

**Promotors and barriers to the implementation and adoption of
assistive technology and telecare for people with dementia and
their caregivers: a systematic review of the literature**

Lydia D. Boyle, MPhil Candidate, lydia@bergensportsmed.no

Supervisors:

Bettina S. Husebø, Professor, MD, bettina.husebo@uib.no

Maarja Vislapuu, PhD Candidate, maarja.vislapuu@uib.no



Centre for International Health and Center for Elderly and Nursing Home Medicine

Department of Global Public Health and Primary Care

Faculty of Medicine

University of Bergen, Norway

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Lydia D. Boyle, PT, DPT

This thesis is submitted in fulfilment of the requirements for the degree of
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Department of Global Health and Primary Care
Faculty of Medicine
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AD	Alzheimer's Disease
ATT	Assistive Technology and Telecare
BPSD	Behavioral and Psychological Symptoms of Dementia
DSM-5	Diagnostic and Statistical Manual of Mental Disorders
EOD	Early Onset Dementia
IoT	Internet of Things
LMIC	Low-and Middle-Income Countries
PD	Parkinson's Disease
PwD	Persons with Dementia
SARs	Social Assist Robots
WHO	World Health Organization
MMSE	Mini Mental Status Evaluation
FAST	Functional Assessment Staging Tool
CDR	Clinical Dementia Rating scale
CASP	Critical Appraisal Skills Programme
UTAUT	Unified Theory of Acceptance and Use of Technology
MIDI	Measurement Instrument for Determinants of Innovation
MRC	Medical Research Counsel framework
PARIHS	The Promoting Action on Research Implementation in Health Services
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RE-AIM	Reach, Effectiveness, Adoption, Implementation and Maintenance

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ABSTRACT

Background

One of the most pressing issues in our society is the provision of proper care and treatment for the growing global health challenge of ageing. Assistive Technology and Telecare (ATT) is a key component in facilitation of safer, longer, and independent living for persons with Dementia (PwD) and has the potential to extend valuable care and support for caregivers (formal and informal) globally. Results of this systematic review are of key importance because well-executed ATT implementation, leading to habitual usage and adoption, can assist and strengthen current healthcare services, improve access to healthcare and decrease societal and caregiver burden.

Objective

The objective of this study is to identify promoters and barriers to implementation and adoption of ATT for PwD and their informal (family and friends) and formal (healthcare professionals) caregivers. In addition, we aim to provide valuable insight for municipalities and healthcare organizations for improved implementation strategies.

Methods

The study was registered in PROSPERO 25th of February, 2021: CRD42021239448. NVivo was utilized for synthesis and analysis of article content. As the results were from diverse disciplines using varied methods of analysis, a semi-systematic approach with narrative synthesis was used for the review. PICO criteria and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines have been used to guide all processes and results. Rayyan and NVivo were utilized for selection of articles and analysis of found themes. In addition, the Critical Appraisal Skills Programme (CASP) has been used to visualize meta-synthesis and meta-analysis results and overall quality of included literature.

Results

This review encompasses relevant information regarding the implementation and adoption of ATT for PwD and their caregivers from five continents and sixty-five countries. It is a true global representation of the growing challenge of ageing. In total, 32 publications were included for review.

Identified primary promoters for the implementation and adoption of ATT were as follows: personalized (tailored) training and co-designed solutions, safety for the PwD, involvement of all relevant stakeholders (multi-faceted approach including PwD), ease of use and support (design and follow up), and cultural relevance. Main barriers for the implementation and adoption of ATT included: unintended adverse consequences, timing and disease progress, technology anxiety, system failures (connectivity, errors, etc.), digital divide and lack of access to or knowledge of available ATT.

Conclusions

The most crucial elements for the adoption of ATT in the future will be a focus on co-design, improved involvement of both the PwD and their caregivers, and the adaptability (tailoring related to context) of ATT solutions over time (disease process). 94% of the literature presented in the review comes from high income countries. There is a significant need for more quality research to be conducted in the regions of the world where population growth and prevalence of dementia is expected to grow most rapidly over the next 30 years.

BACKGROUND

Dementia Etiology

Dementia is an umbrella term used to describe varying conditions which cause progressive and varying degrees of impairment in memory, executive and perceptuomotor functioning, learning, language and cognition (Hugo and Ganguli 2014). Behavioral and Psychological Symptoms of Dementia (BPSD) is defined by the spectrum of non-cognitive and non-neurological symptoms of dementia, such as agitation, aggression, psychosis, depression and apathy. Up to 80% of people with dementia experience BPSD and depression and anxiety can be among the first symptoms of dementia. These symptoms are the primary reason for people with dementia being admitted into residential care.

The degree of dementia is measured along a continuum (Figure 1) and dependent on involvement and impact on functional daily activities (Aisen, Cummings et al. 2017). The current diagnostic criterium for dementia are defined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). The DSM-5 classifies dementia as a Neurocognitive Disorder (Hugo and Ganguli 2014). Despite the classification by the DSM-5 there is still a great deal of confusion, myth and stigma surrounding dementia etiology globally.

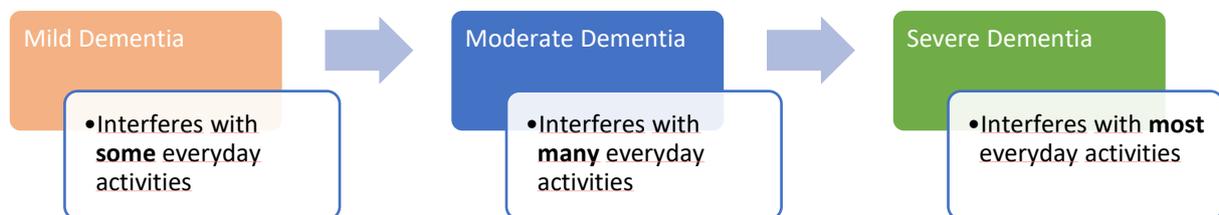


Figure 1. Continuum diagram for stages of AD

The most common type of dementia is Alzheimer's Disease (AD) representing an estimated 60-70% of all cases of dementia (Figure 2). Vascular dementias are common, although most are associated with AD. Vascular dementia is often concomitant with stroke, transient ischemic attack, diabetes and lifestyle factors such as smoking and high blood pressure (DeKosky and Asthana 2019). Other closely related diagnoses associated with dementia are Parkinson's Disease (PD) Dementia, Dementia with Lewy Bodies, Progressive Supranuclear Palsy, Multiple Symptoms Atrophy and dementia related to Chorea Huntington.

The 2020 Lancet Commission report, a continuation of the 2017 report on dementia prevention, lists twelve risk factors believed that if modified can prevent or delay up to 40% of dementias (Livingston, Huntley et al. 2020). These include: excessive alcohol consumption, traumatic brain injury, exposure to air pollution, less education, hypertension, hearing impairment, smoking, obesity, depression, physical inactivity, diabetes, infrequent social contact and loneliness (Livingston, Huntley et al. 2020). It is believed that low-to-middle income countries (LMIC) can have the greatest benefit from prevention policy and investment due to their greater risk factor burden (Livingston, Huntley et al. 2020).

Evidence suggests that many of those diagnosed with dementia also have multi-morbidities. A nationwide survey conducted in Taiwan in 2017 found that 60% of those with dementia had at least one comorbid condition (Chen, Yiao et al. 2017). Studies conducted in the UK and Canada have found a 19-35% chance for PwD to have five or more complex multi-morbidities (Clague, Mercer et al. 2017, Mondor, Maxwell et al. 2017, Livingston, Huntley et al. 2020). Complex multi-morbidities (4 or more) affect life expectancy after diagnosis of dementia. The mean life expectancy for someone diagnosed with dementia is approximately 4.5 years post-diagnosis however studies report longer life expectancies up to 11 years depending on age and number of multi-morbidities (Mondor, Maxwell et al. 2017, Kingston, Robinson et al. 2018, Welsh 2019).

Numbers of people being diagnosed with Early Onset Dementia (EOD) is growing and represents approximately 4% of all dementia cases worldwide (Kvellido-Alme, Brathen et al. 2019, Chiari, Vinceti et al. 2021). EOD represents a diagnosis under the age of 65 and sometimes as early as 30-50 years old. Although it would seem these patients are perhaps most adept to integrate technological solutions for improved function and activities of daily living, the truth of the matter is that this diagnosis comes with a much more progressive and time sensitive form of dementia as well as complications with accuracy of diagnosis due to atypical presentation compared to that of older patients. This atypical presentation is largely due to a larger genetic influence associated with the diagnosis of EOD. (DeKosky and Asthana 2019, Kvellido-Alme, Brathen et al. 2019, O'Malley, Parkes et al. 2019, Chiari, Vinceti et al. 2021).

A 2014 International survey conducted by the Alzheimer's Association, found that 59% of people incorrectly identified dementia as a normal part of aging. According to the 2018 World Alzheimer's Report, the diagnosis of AD is associated with more deaths yearly in the United States than breast cancer and prostate cancer combined. Dementia is a feared and

highly stigmatized diagnosis throughout the world and a growing concern for global health. (Brooke and Ojo 2020, Nguyen and Li 2020).

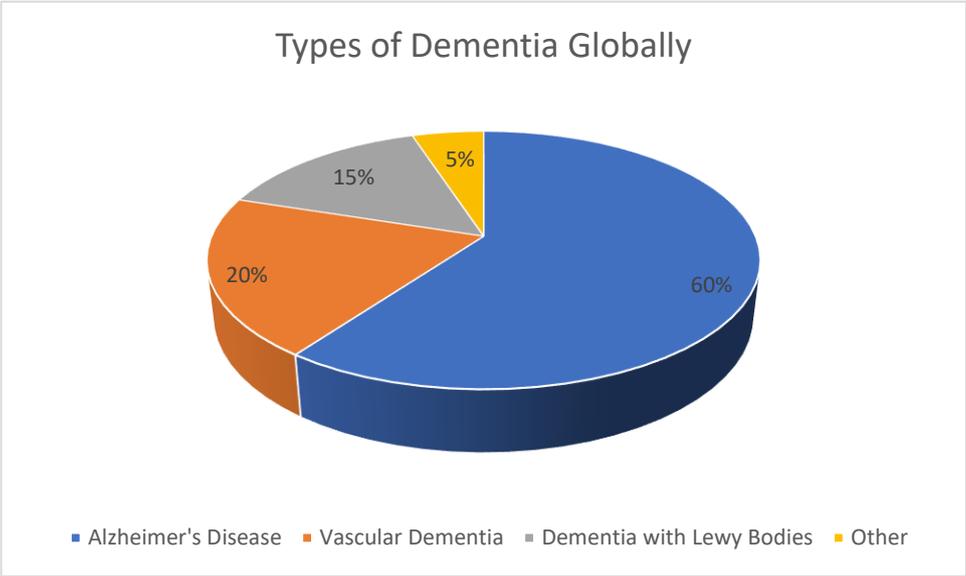


Figure 2. Types of Dementia Globally (Alzheimer’s Research UK, Dementia Statistics Hub)

Dementia Globally

Most recent prevalence estimates state that in 2019 there were 57.4 million people living with dementia globally. (Nichols, Steinmetz et al. 2022) According to Alzheimer’s Disease International, numbers of dementia are growing fastest in China, South Asia, India and western Pacific countries. In an updated report on prevalence of dementia worldwide by the Lancet regarding the Global Burden of Disease Study, it is predicted that there will be an average of a 350% increase in prevalence in LMIC over the next 30 years, with some regions in Africa seeing up to a 2000% increase by 2050. Overall global prevalence is estimated to increase by 166% by 2050 (Figure 3). (Nichols, Steinmetz et al. 2022)

Women are currently more affected than men and this trend is said to continue as global population and numbers of aged persons increases. Research suggests however that age alone, and the fact that women traditionally live longer than their male counterparts, is not the only influence in regards to the gender gap concerning higher rates of AD for women. Women typically develop higher amyloid proteins over their lifetime, resulting in

mitochondria generating higher levels of oxidative stress. Estrogen, and particularly the decreased protective factor from estrogen with age, also plays a significant role. (Vina and Lloret 2010). According to the World Health Organization (WHO) in 2010, 65% of total deaths due to dementia are women, and disability-adjusted life years (DALYs) due to dementia are roughly 60% higher in women than in men. Additionally, women provide the majority of informal care for people living with dementia, accounting for 70% of caregiving hours.

Prevalence and concern over a growing aged population is also rising in high income countries at alarming rates. For example, in high income countries such as the United States and Norway, there is an expected 100-140% increase in prevalence over the next 30 years. (Nichols, Steinmetz et al. 2022) In 2021 the Norwegian Minister of Finance, Jan Tore Sanner, estimated that by the year 2060 there will be a need for an additional 260,000 man-years mainly driven by the increase in needs within the elder care sector. This means that currently 1:8 healthcare workers in Norway are in the elder care segments, however by 2060 this will change to 1:3 based on current projections. The WHO estimates that as of 2019 total societal costs of dementia were approximately USD 1.3 trillion. Worldwide, the WHO predicts that total societal cost of dementia related illness could reach USD 2.8 trillion by 2030 (Alzheimer’s International, World Alzheimer’s Report 2015).

