 45–53 55–63 65 86 94 97 103 107 115–119}

Improving cognition

The varied application of DATs can enhance cognitive abilities, as indicated by 34 studies. They demonstrated that patient monitoring,⁴³ care support^{30 45} and digital therapeutics^{21–23 26–28 30 31 40 45 46 53–55 65 71 75 83–85 90 95 98 103 115–117 119–124} can lead to improvements in cognitive functioning.

Maintaining dignity

In contrast to autonomy, dignity refers to the ability to preserve self-respect and personhood, while being

recognised and valued in society, and discussed in 13 studies using diverse DAT categories: digital therapeutics^{21 25 35 41} and patient monitoring.^{8 21 22 25 35 41 56 58 62 77 78 81 108} These categories are specifically designed to uphold and promote ageing in place, as demonstrated in the review of Gettel *et al.*²¹ by the use of pet robots to maintain the resident's dignity and self-worth.⁷⁸

Managing BPSD

There are 12 BPSD, which include aberrant motor behaviour, agitation, anxiety, apathy, appetite changes, delusions, depression, disinhibition, elation/euphoria, hallucinations, irritability and sleep changes.¹²⁵ Different BPSD were shown to be managed by DATs in 64 studies through digital therapeutics^{8 23 26–28 30 40 41 48 55 60 67–72 75 77 78 81–86 88 89 91–93 95 97–102 104 105 107 109 111–113 115–117 120 122–124 126–136} or by patient monitoring devices.^{30 48 69 86 93 98 133} All the DATs were reported to have a positive effect on BPSD.

Safety/surveillance

Thirty-four of the included studies demonstrated that DATs can enhance the safety of PWD, for instance through patient monitoring,^{19–31 33–44 46 88 137 138} care support³⁰ and digital therapeutics.^{21 23 25–27 29–31 37 44 49 53 56 62 71 138}

Negative impacts of DATs on QOL dimensions

Among the included studies, 18 studies reported negative impacts of DATs on the QOL.^{8 25 38 41 53 55 56 60 61 63 65 81 97 101 104 120 127 130} These negative impacts included increased anxiety,^{8 81 97} worsened agitation,¹²⁷ decreased interactions with caregivers,⁵⁵ confusion,⁵³ worsened BPSD,^{31 53 127} increased hallucinations and decreased mood,⁵³ anxiety towards the technology,^{8 75 81} as well as aggression, rejection or disliking the technology.⁸¹

Instruments measuring the QOL

As demonstrated, DATs can diversely impact aspects of QOL. It was observed that numerous studies employ specific measures to assess these impacts, which can manifest in various forms. During the charting process, 33 studies revealed the utilisation of different units of measurement in this context. In 18 studies, the *Quality of Life in Alzheimer's Disease Scale (QOL-AD)* was used,^{8 22 41 48 55 67 71 77 92 95 97 105 110 112 115 122 127 130} and in 11 studies, the *Quality of Life in Late-Stage Dementia scale (QUALID)*.^{8 27 60 70 71 77 97 112 126 127 134} Additionally, the *self-reported Dementia Quality of Life measure (DEMqOL)* was employed in 4 studies,^{60 79 97 114} the *Dementia Quality of Life Instrument (DQoL)* in 3 studies^{27 28 71} and the *EQ-5D-5L* in 3 studies.^{60 62 124} Other measuring instruments were used only once in each case: *Quality of Life (GQL8)*,¹¹⁹ *Quality of Life for People with Dementia (QUALIDEM)*,⁷¹ *Quality of Life Alzheimer's disease (QoL) scale*,¹¹⁷ *SF-36 quality of life instrument*,³² *Cantril QoL ladder*,⁹³ *Carer-QoL-7D*,⁷⁹ *EUROHIS-QoL-8* and *EuroQoL 5 Dimension Questionnaire*.⁸

DISCUSSION

This scoping review and synthesis of 122 studies provided a detailed mapping of the different kinds of DATs available which target QOL for PWD, and the diverse study designs contributing to the research community. This is particularly useful for future researchers to identify whether certain designs (ie, reviews, n=56) have been more extensively explored than others (ie, RCTs, n=16; case studies, n=15), encouraging more empirical evidences to be reached in order to truly understand the effects of DATs in improving the QOL of PWD.