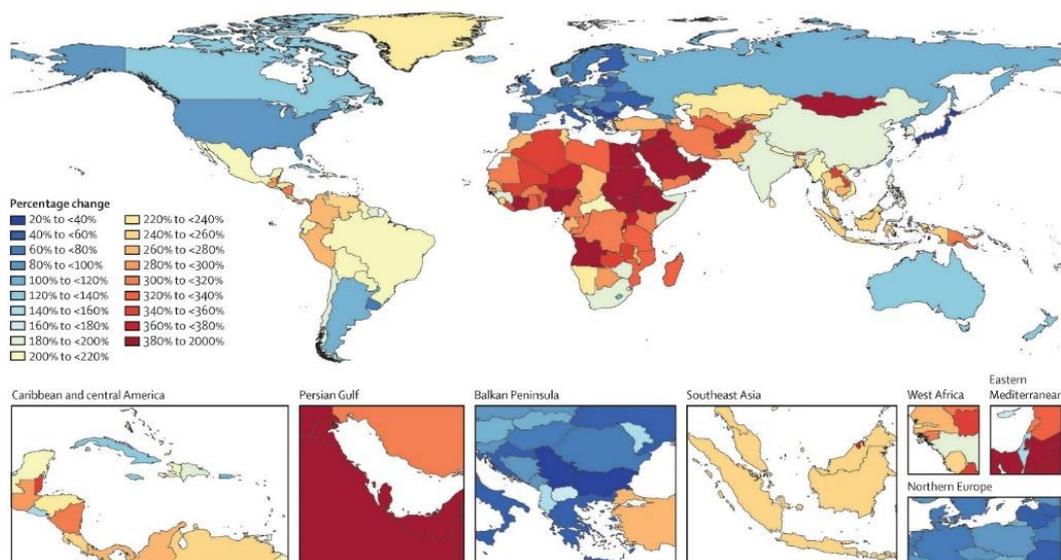


Figure 3. The Global Burden of Disease Study, Lancet 2019

Rationale: ATT as a solution for enhanced care options.

PwD are faced with a multitude of varied and complex symptoms including, but not limited to memory deficits, BPSD, loneliness, pain, potential for falls and subsequent hospitalization. Caregivers are further subjected to high levels of burden which includes economic consequences, psychological and physical decline and a decreased quality of life. On a societal level, these symptoms and consequences of dementia translate to loss of productivity in the workforce, increased sick-leave, increased hospitalization due to lack of resources, tremendous caregiver burden, lack of access to nursing facilities, violence towards and restraint of the PwD due to significant BPSD, and systemic economic burden within healthcare systems.

Globally, there is a need for better solutions and added values within the scope of home-dwelling PwD and their supportive palliative care. A progressive and innovative article from the Lancet in 2022 explored dying in the 21st century and the “value of death”. The authors state that the palliative process is currently unbalanced and that many remain undertreated, dying of preventable conditions and without access to basic pain relief. They conclude that in order to achieve balance, radical change is needed. (Sallnow, Smith et al. 2022)

In addition, consequences of the recent pandemic have highlighted an even greater demand for healthcare solutions, such as ATT innovation, to better serve these populations. Specifically, there is an exigency for ATT options that help to expand possibilities for intervention, prolong opportunity for care at home, offer support and broaden interdisciplinary communication during times when access to healthcare is limited for PwD and their caregivers.

In conclusion, well implemented and managed use of ATT as a novel solution to these challenges can assist to extend time at home for PwD, decrease burden of care for caregivers, improve access to healthcare and decrease strain to healthcare systems. Dementia is a complex diagnosis that demands innovative multi-component solutions for treatment and management of disease process. (Husebo, Allore et al. 2020, Sallnow, Smith et al. 2022) The concept of aging with dignity includes the right to live and thrive within a home environment as long as possible and ATT is one valuable option in efforts to provide dignity and value to life and death alike for PwD.

Assistive Technologies and Telecare

Assistive technology and telecare defined

ATT is broad in definition and the healthcare digital revolution, most recently fueled by COVID-19, has seen exponential growth. Within this review we will focus on ATT which is supported by documented evidence and with reflections or insight regarding the main topic of implementation and adoption (habitual daily use). Implementation is generally defined as “the process of putting a decision or plan into effect; execution”. For purposes of this review, implementation can be defined as the process of putting ATT in place (home or care home) with the goal of eventual adoption and habitual daily use of ATT in a “real world” setting.

This review will focus on understanding what, why and how ATT interventions are implemented and propose approaches to improve future implementation and adoption. Adoption and implementation are terms that are often used interchangeably, however adoption should be understood as an evaluated consequence and potential result of implementation. Simply, adoption can be seen as putting a technology to habitual use after implementation, while implementation is at the point when the technology becomes available. The ATT most frequently included in related literature reviews are wearables such as wrist bands, motion detection systems, smart home sensor rays, robotics, apps and communication devices (Husebo, Heintz et al. 2020, Stavropoulos, Papastergiou et al. 2020, Ozdemir, Cibulka et al. 2021, Pappadà, Chattat et al. 2021). This review will however take a broader aim and include a variety of ATT which has been investigated by recent literature (since 2011).

Terminology

Telehealth, e-Health, telemedicine, telecare, assistive technology, welfare technology, digital therapeutics, and information and communication technology are commonly used interchangeably within the literature (Table 1). For purposes of this paper, we will consider these terms to include any digital tool or technology that is used as a means of remote healthcare service for the PwD or caregiver. These can include videoconference evaluation or treatment, wearables, sensors, smart homes, smart phones, apps, internet-based programs and digital devices which expand homebound services and support for PwD and caregivers.

Telehealth	The provision of healthcare remotely by means of telecommunications technology.
e-Health	Healthcare services provided electronically via the internet.
Telemedicine	The remote diagnosis and treatment of patients by means of telecommunications technology.
Telecare	The use of technologies such as remote monitoring and emergency alarms to enable the unwell, disabled, or elderly to receive care at home so that they can live independently.
Assistive Technology	Any item, piece of equipment, software program, or product system that is used to increase, maintain, or improve the functional capacities of persons with disabilities.
Welfare Technology	All technology which in one way or another improves the lives of those who need it. It is used to maintain or increase security, activity, participation or independence for people with disability or the elderly.
Information Technology	The use of any computers, storage, networking and other physical devices, infrastructure and processes to create, process, store, secure and exchange all forms of electronic data.
Communication Technology	The transfer of messages (information) among people and/or machines through the use of technology.
Digital Therapeutics	Deliver evidence-based therapeutic interventions that are driven by high quality software programs to prevent, manage, or treat a medical disorder or disease.

Table 1. Definitions of commonly used terminology

Sensor Technologies

Sensor technology will be highlighted as these solutions are on the market and currently being readily adopted globally. Data gathered using sensor devices and wearables can be studied as a proxy for behavioral changes. Monitoring of behavior and predictive value for early detection of disease is a main focus of current sensor technologies however some are being used as intervention approaches based on feedback from the device (Ray, Dash et al. 2019).

A 2020 systematic review synthesizing evidence on sensor technology for PwD found that sensors are most frequently used to monitor behavioral symptoms such as sleep disturbances, agitation, and wandering (Husebo, Heintz et al. 2020). Internet of Things (IoT) technology is a fairly new concept of in-home sensor monitoring that offers promising options for home-dwelling PwD. IoT technology can include wearables, biometric sensors, smartphones, apps, smart home ambient sensors, environmental sensing, indoor positioning sensors, microphones, wearable and mounted cameras (Stavropoulos, Papastergiou et al. 2020). Wearables, such as FitBit, are another popular IoT on the market which is being used to detect and monitor levels of activity and biomarkers such as heart beat, sleep patterns, and blood pressure (Stavropoulos, Papastergiou et al. 2020).

Smart Homes

Smart home design is another fairly new initiative which incorporates sensing technology, wearables, smart phones and integrated in assistive devices that can include cameras, touch screens and voice technology to increase safety and independence for PwD living at home. Smart homes are also seen as a way to relieve caregiver burden of care and ease anxiety over potential safety issues of independent living during advanced stages of dementia. In Norway, The Center for Elderly and Nursing Home Medicine, Department of Global Public Health and Primary Care, University of Bergen, in collaboration with the Centre for Clinical Treatment of Neurological Diseases, Neuro-Sysmed, and Haukeland University Hospital, is in preparation for a large study called “Active Ageing”. The study will investigate monitoring of disease patterns and etiology of approximately 80-100 subjects with PD using a smart home environment. Digital phenotyping and artificial intelligence methods will be used to analyze data from the study with the aim for a better understanding of the disease process and the potential for extended care at home for the person with PD.

In existing literature, terminology related to smart homes has evolved and is often referred to as “unobtrusive in-home health monitoring” (Wang, Spicher et al. 2021). Most current studies show positive effect of smart home design however are based on case-study methods or small data sets, highlighting that the results from larger studies such as “Active Ageing” will be highly anticipated for the future of these technologies (Lotfi, Langensiepen et al. 2011, Wang, Spicher et al. 2021).

Robotics

Robots as a means for social care, communication and intervention for PwD is another emerging novel concept. These are now commonly referred to as socially assistive robots (SARs) in current literature. SARs include a category of robots referred to as “petbots” such as the Paro design which has been readily available on the market since 2004. Paro has had successful implementation globally over the last twenty-years within care homes and private homes alike. It has been studied extensively and benefits of use include decreased loneliness, stress, depression, agitation and pain. Paro is widely used in care facilities in Japan and Denmark and prescribed as an alternative therapy for home care in the USA (Ozdemir, Cibulka et al. 2021).

OBJECTIVES

Main objective

The main objective of this review is to identify promotors and barriers to implementation and adoption of ATT for PwD and their informal (family and friends) and formal (healthcare professionals) caregivers.

Specific objectives

- a. To identify promotors and barriers that are common across research settings (home and institution environments).
- b. To identify and analyze common themes within the literature.
- c. To propose novel implementation strategies which may improve implementation and adoption of ATT globally.

METHODS

This systematic review offers literature from both quantitative and qualitative methods. A semi-systematic approach was chosen because the review topic has been studied within diverse disciplines and through varied methods. This review will follow the recommendations established by Snyder in 2019 to ensure quality of content and results. (Snyder 2019)

In addition, PRISMA guidelines and flow diagrams have been used to ensure proper inclusion categories within the review and quality, transparent reporting (Liberati, Altman et al. 2009, Moher, Liberati et al. 2009).

Protocol and Registration

This review followed guidelines and reported in accordance to the PRISMA checklist published in 2020. The study was registered in PROSPERO 25th of February, 2021 [CRD42021239448] and in accordance to the PROSPERO regulations, registration was completed prior to analysis of literature.

Identifying relevant literature

In consultation with a librarian from University of Bergen, a search strategy was developed for searching Medline (Ovid), CINAHL, Web of Science, APA PsycINFO and EMBASE. Epistemonikos was searched in an effort to identify related published systematic reviews with a focus on implementation of ATT for PwD or caregivers prior to conducting the initial searches. The search strategy for this was as follows: “dementia” AND “assistive technology” OR “telecare” OR “telemedicine” OR “e-health” AND “implementation” OR “barriers” OR “promoters” OR “facilitators”. Search strategy and key terms were further developed using these resources.

Methodology concerning search terminology: three (3) central themes

1. Dementia

Keywords included MeSH terms and phrases synonymous with “dementia” and free text words within title and abstract, “dementia” OR, “Alzheimer*” OR, “cognitive decline” OR, “lewy body disease” OR, “neurocognitive disorder*”

2. Assistive Technology

AND MeSH terms and phrases synonymous with, “telemedicine” and free text words within title and abstract, “assistive technolog*” OR, “telecare” OR, “telemonitor*” OR, “smart home*” OR, “telehealthcare” OR, “robotic*” OR, “voice technolog*” OR, “smart phone*” OR, “wearable*” OR, “gerontechnolog*” OR, “web-based” OR, “digital” OR, “sensor*” OR, “telemedicine”, OR “telehealth” OR, “ehealth” OR, “telerehabilitation”

3. Implementation

AND free text words within title and abstract, “implement*” OR, “barrier*” OR, “promot*” OR, “facilitat*” OR, “installation” OR, “usage” OR, “motivat*”. See full list of searches and key terms within supplemental material.

Figure 4. Methodology for key terms (themes)

An initial focused search utilizing identified key terms was conducted for peer-reviewed publications in the following databases from February 1-23, 2021: Medline (Ovid), CINAHL, Web of Science, APA PsycINFO and EMBASE. The details of the searching strategy with key words and initial hits are provided (Figure 5) to ensure reproducibility of the search. Peer-reviewed publications, applying both qualitative and quantitative research methods will be included. Opinion papers, literature reviews, theoretical papers, study protocols, conference abstracts and unpublished literature reviews will be excluded.