DATs were categorised into the *DTx Alliance* categories, with the largest category being digital therapeutics (n=109), followed by patient monitoring (n=30), digital diagnostics (n=2), care support (n=2) and health system clinical software (n=1). This distribution can be attributed to the search strategy, which specifically targeted DATs with a therapeutic focus.

This review highlights that DATs have the potential to impact the QOL of PWD in several identified thematic areas: preserving autonomy, engagement, social interaction, health monitoring and promotion, improving ADL, cognition, maintaining dignity, managing BPSD and safety/surveillance. The different categories of DATs can provide diverse forms of support to PWD across these thematic areas, enhancing their overall QOL. DATs help PWD to age in place, live independently and maintain their dignity, especially when supported by DATs that help PWD keep or regain their ability to engage in daily activities. DATs were also shown to help promote health by tracking bodily functions and encouraging engagement and social contact. Overall, impacts could be seen on individuals' cognitive abilities, to manage BPSD, and improvements to their general well-being and safety.

However, in a few instances, negative impacts of DATs on the QOL of PWD were also identified.^{53 55 81 97 127} For example, worsened BPSD, worries about negative results, anxiety and aggression towards the technology, or disliking the technology.

In addition to the qualitative impacts, various quantitative quality-of-life instruments were examined. It was found that 12 different instruments were used across 18 of the included studies. The most frequently employed instrument was the *Quality of Life in Alzheimer's Disease Scale (QOL-AD)*. Furthermore, it was observed that DATs are used to support therapy,²⁷ and can serve as therapeutic tools to even constitute a distinct form of therapy in themselves.⁸⁴

Strengths and limitations

This scoping review first attempted to provide an extensive overview of various DATs and their impact on the QOL for PWD. A comprehensive search strategy was implemented to achieve this, covering five electronic databases over a decade. However, considering the rapidly expanding landscape of DATs and the exclusion of conference proceedings, book chapters, pilot and feasibility studies, it is conceivable that this scoping review might overlook

ongoing or planned studies that could shed light on alternative DATs or different impacts on QOL. Additionally, concepts of autonomy and dignity were not incorporated in the initial search strategy as their prominence in relevant literature was only discovered by authors during the coding stage. Therefore, there is a possibility that this could have led to some missed studies relating to these concepts. Further, it should also be pointed out that while ‘accessible DATs’ were not further defined in the objectives of this study, we used the terms colloquially to imply that there might be solutions that cannot be accessed by our search strategy.

Conducting a scoping review instead of a systematic review has its limitations. In this approach, an assessment of the quality of the included studies or an evaluation of intervention effectiveness needs to be incorporated. Therefore, the validity of interventions on their measured outcomes may present bias or need to be better analysed and reported in included studies. The search strategy prioritised patient-facing DATs, thereby introducing a potential bias that elucidates the high predominance of digital therapeutics in the included literature. Another limitation of this work arises from the challenge of providing a conclusive quantitative assessment of the effects of DATs on QOL. While the primary objective of our work was to offer a comprehensive and broad understanding of the subject, we envision that this scoping review can lay the groundwork for subsequent systematic reviews and meta-analyses, which would employ specific research questions and analytical strategies for dedicated quantitative evaluations.

Nonetheless, due to the restricted availability of evaluative research in this domain, the primary objective was to explore the impact of DATs on the QOL for PWD, which this study has provided.

CONCLUSION

A variety of DATs are available, offering versatile applications and holding the potential to serve as promising instruments for enhancing the QOL among PWD. Further research must be conducted to examine the ongoing developments in DATs and their increasing impact on QOL, including their long-term effects, and a deeper conceptual understanding of how certain interventions correlate to improving QOL. Moreover, future research could consider placing a particular emphasis on the less-represented DHT categories, such as care support, health & wellness or software. Digital innovations offer significant potential in addressing the global increase in the elderly population and revolutionising various aspects of elderly care.⁴ Considering future research directions, for example, in the context of voice assistants and advancements in large language models,^{139 140} would be of importance, as they facilitate the development of an interface that is more intuitive and natural, without demanding a high degree of dexterity.

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