1. dementia.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]
2. dementia.m_titl.
3. "alzheimer*".m_titl.
4. cognitive decline.m_titl.
5. lewy body disease.m_titl.
6. neurocognitive disorder.m_titl.
7. telemedicine.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]
8. telemedicine.m_titl.
9. "assistive technolog*".m_titl.
10. telecare.m_titl.
11. "smart home*".m_titl.
12. telehealthcare.m_titl.
13. "robotic*".m_titl.
14. "voice technolog*".m_titl.
15. "smart phone*".m_titl.
16. "wearable*".m_titl.
17. "gerontechnolog*".m_titl.
18. web-based.m_titl.
19. digital.m_titl.
20. "sensor*".m_titl.
21. telehealth.m_titl.
22. ehealth.m_titl.
23. telerehabilitation.m_titl.
24. "implement*".m_titl.
25. "barrier*".m_titl.
26. "promot*".m_titl.
27. "facilitat*".m_titl.
28. installation.m_titl.
29. usage.m_titl.
30. "motivat*".m_titl.
31. 1 or 2 or 3 or 4 or 5 or 6
32. "telemonitor*".m_titl.
33. 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 32
34. 24 or 25 or 26 or 27 or 28 or 29 or 30
35. 31 and 33 and 34

Figure 5. Medline Ovid, APA PsycINFO, EMBASE: February 17, 2021 search terms

Eligibility Criteria

Inclusion criteria

Studies were included if they met all of the following criteria: (a) uses ATT or other defined technology-based intervention to deliver an individually tailored solution to PwD and/or their formal or informal caregivers, (b) reports findings or thoughts as to the implementation of these interventions within the abstract or text and/or barriers to implementation of assistive technologies, (c) PwD are classified by a health professional as having mild-severe dementia based on a validated cognitive outcome measure such as the Mini-Mental Status Examination (MMSE), Functional Assessment Staging Tool (FAST) or Clinical Dementia Rating scale (CDR), (d) publications were not published prior to 2011 (10 years prior) and, (e) written in the English language.

Exclusion criteria

Studies were excluded if they met any of the following criteria: (a) technology related specifically to COVID-19 interventions, (b) report findings solely relating to general technology rather than the PwD and/or their formal or informal caregiver, (c) findings that do not directly or indirectly address the topic of implementation of and/or barriers to implementation of technology-based interventions, d) interventions related to comorbidities and other diagnoses such as stroke, diabetes, HIV or heart disease, e) literature regarding specific categories of ATT such as wheel chairs or occupational therapy devices for activities of daily living, (f) publications were published prior to 2010 and publications not written in the English language.

PICO	Inclusion Criteria	Exclusion Criteria
Population	<ul style="list-style-type: none"> ● PwD ● Caregivers (formal and informal) ● PwD classified by a medical professional with mild to severe dementia based upon validated outcome measures (MMSE, FAST, CDR). 	<ul style="list-style-type: none"> ● General population without diagnosis of dementia ● Caregiving not related to a PwD
Intervention	<ul style="list-style-type: none"> ● ATT, Technology-based intervention, assistive technology, telemedicine, e-Health or other categories of technology related assistance specific to the population: PwD and/or their caregivers. 	<ul style="list-style-type: none"> ● General technology intervention unrelated to care for specific population: PwD and/or their caregivers. ● Specific categories of assistive technology such as wheel chairs or occupational therapy devices for activities of daily living. ● Specific interventions related to diagnoses such as stroke, diabetes, HIV or heart disease; primary focus on dementia care.
Comparison	<ul style="list-style-type: none"> ● Undefined 	<ul style="list-style-type: none"> ● Undefined
Outcomes	<ul style="list-style-type: none"> ● Implementation and related barriers/facilitators ● Novel implementation and education programs ● Solutions for improved implementation 	<ul style="list-style-type: none"> ● Literature that does not directly or indirectly refer to implementation, barriers or facilitators related to technology-based interventions

Table 2. Established PICO criteria

Article screening and data extraction

The initial search generated a total of 1,611 potential publications from Medline Ovid (21), CINAHL (436), Web of Science (1109), APA PsycINFO (12) and EMBASE (33), of which 30 papers were identified as relevant for full-text evaluation. Of these, 29 were qualitative, and 3 were quantitative (randomized control trials - RCTs). Two of the included articles were added using snowballing techniques. The total inclusion for the review was 32 articles (29 qualitative, 3 RCTs). Of the 1,611 articles identified, 649 were duplicates and removed prior to screening. After removal of all duplicates Rayyan QCRI software was utilized for screening of all literature. Rayyan QCRI is a selection and screening software designed for use with systematic reviews. Rayyan effectively loads all found literature and

screens for duplicates. In addition, it enables up to three collaborators to be blinded for initial selection of literature based on title and abstract.

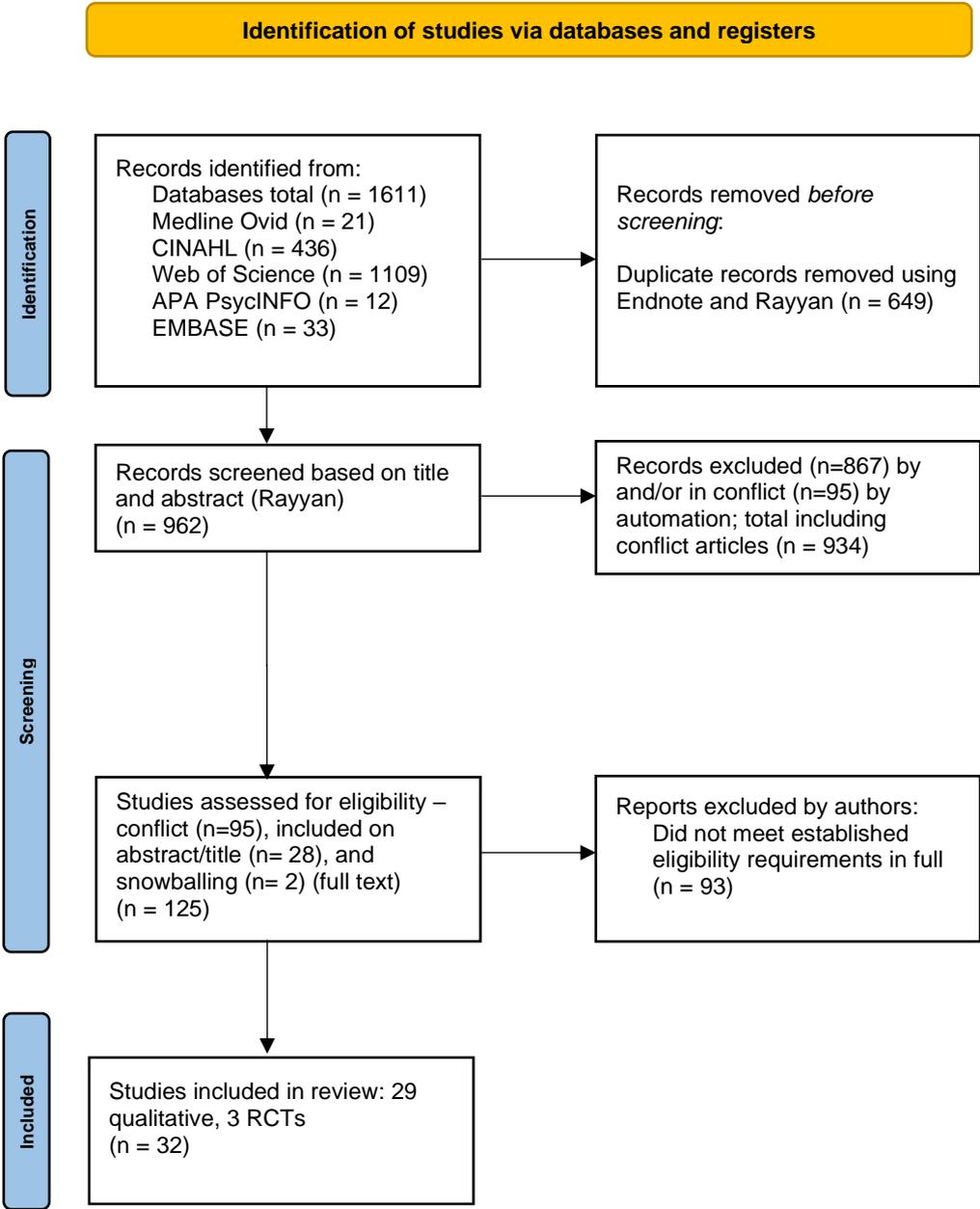


Figure 6. 2020 Prism flowchart: reported identification of studies

Initially, articles were screened with Rayyan utilizing blinding of (2) collaborators for decisions based on set inclusion and exclusion criteria. Screened literature was separated into three categories by Rayyan: 1) included (green), 2) excluded (red), and/or 3) conflict (black). (Figure 7) All articles that fell into the “conflict” category were unblinded and the full text article was reviewed and discussed between collaborators prior to a final decision.

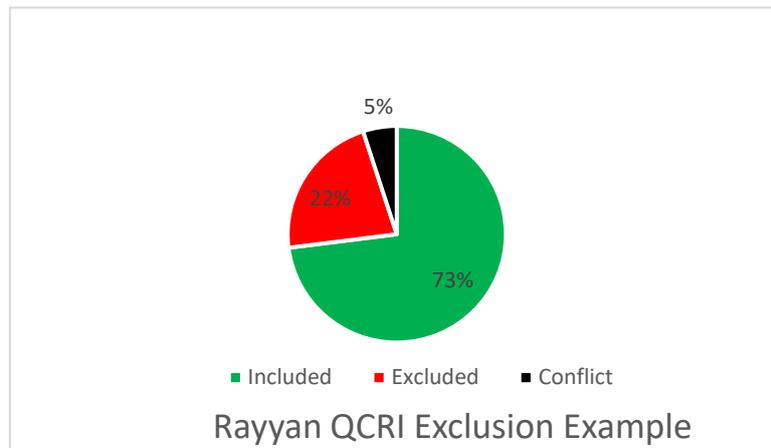


Figure 7. Rayyan QCRI Eligibility Criterium example

Specific data extraction within the study was focused on emerging themes surrounding the main topic of implementation and adoption of ATT for PwD and their caregivers. Data was categorized by demographic information and specific content accordingly, to include: author, title, year of study, participants, country of associated study, type of ATT studied, promotors, barriers, outcomes, and results. Separate, however relevant, categorical data collection were performed for articles that bring to light to the topics of ethics and novel digital implementation programs.

Analysis

Narrative synthesis was used to develop a synthesis of findings from included studies, explore the relationships within the data and assess the robustness of the synthesis (Cooper, 1998). NVivo software was used for support and visualization of the analysis process and to pull themes from the qualitative literature.

Risk of Bias

Quality assessment of the studies included was performed independently by the author. The Critical Appraisal Skills Programme (CASP) checklist was utilized to assess all literature for potential bias and overall quality. CASP has appraisal checklists designed for use with e.g., systematic reviews, RCTs, cohort studies, case control studies, and qualitative studies (Ma, Wang et al. 2020).

RESULTS

In total, the review includes literature representing five continents and sixty-five countries globally (Figure 8). These include both high-to middle income countries as well as LMIC. We consider this review to be a truly global representation of the current and future challenge of ageing.

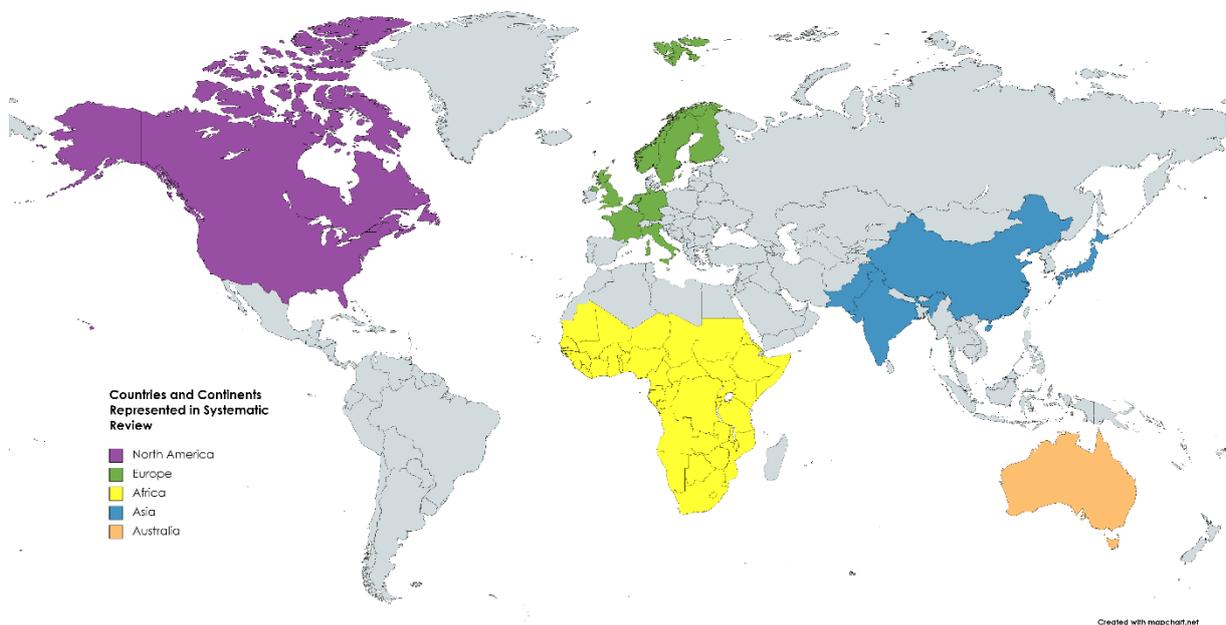


Figure 8. Global perspective of systematic review

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promoters
Asghar, I., et al.	2019	Pakistan	327	Survey	Impact evaluation of assistive technology support for the people with dementia	Mobility Support Cognitive Games Reminder or Prompter Social Application Leisure Support	Operational support Physical Support Psychological support Social Support Cultural match Affordability	AT effectiveness: AT psychological support & AT social support Physical support AT retention: Reduced external help, AT travel help, AT culture match
Dai, B. Z., et al.	2020	Sub Saharan Africa	350	Questionnaire - qualitative	Factors Affecting Caregivers' Acceptance of the Use of Wearable Devices by Patients With Dementia: An Extension of the Unified Theory of Acceptance and Use of Technology Mode	Wearables	Technology anxiety Resistance to change Malfunction of ATT Costs	Subsidized costs Training and clearly communicated benefits of use social influence facilitating conditions (context, cultural, environment) effort expectancy

Table 3. Barriers and Promoters, Literature from LMIC

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promoters
Chiati et al. (UP-TECH project)	2013	Italy	438	RCT	The UP-TECH project, an intervention to support caregivers of Alzheimer's disease patients in Italy: study protocol for a randomized controlled trial	Sensor technology (smart home)		
Fänge et al. (TECH@HOME)	2017	Sweden	640	RCT	The TECH@HOME study, a technological intervention to reduce caregiver burden for informal caregivers of people with dementia: study protocol for a randomized controlled trial.	Sensor technology (smart home)	Not having a clear understand of the benefits, Unreliable technology, Not fitting into habits, Lack of control over device Ethical issues - threat to privacy	Safety for the PwD ATT as a support to make life easier Complemented established care
Lauriks et al.	2018	Netherlands	54 25	RCT	Effects of Assistive Home Technology on quality of life and falls of people with dementia and job satisfaction of caregivers: Results from a pilot randomized controlled trial	alerts, lighting and design (non-obstruction)	Malfunctions, errors Fidelity	See barriers

Table 4. Barriers and Promoters, Quantitative Literature

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promotors
Arntzen, C., et al.	2016	Norway	12	Qualitative	Tracing the successful incorporation of assistive technology into everyday life for younger PwD and family carers	Various ATT	Habitual practices Negative emotions Poor design Not adaptable Not engaging the carer Complexity of ATT	Fit with habitual behaviors Culture Trust user-friendly adaptability
Arthanat, S., et al.	2020	USA	8	Qualitative	Caregiver perspectives on a smart home-based socially assistive robot for individuals with Alzheimer's disease and related dementia	socially assistive robot (SAR)	Technology anxiety Effort expectancy Structure and design of the home Value and worth Digital Divide System failures Dual burden	Trust (fidelity) Personalized training Adaptability (tailoring) Engaging the care recipient Humanoid features
Asghar, I., et al.	2019	Pakistan	327	Qualitative	Impact evaluation of assistive technology support for the PwD	Various ATT	Operational, Physical, Social and Psychological support Cultural match Affordability Compatibility Design	ATT effectiveness: Reduced external help, ATT travel help, ATT culture match
Coco et al.	2018	Finland and Japan	286	Qualitative	Care Personnel's Attitudes and Fears Toward Care Robots in Elderly Care: A Comparison of Data from the Care Personnel in Finland and Japan	Robots	Decreased QoL Fear of job loss Lack of trust usefulness of robot to conduct tasks beyond simple intervention	See barriers

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promoters
Dai, B. Z., et al.	2020	Sub Saharan Africa	350	Qualitative	Factors Affecting Caregivers' Acceptance of the Use of Wearable Devices by PwD: An Extension of the Unified Theory of Acceptance and Use of Technology Mode	Wearables	Technology anxiety Resistance to change Malfunction of ATT Costs	Subsidized costs Training Communicated benefits of use Social influence Context, culture, environment effort expectancy
Dugstad, J., et al.	2019	Norway	67 172 23	Mixed Methods	Towards successful digital transformation through co-creation: a longitudinal study of a four-year implementation of digital monitoring technology in residential care for PwD	Digital night surveillance intervention IoT	See promoters	Development of clear Pre-implementation and Implementation strategies including: Managing risks Reflection Co-creation Tailored training Involving all stakeholders Culture match Common language Continuous evaluation Developing new roles Realizing benefits Compatibility with existing services Scaling up gradually Facilitate dialog Establish a team of champions Promote co-creation through workshops

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promotors
Egan, K. J. and A. M. Pot	2016	USA, Australia, Canada, China, India, Japan, Netherlands, United Kingdom	66	Qualitative	Encouraging Innovation for Assistive Health Technologies in Dementia: Barriers, Enablers and Next Steps to Be Taken	Varied ATT	Stigma Poor accessibility Not accounting for disease progression	Raise awareness Affordability Integrate with existing services Increase collaborative approaches including the PwD
Evans et al.	2017	UK	48	Mixed Methods	The iPad project: Introducing iPads into care homes in the UK to support digital inclusion	ipads - games, memoirs, video conference	Benefits and Barriers: Ease of use Convenience and Flexibility Portability Cost	See barriers
Faeo, S.E. et al	2020	Norway	12	Qualitative	Home-dwelling PwD perception on care support: Qualitative study	Various ATT	Safety with saide-effects (unintended consequences) unmet expectations for volunteerism diversity of care and services	A way to braoden PwDs everyday environment Ability to have more freedom - walking, out from house Maintained dignity
Fange, A.M.	2019	Norway	9 21	Qualitative	Using sensor-based technology for safety and independence - the experiences of PwD and their families	Sensors	Not having a clear understand of the benefits of ATT Unreliable technology Not fitting into habits Lack of control over an installed device Ethical issues - privacy	Safety for the PwD ATT as a support to make life easier Complemented established care

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promotors
Gibson, et al.	2015	UK	13 26	Qualitative	The everyday use of assistive technology by PwD and their family carers: a qualitative study	DIY ATT, off the shelf solutions	Too little too late from formal care (ATT) Cost	Role of the caregiver as facilitator Easily integrated with current habits/routines
Gibson, et al.	2019	UK	13 26	Qualitative	Personalisation, customisation and bricolage: how PwD and their families make assistive technology work for them	DIY ATT, off the shelf solutions	Inaccessibility Cost No information about technology for PwD "Crisis model" of implementation	Ability to incorporate into habitual practices Informal caregivers as facilitators and bricoleur Off-the-shelf solutions (accessibility and cost)
Hall A. et al	2017	England	36	Qualitative	Implementing monitoring technologies in care homes for PwD: A qualitative exploration using Normalization Process Theory	Sensors, Memory aides	Key stakeholders not involved in implementation process Limited understanding from stakeholders regarding benefits and challenges of ATT	Enhanced safety Personalized training for staff & caregivers
Heuvel et al.	2012	UK	25	Qualitative	Awareness, requirements and barriers to use of Assistive Technology designed to enable independence of people suffering from dementia	Various ATT	Lack of information unknown benefits of use	See barriers
Holthe, T. et al.	2020	Norway	24	Qualitative	Community Health Care Workers' Experiences on Enacting Policy on Technology with Citizens with Mild Cognitive Impairment and Dementia	Various ATT	Unsystematic approaches Contested responsibility Citizen capabilities	Knowledge and training User friendliness

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promotors
Holthe, T. et al.	2018	Norway	13	Qualitative	Benefits and burdens: family caregivers' experiences of assistive technology (AT) in everyday life with persons with young-onset dementia (YOD)	Various ATT	Waiting times Lack of information from public services Untimely information about ATT	Simply designed ATT Committed caregiver Need based provision Incorporation into habitual routines
Ienca et al.	2018	Switzerland Germany Italy	17	Qualitative	Health professionals' and researchers' views on Intelligent Assistive Technology for psychogeriatric care	Various ATT	Mismatch between patients' needs and ATT Technical limitations Translational problems	See barriers
Jarvis et al.	2017	Australia	85	Qualitative	Technology for dementia: attitudes and practices of occupational therapists in providing assistive technology for way finding	Way-finding technology	Limited awareness of how ATT is used for support PwD Limited knowledge of available ATT Lack of time and information Costs Difficulty learning new skills	See barriers
Kerssens et al.	2015	USA	7	Mixed Methods	Personalized Technology to Support Older Adults With and Without Cognitive Impairment Living at Home	The Companion - touch screen with Psychosocial interacts for PwD	Not offering a feature counted on Caregivers ignoring or muting shows Recipients ignoring interventions Not having enough time Unwillingness to share experiences Unmet expectation	Relaxation Enjoyment of life Reminisce

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promoters
Lindqvist et al.	2015	Sweden	14 14	Mixed methods	Experienced usability of assistive technology for cognitive support with respect to user goals	Various - based on interviews with PwD and caregivers	Out of sight-out of mind Non-relevant info Professionals needed for updating features Small buttons Settings easily manipulated by mistake No instructions or feedback	Visibility of the ATT Visualized reminders Customizable features (user) Reminders delivered to mobile phone Personalized buttons Feedback and guidance on display
Lindqvist et al.	2013	Sweden	17	Qualitative	Significant junctures on the way towards becoming a user of assistive technology in Alzheimer's disease	Various ATT	See promoters	Trust for the ATT Perceived capacity for use Fitting into routines Pre-planning for a decision on which ATT was most appropriate
Mehrabian et al.	2015	France	92	Mixed methods	The perceptions of cognitively impaired patients and their caregivers of a home telecare system	Various ATT	Complexity Expectation vs reality Perceptions of need by the caregiver Technology anxiety Costs Limited access to internet in the homes	Security and safety for the user Assisting in case of emergency Enable cognitive stimulation Reminders for meds Improvement in day-to-day living

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promotors
Niemeijer, A. R. et al.	2014	Netherlands Holland	43 28	Mixed methods	The Use of Surveillance Technology in Residential Facilities for People with Dementia or Intellectual Disabilities: A Study Among Nurses and Support Staff	surveillance technology	False alarms Alarm fatigue Not using the technology to full potential Forgetting to take devices off Perception of staff	Vision of safe autonomy Informing of participants (risks and benefits) Instructions and training of staff Willingness to use new technology
Pino et al.	2015	France	25 7	Mixed methods	"Are we ready for robots that care for us?" Attitudes and opinions of older adults toward socially assistive robots	SARs	Negative impact on autonomy Size of SAR Privacy concerns Fear of robots replacing humans/jobs Suitability for level of dementia Negative attitudes Generational gap Perceived usefulness Fear of the future	Cognitive support Communication and companionship Safety and healthcare use Supports independent living Alleviates caregiver stress
Snyder et al.	2020	USA	4	Qualitative	Remote Monitoring Technologies in Dementia Care: An Interpretative Phenomenological Analysis of Family Caregivers' Experiences	remote monitoring technology	Lack of technical ability Perception of technology as confusing or unclear Ease of use Not tailored to needs Lack of knowledge of benefits of use Ethical issues	caregiver peace of mind better communication with PwD caregiver confidence caregiver and care recipient independence

Author	Year	Country	N	Design	Title	Assistive Technology	Barriers	Promotors
Steils et al.	2021	England	114	Mixed methods	Carers' involvement in telecare provision by local councils for older people in England: perspectives of council telecare managers and stakeholders	Various ATT	Lack of information unknown benefits of use carers level of knowledge of technology	Tailored solutions Involvement of carers
Thorpe et al.	2016	Denmark	10	Mixed methods	Pervasive assistive technology for people with dementia: a UCD case	Sony SmartWatch 3 and Sony Xperia E4	Navigation and emergency support	Scheduling features Familiar design Personalization
Yaddadin et al.	2020	Canada	24	Qualitative	Using a cognitive orthosis to support older adults during meal preparation: Clinicians' perspective on COOK technology	Various ATT	Complexity of ATT Difficulty adapting Requires a large number of resources (time and costs) Resistance to the use of a technological aid	Learning potential Interdisciplinary collaboration (including the family) Experience Varied features of COOK
Øksnebjerg, L. et al.	2020	Denmark	19	Mixed method	Self-management and cognitive rehabilitation in early stage dementia - merging methods to promote coping and adoption of assistive technology. A pilot study	ReACT app	See promotors	Identification of goals prior to implementation Ease of use Individual and group-based activities

Table 5. Barriers and Promotors, Qualitative and Mixed Methods Literature

Promotors

Personalized (Tailored) Training and Education

The top promotor to implementation and adoption of ATT for PwD and their caregivers was a need for more tailored training and education for all stakeholders involved in the implementation. Suggestions within the literature included university sponsored courses or workshops, online-learning, demonstrations of the technology for the family (including the PwD and caregivers), hands-on-practice with the ATT prior to implementation, support networks for post-implementation trouble-shooting and designated “super-users” at various levels for continued support. (Gibson, Dickinson et al. 2015, Evans, Bray et al. 2017, Coco, Kangasniemi et al. 2018, Dugstad, Eide et al. 2019, Arthanat, Begum et al. 2020, Holthe, Halvorsrud et al. 2020, Oksnebjerg, Woods et al. 2020, Yaddaden, Couture et al. 2020) In several of the included studies, education was seen to play a crucial role in the acceptance of the new technology and in establishing positive attitudes towards its reliability. (Coco, Kangasniemi et al. 2018, Dugstad, Eide et al. 2019, Arthanat, Begum et al. 2020)

A qualitative study by Coco et al. (2018) (n= 286) compared findings regarding the acceptability of SARs among healthcare workers in nursing homes in Finland and Japan. They conclude that management plays a vital role in education efforts for personnel and that training and education is crucial for acceptance of new innovation, understanding of benefits for ATT, diminishing fears and negative thoughts, and in changing attitudes which could detour adoption. This was especially emphasized concerning situations where ATT is being implemented in varied cultural contexts. (Coco, Kangasniemi et al. 2018)

Dugstad et al. looked at “Building competence & organizational learning: Tailoring competence building across shifts and roles” within their 4-year implementation study of monitoring technology in Norwegian nursing homes (n= 67 care facilities). They conclude that personalized training should be initiated for a variety of stakeholders taking into consideration the importance of focusing on necessary skills and on development of a common “language” to bridge gaps between various professionals and stakeholders. (Dugstad, Eide et al. 2019)

Safety for the PwD

The consideration of safety and wellbeing for the PwD often superseded ethical considerations in regards to the decision for implementation of ATT. (Malmgren Fange, Schmidt et al. 2017, Ienca, Lipps et al. 2018, Asghar, Cang et al. 2019, Arthanat, Begum et al. 2020, Holthe, Halvorsrud et al. 2020, Malmgren Fange, Carlsson et al. 2020) Dugstad et al. found that ATT implementation within care home facilities fostered a “safety culture” within the institution itself. This in a sense bolstered the feeling that the new technology could “save lives”. (Dugstad, Eide et al. 2019) This is an interesting finding which seems to suggest that not only the PwD and caregiver may hold this belief, but that this also occurs at organizational levels within healthcare facilities.

Fange et al. conducted a qualitative study exploring experiences, needs and benefits with using sensor-based technologies for safety and independence in the homes of PwD and their family members (n= 30). Participants from the Fange et al. study were recruited from the TECH@HOME (n=640) project (2016-2019) in Sweden, aiming to evaluate the effects of sensor-based technology for safety and independence in homes in efforts to reduce the needs for supervision among family members of PwD. (Malmgren Fange, Schmidt et al. 2017) The main theme which emerged was that ATT was viewed as a support to make life easier and safer. Both studies found that there is a continuous negotiation between safety and privacy for both the PwD and caregivers. Fange et al. states that it is important to continuously gain informed consent from the PwD to use the technology in their home. (Malmgren Fange, Schmidt et al. 2017, Malmgren Fange, Carlsson et al. 2020)

Involvement of Stakeholders (and Leadership Involvement)

Many of the included studies found that only a portion of the stakeholders that should be involved in implementation were included. Primary examples of this were leaving out key personnel; not including the caregiver or PwD, missing key personnel due to a shift change, not including key IT personnel at the municipality level, lack of involvement from management at the healthcare facility, disregard of other non-IT personnel that had indirect impact on implementation such as janitors and support staff, and not informing key home health personnel.

KJ Egan and AM Pot conducted a study looking at barriers, enablers and next steps for implementing ATT for PwD. Using multinational (United States, Australia, Canada, Japan, Netherlands, United Kingdom, China, India) focus groups and including a variety of stakeholders (PwD, representatives working in industry, academic researchers, regulators, research funders, policy makers and formal and informal care providers), the study found six key barriers to the development of ATT: 1) raise awareness and reduce stigma, 2) improve accessibility and affordability, 3) to integrate with existing services, 4) to increase collaborative approaches and make PwD a part of the process, 5) to account for disease progression and 6) to facilitate and develop implementation of innovative ATT. The study concludes that “there is an overriding imperative for a systematic, coordinated multistakeholder approach with the needs of PwD and their caregivers as the centerpiece”. (Egan and Pot 2016)

A survey of occupational therapists (n= 87) conducted in Australia inquired about the prescription of ATT for home-dwelling PwD. 51% of those surveyed stated that they had not prescribed ATT for patients with “wandering” tendencies because of: limited access to knowledge about the type of technology available, limited resources available to provide ATT to their clients, concern about the client and their caregivers ability to meet the costs of the ATT and difficulty learning new skills. (Jarvis, Clemson et al. 2017) Another survey by Steils et al. looked at the perspectives of council telecare managers and stakeholders (n = 114) in the UK concerning caregiver involvement in telecare provision. The survey revealed that a vital barrier to the usefulness and adoption of ATT was lack of information and knowledge. The authors suggest that improved training, provision for self-installation and better support packages for caregivers post-implementation were solutions to this key barrier. (Steils, Woolham et al. 2019)

In the study by Dugstad et al, they found that with proper planning, the implementation process was a great way to establish bonds between stakeholders and that it created opportunity for a common “language” between professional groups.(Dugstad, Eide et al. 2019) Ienca et al. investigated this concept from the perspective of multinational (Switzerland, Germany, Italy) health professionals and researchers (n= 17) and suggested that the creation of an intermediary platform could potentially bridge the gap across relevant stakeholders, for example between clinicians and tech-producers. The study also addressed the “language barrier” between medicine and engineering. (Ienca, Lipps et al. 2018)

Ease of Use

Not surprisingly, the ease of use of the ATT is considered a significant promotor to implementation and adoption of technology. In fact, the simplest of technology was often the most likely candidate to be successfully incorporated into daily habitual habits of the PwD and caregivers. These technologies were seen to enhance the already established daily routines. Some terminology within the literature that was used by the PwD and caregiver to describe “ease of use” was: flexibility, convenience, simple, portable, clear and direct instructions and enlarged font size (reduced visual load). (Lindqvist, Larsson et al. 2015, Pino, Boulay et al. 2015, Evans, Bray et al. 2017, Ienca, Lipps et al. 2018, Yaddaden, Couture et al. 2020)

Evans et al. (n= 48) iPad Project introduced iPads into care homes (n= 63 care homes) in the UK to explore the experiences and potential benefits of technology use for PwD and their formal and informal caregivers. The ease of use of the iPad and its ability to be integrated into everyday activities and tasks was a key promotor for successful implementation and adoption of the technology, and in fact the authors found there was a 5-fold increase in use (from 15-80%) after the project was completed.(Evans, Bray et al. 2017)

Cultural Relevance

Differences in usefulness and adoption were noted between cultural groups within the studies, therefore pushing cultural relevance forward as a primary influencer for promotion of implementation and adoption of ATT. Cultural differences are relevant between varied country settings, such as in the study by Coco et al. (n= 286) investigating beliefs surrounding implementation of care robots in Finland and Japan. In this study the authors found that the implementation of assistive robotic technology was much more accepted in Japan than in Finland and that in fact 40% of the respondents in Finland considered the introduction of a SAR to be inhumane (compared to 8% in Japan). (Coco, Kangasniemi et al. 2018) Perhaps a less obvious cultural barrier was identified between healthcare organization professional groups in the study by Dugstad et al. The authors found that each stakeholder involved in the implementation process, from management, IT professionals and healthcare workers to the janitor, presented with their own unique culture and “language”. (Dugstad, Eide et al. 2019) This is important to note as the term culture can constitute many definitions.

Barriers

Unintended Adverse Consequences

Unintended consequences due to the introduction of ATT appears to be a driving determinant of the success of implementation and future adoption of the technology. Many of the examples stated within the literature include descriptions of negative emotions from both the PwD and caregivers alike. From the point of view of the PwD, failed attempts to use the ATT often caused feelings of incompetence, confusion, annoyance and stress. (Gibson, Dickinson et al. 2015, Lindqvist, Larsson et al. 2015, Malmgren Fange, Schmidt et al. 2017, Holthe, Jentoft et al. 2018, Holthe, Halvorsrud et al. 2020) The caregivers expressed a wide range of feelings associated with fear, which included fear of being replaced by the ATT, fear that the ATT dehumanized, increase loneliness or infantilized the PwD and fear for the safety of the PwD due to malfunctioning ATT. (Pino, Boulay et al. 2015, Coco, Kangasniemi et al. 2018) There were also feelings of fatigue, confusion, mistrust of the ATT and increased stress from the caregivers. (Holthe, Halvorsrud et al. 2020, Snyder, Dringus et al. 2020)

Timing of Implementation and Disease Progression

Providing timely information and opportunity for implementation is a strong predictor for adoption of ATT. Considering the progressive nature of dementia, this element would perhaps be seen as common sense. However, there appears to be a lack of attention to this important element when ATT is being developed and introduced to the PwD and their caregivers. Healthcare workers often felt they did not have adequate information, training or support for recommendation of ATT. Gibson et al. conducted a qualitative study in 2019 (n=39) and found that not only was ATT being introduced too late but that it was also mostly introduced post-crisis, such as after a fall or wandering incident. (Gibson, Dickinson et al. 2018) There is a need for development of subsequent strategies that emphasize a proactive vs. reactive goal for adoption of ATT by the PwD and their caregivers.

Most agreed that ATT should be given as an option in the earliest stages of diagnoses, and in some instances before diagnoses when the PwD is experiencing beginning signs and symptoms of the illness. A qualitative study by Holthe et al. (2018) (n= 13) found however,

that during these early phases too much general information concerning ATT can be overwhelming especially considering the PwD and caregivers are having to take in a lot regarding the diagnosis and treatment options. (Holthe, Jentoft et al. 2018) In this case, the information was distributed in the form of brochures at a community memory clinic. Perhaps a tailored information approach should be considered to reduce this potential adverse effect. Another qualitative study by Arntzen et al. (2016) (n=26) looked at successful incorporation of ATT for young PwD and family caregivers and concluded that the degree to which the ATT could be tailored to meet the PwD's cognitive condition was of huge importance. (Arntzen, Holthe et al. 2016)

There is reference within the literature to a phenomenon within the disease trajectory of dementia called *ingression*. (Lindqvist, Larsson et al. 2015, Malmgren Fange, Carlsson et al. 2020) *Ingression* is defined by Fange et al. as a metaphor of Russian dolls; layers and experiences comprised of an inner core of early abilities and memories. (Malmgren Fange, Carlsson et al. 2020) PwD rely on these earliest memories and experiences as their disease progresses. The PwD would often discontinue use of the new ATT intervention in leu of "old habits" previously established as the disease progressed. This transition within the disease progress should be viewed as an opportunity to reassess the most appropriate options for the PwD and their informal caregivers. This junction seems to be a pivotal point where instead of abandonment of ATT occurs, there is a new opportunity for uptake of new or more specifically tailored ATT which better accommodates the PwD and their caregivers.

Technology Anxiety

Technology anxiety emerged as an important predicting factor for success of implementation. Within the found literature we see repetitive mention to technology anxiety as a barrier to adoption of new innovation. (Lindqvist, Larsson et al. 2015, Mehrabian, Extra et al. 2015, Arntzen, Holthe et al. 2016, Egan and Pot 2016, Malmgren Fange, Schmidt et al. 2017, Ienca, Lipps et al. 2018, Asghar, Cang et al. 2019, Steils, Woolham et al. 2019, Dai, Larnyo et al. 2020, Holthe, Halvorsrud et al. 2020, Malmgren Fange, Carlsson et al. 2020, Snyder, Dringus et al. 2020)

The randomized controlled trial TECH@HOME Project (n=640) implemented smart home sensor technology to investigate informal caregiver burden and found that some healthcare workers seemed to be afraid and distressed by new technology and at times

unintentionally tampered with hardware without knowing what they were doing or how to fix it. (Malmgren Fange, Schmidt et al. 2017) Technology anxiety can be reduced and addressed by deploying specific strategies for dialog with both the PwD and their caregivers, planned inclusion of all possible stakeholders in the education and implementation process and continued, tailored support throughout the lifespan of the implemented ATT.

Caregiver's (informal) involvement in telecare provision from the perspective of council telecare managers and stakeholders was studied by Steils et al. The study involved a three-stage mixed-method design including interviews with telecare managers (n= 27), case studies (n= 21) and a survey of councils (n= 114). The results of the study reported on reasons why formal telecare had been decommissioned at the request of the recipient or caregiver. One main finding was that this occurred because the caregiver felt it had become invasive and caused anxiety to the older person, and/or that the PwD was unable to unreliably operate the device. This had a direct negative impact upon the caregivers. (Steils, Woolham et al. 2019)

System Failures, Errors, Lack of Connectivity

System failures were seen as detrimental to adoption of new technology. Burdens such as system failures, various errors in programming and issues with connectivity were viewed to have the potential to “tip the scale” in favor of rejection of ATT. In some instances, failures in initial processes and planning for the implementation were reason for eventual system failure, and overall rejection of the ATT.

An example was given by Dugstad et al. in 2019 in a longitudinal 4-year study (n=67 installations) which investigated co-creation and the implementation of monitoring technology in residential care for PwD. The study refers to an integral period they call “pre-implementation”. Here the authors found that important factors in this pre-planning phase were missing in 7 of 8 municipalities included within the study. These included basic elements such as initial risk assessments, patient safety assessments, compatibility assessment between current and future technology, security assessments and involvement of all required key stakeholders. The result was that inevitably instability and error occurred, creating an array of frustration, poor service delivery, security risks to the PwD and instability in the overall infrastructure at the municipality level. The study concluded that reliability of the technology was crucial and that IT infrastructure and mobile network instability were the major persistent barriers to implementing the monitoring system. (Dugstad, Eide et al. 2019)

Poor quality of hardware and software was seen as a risk factor that could harm the overall reputation of the ATT market. A 2018 qualitative study by Ienca et al. (n=17) investigated technology for psychogeriatric care using interviews in a multinational context (Switzerland, Germany and Italy) and looked at health professionals and researchers views on intelligent ATT. One viewpoint taken from the interviews was that the ATT market included numerous poorly designed, clinically ineffective and insufficiently validated devices. (Ienca, Lipps et al. 2018)

Digital Divide (digital inclusion)

Digital literacies or competences can be described as the knowledge, skills and dispositions needed in order to utilize ATT. As the complexity of available and emerging technology increases, the concept of digital literacies presents as a challenge and is a highly debated topic in the fields of healthcare, education and research currently. When specifically applied to persons with cognitive impairment, competency and understanding of topics such as ethics and sustainability of digital services also take center stage as these users are especially vulnerable. Within the last decade there has been a push to standardize the approach to digital literacies. Some argue that universalization of digital literacy approaches can be problematic and that a better solution may be a cross-national, multidisciplinary blending of concepts (Pangrazio, Godhe, Ledesma. 2020)

Lack of Access to or Knowledge of ATT

Limited access to knowledge about the type of technologies available and limited resources available for the provision of ATT are a barrier to the implementation of ATT in various contexts. One may assume that this context is referring to primarily LMIC settings. Although accessibility may fall into a larger category within the hierarchy of barriers, it is certainly not limited to LMIC. Accessibility limitations in mid-high level income countries still include lack of basic provision such as internet access (although to a lesser degree), but main access limitations here are due to lack of knowledge and organizational restraints.

Dai et al. (2020) (n= 350) conducted a survey which looked at factors affecting the acceptance of wearable devices by PwD in Sub-Saharan Africa and found that limited access and availability of wearable devices limited overall use of this ATT and created hesitation by

caregivers to encourage use for PwD.(Dai, Larnyo et al. 2020) Within the reported research from higher income countries, accessibility was defined a bit differently. These included that the general physician and/or healthcare workers had not informed the PwD or caregiver about ATT as a part of the dementia care possibilities, policy restraints and a general lack of knowledge regarding available ATT by both formal healthcare workers and informal caregivers alike. (Jarvis, Clemson et al. 2017, Dai, Larnyo et al. 2020, Holthe, Halvorsrud et al. 2020)

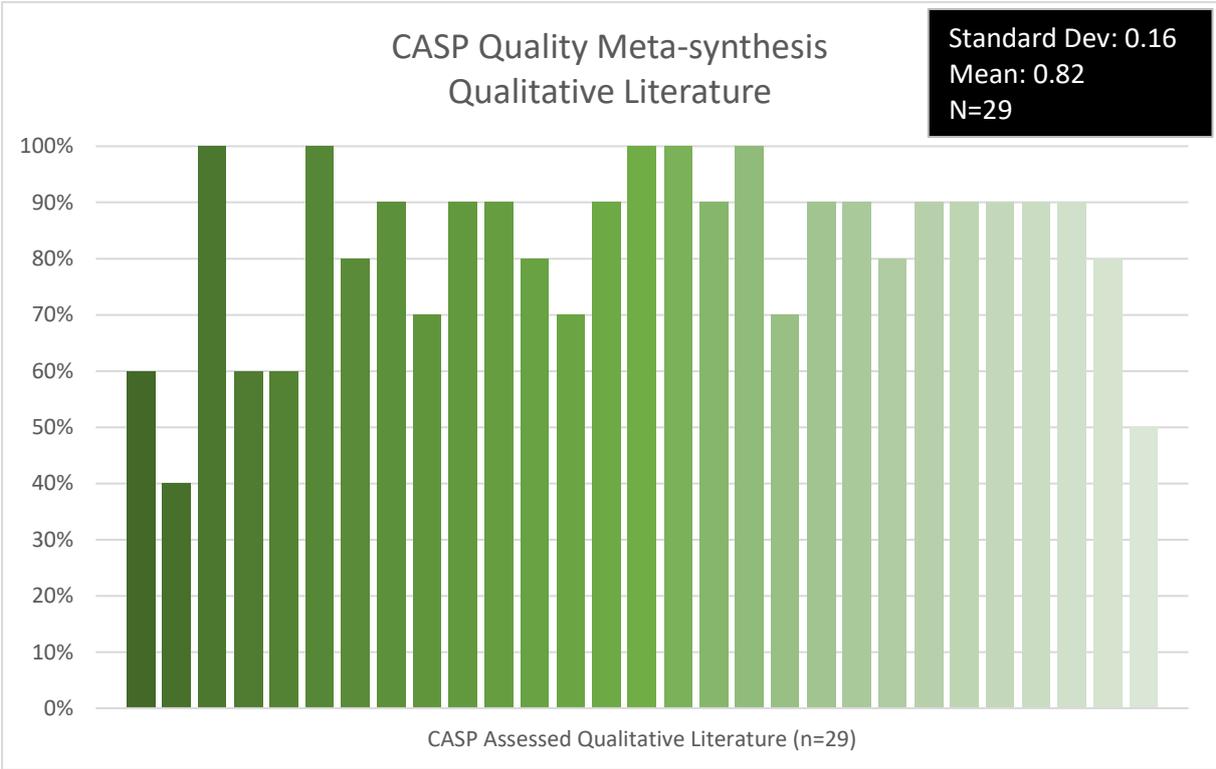


Figure 9. CASP Meta-synthesis of Qualitative Literature

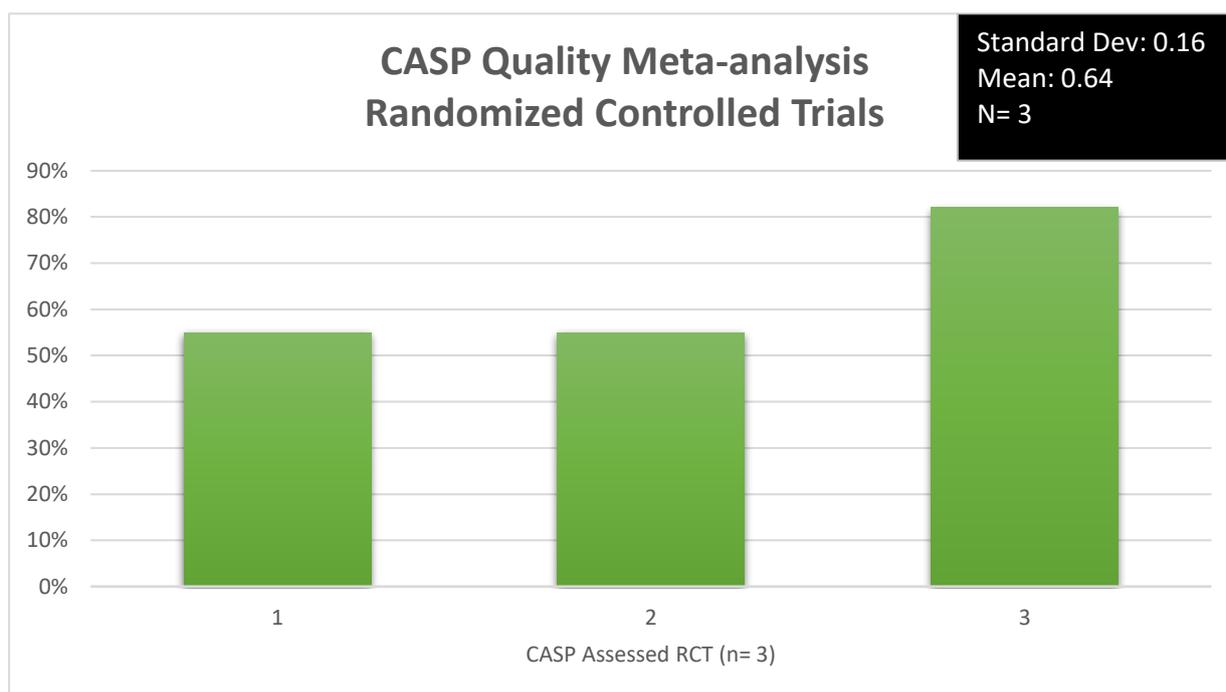


Figure 10. CASP Meta-analysis of Quantitative Literature

CASP Questions for RCT	Yes	Can't Tell	No
Did the study address a clearly focused research question?	3		
Was the assignment of participants to interventions randomized?	3		
Were all participants who entered the study accounted for at its conclusion?		3	
Were the participants [investigators? People assessing/analyzing outcomes] blind to the intervention?			3
Were the study groups similar at the start of the randomized controlled trial?	3		
Apart from the experimental intervention, did each study group receive the same level of care?	3		
Were the effects of the intervention reported comprehensively?	1		2
Was the precision of the estimate of the intervention or treatment effect reported?	1	2	
Do the benefits of the experimental intervention outweigh the harms and costs?	2	1	
Can the results be applied to your local population/in your context?	3		
Would the experimental intervention provide greater value to the people in your care than any of the existing interventions?	1	2	

CASP Questions for Qualitative Studies	Yes	Can't Tell	No
Was there a clear statement of the aims of the research?	29		
Is a qualitative methodology appropriate?	28	1	
Was the research design appropriate to address the aims of the research?	25	4	
Was the recruitment strategy appropriate to the aims of the research?	24	5	
Was the data collected in a way that addressed the research issue?	22	7	
Has the relationship between researcher and participants been adequately considered?	5	22	
Have ethical issues been taken into consideration?	27	2	
Was the data analysis sufficiently rigorous?	23	6	
Is there a clear statement of findings?	29		
How valuable is the research?	24	5	

Table(s) 6. CASP questions and number of studies that met and did or did not meet each question (meta-synthesis and meta-analysis)

Evaluation of Studies: CASP Meta-synthesis and Meta-analysis

CASP scores were calculated using a two-point scale for each of the criteria (10 for qualitative and 11 for quantitative), 0=not or partially met and 1=totally met, to give a score (%) for each article out of 10 (qualitative) or 11 (quantitative). Further, a quality criterion was assigned based on the following scale: 1-4 low, 5-7 average, 8-10 (11) high. Standard deviation and mean were calculated based upon the total scores (qualitative and quantitative). (Figure 9 and Figure 10) The scores ranged from 40-100% for the qualitative articles (n=29), where one (1) article fell in the low category, seven (7) in the average rating, and twenty-one (21) in the high-quality category. Scores ranged from 55-82% for the quantitative articles (n=3), with two in the average rating category and one in the high-quality category. Overall, the total rating for included qualitative articles in this systematic review is high and for quantitative articles is average according to this analysis.

Elements in the Implementation Process

The elements of the implementation process which were most prominent across the included studies were: adoption, usability, appropriateness, cost, feasibility, fidelity, and sustainability. A brief summary (Table 7) of important factors from the elements of adoption & usability, appropriateness, and attitude & acceptance found within the included literature. Further analysis of the elements of cost, feasibility, fidelity and sustainability is provided in the discussion.

Element(s)	Summary of Important Factors	Literature
Adoption & Usability	<p>Old patterns & habits were preferred ATT must fit into an everyday life context PwD or caregiver must be independent with use Psychological, physical and external support have an effect Involving all key personnel Clear instructions - ease of use Integration with current systems Even simple technology required carer support ATT that supports meaningful and safe activities most used Engagement of the caregiver is crucial Ability to independently maintain functions was important Normalizing the use of ATT was important Tailored solutions Experience with technology and interest play a role Confidence in abilities helped with adoption</p>	<p>Arntzen et al Arthanat et al. Asghar et al. Dugstad et al. Fange et al. Gibson et al.1 Gibson et al.2 Holthe et al.2 Ienca et al. Lindquist et al. Niemeijer et al. Pino et al. Snyder et al. Yaddaden et al.</p>
Appropriateness	<p>Alarms were often stressful to PwD ATT was often a "double-edged sword" Must be user-friendly, adaptable and manageable Should not be intrusive within the home Assess risk of unwanted side-effects Mismatch between what carer wants and what PwD is capable of PwD are interested in the possibilities of technology Wearables should be inobtrusive</p>	<p>Arntzen et al. Dugstad et al. Gibson et al.1 Ienca et al. Kerssens et al. Snyder et al.</p>
Attitude & Acceptance	<p>Must address practical, emotional and relational challenges Must fit well into habitual practice & generate positive emotions ATT had to interest the caregiver Adaptation is important Caregivers willingness and attitude influenced the PwD Independent use was important Simple technology was best accepted More readily accepted when the ATT relieved care burden PwD preferred use for social interactions Social influence and acceptance impacts adoption Fear of replacement by some healthcare staff Stigma surrounding lables of ATT for PwD Some PwD tolerated the ATT for the sake of the caregiver In general PwD were positive to the use of ATT Tailored solutions more readily accepted Complicated ATT was less adopted Must address unmet expectations after implementation ATT that improved communications was of great importance Disease progression taken into consideration Ageism and stereotyping are common Peace of mind, safety, independence Benefits in psychoeducation and gained knowledge of dementia</p>	<p>Arntzen et al. Arthanat et al. Asghar et al. Coco et al. Dai et al. Dugstad et al. Egan et al. Fange et al. Gibson et al.1 Gibson et al.2 Holthe et al. Holthe et al.2 Ienca et al. Kerssens et al. Mehravian et al. Niemeijer at al. Pino et al. Snyder et al. Yaddaden et al. Øksnebjerg et al.</p>

Table 7. Elements of the Implementation Process, summary

DISCUSSION

Investigation of the promoters and barriers to implementation and adoption of ATT for PwD and their caregivers revealed five arching topics which we will highlight within our discussion. These include tailored solutions and training, ethics and safety for PwD, timeliness of intervention, cultural relevance, and improved strategies for implementation and future research. Knowledge surrounding these factors can shape how ATT is developed, researched, funded and ultimately accepted within the market (by the end-user). Implementation should be viewed as a “living” process in which there must be contingency and finite strategies for continued evaluation of the appropriateness and effectiveness of ATT for each user. Just as dementia and palliative care is defined along a spectrum, so should tailored ATT interventions be viewed. Sustainable implementation is well planned, continually evaluated, supported and informed by the end-user. Habitual use, or adoption, will only be sustained if ATT solutions are tailored to the individual circumstances of the user over time, again indicating that implementation strategies should be well thought out and based upon knowledge of the promoters and barriers of implementation within this systematic review. Understanding of the evolution and radical change which is potentially necessary at the municipality and government levels within the healthcare supply chain is essential to the future success of ATT implementation. Government healthcare and municipalities should seek to forge new and unique partnerships in order to achieve the aggressive goals heading towards 2050.

Tailored education and training with a multi-stakeholder approach is of utmost importance to the success of implemented ATT. Proper education for the healthcare teams which will provide continuation of care and support of ATT implementation beyond the policy levels should be a key strategy within the implementation plan. These stakeholders are often primary facilitators for the use and adoption of ATT. They should also be viewed as a team facilitator along the course of continued maintenance and support. The pre-implementation phase is of critical importance in identifying all stakeholders and levels of tailored education needed. Healthcare workers have been found to be “late adapters” of new technology according to several studies. (Egan and Pot 2016, Malmgren Fange, Carlsson et al. 2020). These studies indicated that the staff had insufficient knowledge of the ATT, inability to maintain the technology and at times were fearful of the ATT for various reasons including fear of job loss or replacement and having negative feelings towards the appropriateness of

the ATT in regards to maintaining dignity and safety for the PwD. A scoping review by D’Cruz et al. published in 2020 looked at tailored education of adults with cognitive impairments (inpatient hospital setting). Several barriers to tailored education were identified including time constraints (formal caregivers), use of jargon and lack of appropriate communication approaches (client) and caregiver burden and stress (informal caregivers). In regards to education for the persons with cognitive impairment, programs should have variation in delivery of information (verbal and written, various time points, etc.) and should reflect individual cognition levels (re-tested often and systematically) and preferences of the client. (D’Cruz et al., 2020)

Education and training should extend from the healthcare stakeholders to the PwD and caregivers directly and involve a curriculum for improved knowledge of rights, ethics and safety concerning the provision of ATT. With regards to digital literacy for PwD and their formal or informal caregivers, a combined and flexible methodology would fit well with a co-design and patient centered strategy for improved future ATT implementation. This approach could allow for specialized conceptualization of ATT for PwD and caregivers across globalized frontiers. A mixed-method study by Gillie et al. (2022) (n=90) investigated barriers and promoters to prescription of telehealth and telehealth literacy as a social determinant of health in PwD, resulting in creation of a multidimensional questionnaire for telehealth literacy screening of older adults. Development of such novel tools could be useful in determining levels of literacy and subsequent levels of training and education which are needed for successful implementation of ATT for home dwelling individuals. (Gillie, Ali et al. 2022)

Another avenue related to digital literacy is the concept of *dementia literacy*. Having a combined approach of novel education regarding disease process and ATT use, maintenance, and support can strengthen knowledge and awareness of dementia, decrease stigmas, and could intrigue interest for future ATT adoption throughout the spectrum of the disease. The included literature suggests education that includes novel, digitally delivered community support delivered via web conferencing, smartphones and other platforms such as WhatsApp which can promote self-efficacy and confidence in the new technology. Another novel concept that was noted in several of the included studies was that of educating the PwD and caregiver to be able to educate others regarding the technology within their circle of influence. (Evans, Bray et al. 2017, Dugstad, Eide et al. 2019, Oksnebjerg, Woods et al. 2020, Snyder, Dringus et al. 2020) This concept incorporates aspects of ethical consideration for other auxiliary and support staff in the home, for example with use of smart home monitoring

technologies, that may require general understanding and knowledge of the prescribed technology.

Navigation of safety, ethical and privacy concerns are of course a challenge and should be taken into consideration for this vulnerable group (Crutzen, Ygram Peters et al. 2019). The introduction of ATT often raises ethical considerations, and tailored education programs should be developed to address these specific concerns and be tailored for a variety of stakeholders and audiences (policy-makers, municipalities, caregivers, PwD, etc.). (Snyder, Dringus et al. 2020) One interesting revelation within the included literature was that in many cases the PwD and caregivers considered the feeling of “safety” to supersede personal ethical considerations for the implementation of ATT. This also included feelings of new found freedom in completion of daily tasks or the ability to participate in life events in which the PwD gained independence, autonomy or a feeling of “normalcy”. A systematic review by Teipei et al. in 2016 regarding ATT solutions for navigation purposes for PwD, recommends that there should be a clear distinction between safety and autonomy. The authors suggest that future technologies should be better able to assess safety features of the environment and the PwD based upon algorithms designed to recognize safe movement, distress, etc. (Teipel, Babiloni et al. 2016) With the current evolution of Artificial technology (AI), this suggestion could soon be a reality for monitoring technologies, thus helping to better safe guard privacy and autonomy for the user. Hine et al. (2022) explored ethical considerations in the design and implementation of home-based smart care for dementia in a review using a case study from the National Healthcare System in the United Kingdom. They identified beneficence, non-maleficence, autonomy, fairness and transparency as a set of general principals which should guide implementation of AI and sensor technologies. They recommend to design ethics into smart healthcare concepts using a human-centered design, an intersection of various frameworks as guidance, and a network of multi-disciplinary stakeholders as advisers. (Hine, Nilforooshan et al. 2022)

Responsibility for timeliness of ATT implementation falls to healthcare and municipality representatives alike, and on multiple tiers of the healthcare ecosystem. The included study by Holthe et al. found that the provision of ATT took an average of 7.5 weeks within the study. This should be be “food for thought” considering the progressive nature of dementia and the stage in which introduction to ATT is usually made. Introduction to viable options for ATT support for the PwD and caregivers should be made at the earliest possible opportunity in order to fully realize the potential and usefulness of these novel solutions,

rather than in crisis or post-crisis situations. This means that levels of healthcare which are involved in making early diagnosis and providing support care must be educated on the benefits and availability of ATT for PwD and caregivers. In addition, timely implementation of ATT and continued aim towards habitual use should include continual evaluation and tailoring of the interventions to meet individual needs of PwD and caregivers. Guisado-Fernandez et al. (2019) conducted a scoping review and design framework looking at factors influencing the adoption of smart health technologies for PwD and their caregivers. One theme they discuss is condition-related challenges, including appropriate timing for implementation of technology and to what degree of decline (disease progression) the PwD participating in the intervention should be. They state that because dementia is associated with gradual and progressive cognitive and physical deterioration that design considerations must be tailored for implementation of these new technologies. These considerations include unobtrusiveness, ease of use, familiarity, intuitiveness, use of common language, planned onboarding and support, sensory, motricity and durability. (Guisado-Fernandez, Giunti et al. 2019)

Cultural relevance is an important consideration when conceptualizing the potential generalization of results from these often smaller and diverse studies, and from a high-income context to LMIC. Although direct generalization in most cases is not possible, the conceptual knowledge of specific promoters and barriers which influence implementation and adoption of ATT globally, can essentially be viewed as core elements and guide strategies. Necessary adaptation surrounding cultural contexts should be applied when developing future strategies for implementation. Considering the amount of immigration and refugee seekers globally over the last decade this concept will become increasingly relevant in LMIC and high-income countries alike. As mentioned in the background section of this review, myth and misunderstanding of general disease etiology as well as stigma surrounding the diagnosis of dementia is a global problem. It is common to see both public and personal stigmas surrounding the diagnosis of dementia. Fear, shame, stereotypes and prejudices are some of the emerging themes found in recent studies (Calia, Johnson et al. 2019, Nguyen and Li 2020). A study conducted in the United Kingdom investigating stigma among primarily Black African and Caribbean communities found that there was a general perception that dementia was a “white person’s illness” (Berwald, Roche et al. 2016). A systematic review by Brooke and Ojo revealed that there is a common belief in Sub-Saharan Africa that PwD are witches, resulting in abuses and improper care (Brooke and Ojo 2020). African American and Latino

populations in the USA consistently show higher risk rates for MCI and AD and it is theorized that cultural aspects such as ethnicity, language, country of origin, immigration status, acculturation and healthcare disparities can be associated with these higher rates (Gentry, Rummans et al. 2021). Dementia prevalence among African Americans remains high, however has declined since 2012. It is hypothesized that this trend may be related to successful campaigns directed towards hypertension prevention for this minority group. African Americans typically have higher rates of vascular dementia, thus campaigns aimed at improvement of heart health may have had a combined positive effect on hypertension and dementia.

Clearly, the complexities of culture and migration globally should be considered when developing implementation strategies and novel education for ATT for PwD within ethnically diverse communities. Improving programs aimed at digital and dementia literacy could empower PwD and caregivers and assist in decreasing global stigma surrounding the disease. Another point which is related to improved knowledge and culture is that the “hesitancy to prescribe” concept depicted by Dai et al. may well be in play within varied cultural contexts where knowledge of ATT and its benefits is generally limited. (Dai, Larnyo et al. 2020) This would in theory mean that socio-economic level would play a lesser role in these contexts, meaning that this “hesitancy to prescribe” phenomenon presents equally in middle-to-high income countries and LMIC. Should digital and dementia literacy be improved, you could hypothesize that the desired end result of increased adoption should follow. Further studies are needed to investigate this concept in varied economic and cultural settings taking into consideration certain confounding factors such as overall access to ATT and connectivity (WIFI).

Implementation Research Outcomes

The elements of implementation identified within this systematic review which had an impact on resulting adoption of ATT included: appropriateness, cost/expense, feasibility, fidelity, and sustainability. We provide in this review a quick summary of all of the relevant findings under several of these elements (Table 7). In addition, we would like to further discuss several aspects regarding cost/expense, fidelity and sustainability that we feel are relevant for future researchers, developers and various stakeholders (private and public healthcare organizations, government/municipalities) surrounding the topic of ATT implementation for PwD and their caregivers.

Costs/Expense of ATT

Some interesting suggestions emerged within the found literature in regards to expenses associated with ATT. Development of ATT usually requires large financial investments (public and private) and can lead to social and economic loss. This sometimes means that development is delayed and at more commonly stopped due to waning financial support. Therefore, strategic collaboration between public and private entities is essential in pushing the development of new innovation towards a market ready product. These collaborations may be forged between unlikely partners in the future and could include avenues such as private health insurance providers, industry corporate giants, banks, influencers (social media) and private investors with humanitarian interests. The usual stakeholders should also have a financial interest in the development and forging of market ready ATT for communities. These include government level leadership, universities, municipalities and healthcare systems.

There could also be a need for more alliance of private health entities, in countries such as Norway, that depend on a primarily public healthcare system currently. In Norway, we can see that the private sector is growing. This is largely due to increased private insurance benefits within large corporations, but also connected to the challenges in the public system such as overcrowding, long waiting periods and lack of access in rural areas. There is a need for private healthcare within the ecological flow of these healthcare systems. This means leadership should prioritize setting politics aside and creating strategic alliances with private partners. This could create more opportunity for development and implementation of ATT within communities.

Once an ATT product is ready for the market, the expense of these items directly affects the implementation and adoption choices of PwD and their caregivers. Elderly patients often have little to no disposable income and responsibility of purchasing ATT falls to the spouse or children. Some specific suggestions to assist with implementation and adoption of market ready ATT from caregivers within the literature included: government assistance, low interest loans, leasing options, subsidized costs and complimentary basic support. The idea of a “mixed-economy” approach to service provision was suggested, meaning that state funded social care and private individuals fund ATT provision. This model could be set on a need basis

regarding resources of the PwD and the family. It is clear that more creative options are needed to promote implementation and adoption in this arena. (Gibson, Dickinson et al. 2015, Pino, Boulay et al. 2015, Egan and Pot 2016, Gibson, Dickinson et al. 2018, Asghar, Cang et al. 2019, Arthanat, Begum et al. 2020, Dai, Larnyo et al. 2020, Yaddaden, Couture et al. 2020)

Fidelity

Fidelity is most commonly defined as whether the ATT does what it is intended to do. Value, trust and worthiness of the ATT intervention is often determined by the fidelity and has a significant impact on adoption. With regards to the implementation of new technology we also see that this definition includes the use of the ATT for other intended purposes. For the purposes for this review, we are defining this as *contamination*.

Sustainability

The existing healthcare ecosystem, relying on external service providers for technology design, support and provided competence, is not a sustainable model. (Arntzen, Holthe et al. 2016, Asghar, Cang et al. 2019, Dugstad, Eide et al. 2019, Arthanat, Begum et al. 2020) In the future, more advanced IT competence must be integrated directly at the municipality and healthcare system levels. An established timeframe for this transition should be considered, combined with co-creation activities between stakeholders. Learning must occur with and between stakeholders at various levels in the ecosystem. Resource integration is an important part of the larger process towards sustainability. Sharing of knowledge, tools and other resources should occur from the top levels to the end-users. This model can assist with a “shared-economy” approach and offer the end-users support throughout the implementation process.

Implementation Frameworks & Theories: What is Implementation Science?

Just six of the thirty-two (32) included studies in this review utilized the assistance of an implementation framework or theory, and very few provided a quality description of implementation strategies used. (Steils, Woolham et al. 2019, Arthanat, Begum et al. 2020, Dai, Larnyo et al. 2020, Oksnebjerg, Woods et al. 2020) The included frameworks within the review were: United Theory of Acceptance and Use of Technology (UTAUT), Measurement

Instrument for Determinants of Innovation (MIDI), Twigg and Atkin’s typology, and the Medical Research Council (MRC) framework.

<p>UTAUT (Momani 2020)</p>	<p>UTAUT consists of objective and subjective constructs which assess the acceptance and satisfaction of the adoption of new technologies. It consists of four core constructs: performance expectancy, facilitating conditions, effort expectancy and social influence.</p>
<p>MIDI (Fleuren, Paulussen et al. 2014)</p>	<p>Based on research published in 2004 regarding fifty potential determinants of the implementation of innovations. Determinants are concerned with the innovation itself, adopting person, organization and socio-political context.</p>
<p>Twigg and Atkin’s typology (Steils, Woolham et al. 2019)</p>	<p>Developed in 1994 and based on Twigg’s original typology developed in 1989. The conceptual framework encompasses four models describing how carers are typically perceived: resources, co-workers, co-clients or “superseded” carers.</p>
<p>MRC framework (Skivington, Matthews et al. 2021)</p>	<p>Revision commissioned in 2020 by the National Institute of Health Research (UK) and the MRC and widely used for developing and evaluating complex interventions in healthcare.</p>

Table 8. Explanation of included frameworks and theories

Implementation Science is an emerging field of study which focuses on the *research-to-practice gaps* that have unfortunately been very prominent and often criticized in recent years. Bauer defines Implementation Science as “the scientific study of methods to promote

the systematic uptake of research findings and other evidence-based practices into routine practice, and, hence, to improve the quality and effectiveness of health services”. (Bauer, Damschroder et al. 2015) Implementation research outcomes may include topics such as acceptability, adoption, appropriateness, feasibility, fidelity, implementation costs, coverage, and sustainability (Peters, Adam et al. 2014).

The MRC created an evaluation framework in 2000 for evaluating complex interventions that has since been revised in 2020. The revision commissioned jointly by the MRC and the National Institute for Health Research takes into account recent developments in theory and methods and the need to maximize the efficiency, use and impact of research. (Skivington, Matthews et al. 2021) One of the key elements of the framework is implementation which is considered a long-term process of assisting and monitoring intervention usefulness. Implementation can notably be influenced by external complex factors such as implementation strategies by investors which may compromise the effectiveness of the intervention (Craig, Dieppe et al. 2008). Researchers must therefore be prepared to challenge decision makers to ensure a balance between compromises made and must address the important topics of fidelity (delivery as originally designed) and adaptation by identifying core and discretionary components of their interventions. (Craig, Dieppe et al. 2008)

There are a limited number of implementation frameworks which include a variety of comorbid factors based on interplay of complex disease processes. Most fail to consider the web of additional cultural, psychosocial, internal and external factors that could ultimately impact adoption of ATT for PwD and caregivers. It appears the most effective implementation studies utilize a variety of combined frameworks and theories in order to include important elements such as factoring for complexity of intervention (or disease), maintenance of implementation, evaluation, context, scale-out and scale-up, adaptation, identification of core and discretionary components, social validity, fidelity, drift, replication and follow up. (Movsisyan, Arnold et al. 2019) Recent research emphasizes the need for more tailored-ATT approaches and implementation; the combined use of frameworks and theories specific to implementation science can assist in efforts to generalize results in varied contexts and should be more readily utilized in future studies. (Craig, Dieppe et al. 2008, Peters, Adam et al. 2014, Oksnebjerg, Woods et al. 2020, Pappadà, Chattat et al. 2021)

One framework suggestion for future studies we would like to highlight as an example for the purpose of this review is “The Promoting Action on Research Implementation in Health Services”, or PARIHS framework. Harvey and Kitson describe the evolution of the PARIHS framework to the now revised I-PARIHS framework and state that it “was developed in an attempt to represent the dynamic and multi-faceted nature of implementation in healthcare”. (Harvey and Kitson 2016) The main construct of the now I-PARIHS framework is the use of a facilitator(s) as the “active ingredient” of implementation, driving the implementation efforts, applying and revising strategies, engaging relationships with stakeholders and negotiating barriers within a contextual setting.

The idea of the healthcare worker and/or the caregiver as the facilitator(s) of ATT implementation could provide a working model at the municipality level for better uptake of innovation and eventual desired result of adoption of new technology. In addition, a framework such as RE-AIM could be combined to assess the elements of maintenance and evaluation missing from the I-PARIHS framework: Reach, Effectiveness, Adoption (setting and staff), Implementation and Maintenance (individual and setting). RE-AIM is widely used across diverse study designs and is easily adaptable. (Glasgow, Harden et al. 2019) Although we highlight I-PARIHS and RE-AIM, it is important to keep in mind that there are many available resources in the field of Implementation Science that can be utilized for future studies in efforts to strengthen study design and address research-to-practice gaps surrounding implementation and adoption of ATT for PwD and their caregivers.

Improved Implementation Strategies

It appears that the “ISLAGIATT” principal, which stands for “It Seemed Like A Good Idea At The Time”, is the current dominant philosophy employed when planning for the implementation of ATT. The “ISLAGIATT” principal focuses on inertia from “things we have always done”, lacks the general understanding of the barriers and facilitators surrounding implementation of ATT and most often fails to create the outcome of wanted future behaviors, such as adoption. (Powell, Fernandez et al. 2019) Powell et al. investigated how we can enhance the impact of implementation strategies in healthcare and move away from the “ISLAGIATT” principal. The study found that 5 priorities should be established in order to achieve this goal. They are 1) enhance methods for designing and tailoring implementation strategies (mapping), 2) specify and test mechanisms of change, 3) conduct more effectiveness research on discrete, multi-faceted, and tailored implementation strategies,

4) increase economic evaluations of implementation strategies, and 5) improve tracking and reporting of implementation strategies. (Powell, Fernandez et al. 2019)

One study we would like to highlight from this review that provided an excellent summary of strategies used is Dugstad et al.'s 4-year longitudinal study of the implementation of co-created monitoring technology in 67 care homes in Norway. The authors state that this implementation effort represented “radical innovation” and required many more resources and changes than anticipated. They conclude that successful implementation is often time-consuming and complex.(Dugstad, Eide et al. 2019) The study places large emphasis on the pre-planning phases and offers suggestions, based on the barriers and facilitators they encountered, for implementation strategies. Although this study is focused on implementation at a healthcare organization level (care homes), the authors provide a useful and adaptable model for use at various levels of implementation in regards to strategy development. The most salient pieces which align with this review are the inclusion for extensive pre-planning, involvement of key stakeholders, co-creation, tailored training and continued evaluation, reflection and revision during the lifespan of the implementation process. (Table 9)

Key Strategies	Defined	Facilitators and Barriers	Defined
Pre-Implementation preparations	<ul style="list-style-type: none"> Involving key agents Exploring system risks and compatibility Allocating resources Defining roles and responsibilities Maintaining leadership involvement 	<p><i>Technology stability and usability</i></p> <p><i>Building competence and organizational learning</i></p> <p><i>Service transformation and quality management</i></p>	<ul style="list-style-type: none"> Improving reliability Problem solving readiness Developing usability through co-creation Recognizing tacit knowledge Keeping up iterative improvement Tailoring iterative competence building across shifts and roles Focus on skills Overcoming language difference Organizing for reflection Managing risks Recognizing concerns Reviewing IT operations and service routines Making instructions and routines explicit and accessible to all Developing new roles Realising benefits Scaling up gradually Preparing for co-creation Recognizing differences between professional cultures Facilitating dialogue and translation between professional cultures Establishing a team of champions Promoting co-creation through workshops
Implementation			

Table 9. Dugstad et. al, Lifespan of the Implementation of Digital Monitoring Technology

Concept of Contamination

An interesting finding was something that was referred to in the literature as “bricolage” which references a “do it yourself” strategy for implementation of ATT. We are further defining this however as “contamination” referring to a reference from *Components of Process Evaluation*, and meaning that it is an evaluation of the use of something other than the intended intervention or use of the intervention for unintended purposes (i.e.: prescribed ATT). (Baranowski and Stables, 2000) This concept was highlighted within the literature as an emerging and growing trend and is a consequence of the barriers for implementation. ATT inclusion in daily life was often most convenient and readily adopted when the caregiver took a role as “bricoleur” and used a variety of off-the-shelf options, modifying existing household products and combining various ATT (municipality prescribed and private sector ATT) with current habitual habits (pen and paper, sticky notes, etc). Greenhalgh et al. (2013) said a ‘bricoleur’ is: a person who was open and knowledgeable about technologies and who could integrate them into care. (Greenhalgh, Wherton et al. 2013) A consequence is that caregivers sometimes feel obligated to act as bricoleurs because of a lack of assistance from health and/or social care services. This seems to be an emerging strategy to obtain ATT quickly, affordably and tailor-designed to meet personalized needs.(Gibson, Dickinson et al. 2015, Arntzen, Holthe et al. 2016, Gibson, Dickinson et al. 2018, Holthe, Halvorsrud et al. 2020) This trend highlights the need for more comprehensive and standardized programs at the municipality and/or public healthcare levels to include a variety of quality ATT providers and sustainable solutions for tailoring, co-design, and of utmost importance, the inclusion of the PwD and the caregiver within the lifespan of the process. A model for inclusion of existing habitual behavior as a way to compliment the routines of the PwD and caregivers can further provide an atmosphere for improved adoption of ATT.

Limitations of the Study

Potential limitations include the potential of missed studies, missed outcomes and compromised detection of missed information. Selective reporting bias and study publication bias can occur which can alter or influence the reported results from the study. The absence of information can affect the overall validity of the review. Small study bias can occur and should be accounted for by investigating the relationship between effect and sample size. In this case, a smaller study may yield a larger than realist estimate of the effect (Liberati,

Altman et al. 2009). A limitation of meta-synthesis and meta-analysis is that the information is analyzed solely based on the quality assigned to the included articles. In order to reduce bias in this instance the author has in addition included thorough analysis of thematic topics identified within the literature, bringing the focus of the review back to the original aim and research questions.

A limitation of this study is the exclusion of technology specific databases which may have yielded more results for inclusion. Another limitation of the study is that there is no standardized method for assessing the quality of research currently, however the CASP evaluation tool is widely used across various research settings. A final limitation of meta-synthesis and meta-analysis is that the thematic analysis of data is subjective, based on the authors background and understanding of the topic. In order to reduce bias in this instance, two collaborators were involved in the synthesis and convergent interpretation of the results.

Ethical Considerations

Ethical approval was not needed for the review, however ethical consideration was held in high regard when constructing the study design and reporting all subsequent results and outcomes.

CONCLUSION

Top promotors for the implementation and adoption of ATT included: personalized (tailored) training, safety for the PwD, involvement of all relevant stakeholders (multi-faceted approach including PwD), ease of use and support (design and follow up), and cultural relevance. Top barriers for the implementation of ATT included: unintended adverse consequences, timing and disease progress, technology anxiety, system failures (connectivity, errors, etc.), digital divide and lack of access to or knowledge of available ATT. The most crucial elements for the adoption of ATT in the future will be a focus on co-design, improved involvement of both the PwD and their caregivers, and the adaptability (tailoring related to context) of ATT solutions over time (disease process). Future studies with an exploration of a deeper understanding of the promotors and barriers within this review will assist in strengthening implementation strategies across research settings. This in theory should result

in the improved ultimate goal of adoption of ATT for PwD and their caregivers along the spectrum of the disease process.

There is a significant need for more quality research to be conducted in the regions of the world where population growth and prevalence of dementia is expected to grow most rapidly over the next 30 years. Cultural relevance and consideration should be of high importance when considering appropriate strategies for future ATT implementation. With a culturally relevant and personalized (adaptable) focus, a global, multi-national implementation guideline should be developed in order to encompass the changing global environment in both high and LMIC. This systematic review can be utilized as a guide for future implementation efforts. Existing resources, such as implementation frameworks and theories, should also be considered to enrich context and allow for generalization of future studies.

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