Review of Systematic Reviews: Telecare Interventions for the Ageing Population

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Contents

Abstract

Background: Telecare provides a largely viable solution to the care needs of our ageing population. As many elderly people wish to maintain independence at home, sensors and other assistive technology, have the potential to enable safe living. Despite inadequate evidence, telecare continues to expand.

Aims: This review of systematic reviews aims to discover the knowledge base surrounding telecare. To ensure the best use of evidence, the use and value of telecare in supporting independent living amongst older adults, as well as the impact of telecare on users.

Method: Eleven databases were searched for systematic reviews and meta-analyses published between 2010-2022. Adults aged 50+ with or without a disability or health condition were included. The intervention of interest was telecare. All outcomes of interest were considered to ensure a broad inclusion of evidence (including activities of daily living, level of dependency, clinical and care-related outcomes, perceived QoL, adverse events resulting from the use of telecare, cost effectiveness, and effects of telecare on carers, family, friends). The JBI critical appraisal instrument for Systematic Reviews and Research Synthesis was used to assess the quality of 67 reviews. 29 reviews were selected for analysis.

Results: The majority of reviews included overlapping outcomes, focusing mostly on clinical outcomes (N=9), user experience (N=8), ageing in place (N=3), safety (N=3), Activities of Daily Living (N=3), effects on carers (N=3) and cost outcomes (N=2). The strongest evidence relates to safety and functioning, while stronger evidence is needed to show improvements to health and well-being.

Conclusions: Telecare offers a promising solution to supporting ageing in place, emphasising significant benefits to the safety and functioning of elderly persons. It is important that the needs of users are met to minimise barriers to long-term adoption. Despite expansion of telecare, further research in a home environment is required to evidence effectiveness.

Keywords:

Telecare, Older Adults, Digital Health, Digital Innovation, Systematic Review, Homecare

Introduction

One of the greatest challenges presented to health and social care is our ageing population[1]. Seeking solutions that will improve the welfare and well-being of elderly people (80+) is essential to ensure longer, healthier, active, and independent lives[4,5]. For a large number of elderly people, progressing age is associated with frailty[40]. Thus, management of risky conditions such as falls can be a difficulty for elderly persons who live alone, specifically for those aged eighty and above[2,3]. The provision of safety at home has been made technology feasible by recent advancements in information and communication technology[6]. Technology enabled care at home or in the community can aid in enhancing quality of life (QoL) while reducing healthcare costs[7]. However, multiple reviews have underscored the need for more vigorous evaluation to assess effectiveness, especially cost-effectiveness utilising sufficient quality evidence and to better understand user experiences.[5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17].

The demand for homecare is imperative when considering an ageing population in association with the presence of new and innovative technologies[2]. Telecare is intended to support prolonged independent living by using a mixture of sensors, alarms, and other equipment. Activity changes are monitored over time and will alert a call for assistance in emergency situations, such as a fire, fall, or flood[18]. As opposed to primarily centring on medical aspects of health conditions like telehealth and telemedicine, telecare generally uses assistive technology (AT) to enhance and maintain functional capabilities and independence, therefore aiming to promote safety and security at home[19]. The overlap and intersection between telecare, telehealth, and telemonitoring can create ambiguity due to lack of clear definitions[20]. However, this review aims to solely focus on telecare-related technologies, with some deviation to appropriate telehealth-related technologies used among the targeted age group.

Considering the growing use of telecare, it is important to establish actual and potential benefits to consumers through assessing outcomes of interest[17]. This umbrella review aims to provide an overview of the current body of systematic review evidence surrounding telecare. All relevant outcomes are considered, including activities of daily living, level of dependency, clinical and care related outcomes, perceived QoL and well-being, adverse events resulting from the use of telecare, cost-effectiveness, and effects of telecare on carers.

Objectives

Primary objective

To review and assess existing evidence about the use and value of telecare in supporting independent living among elderly persons (effect on activities of daily living, degree of dependency, admission to long-term care).

Secondary objective

To review and assess the evidence that explores the impact of telecare on users (adoption; usefulness and user-friendliness; autonomy); need for informal and formal care; carer burden; perceived quality of life; self-esteem; adverse events (falls); formal carer work satisfaction and feelings.

The subsequent section describes the methodology chosen. Next, an overview of the findings will be presented. Lastly, the paper concludes with a discussion of the findings, followed by implications and recommendations for future research.

Materials and Methods

An initial scope of the literature revealed that most studies relating to telecare overwhelmingly represent the older population. Focus is placed mainly on the elderly population in receipt of telecare to utilise the best available evidence while achieving a greater degree of generalisability. However, additional vulnerabilities were not excluded if usefulness of telecare was presented.

Data sources and searches

A systematic search of Cochrane Database of Systematic Reviews (CDSR), EBSCO, Ovid, PubMed, Web of Science, Science Direct, Epistemonikos, Health Systems Evidence, MEDLINE, Prospero, and Google Scholar was performed between March-April 2022 (Appendix 1). Searches were updated between June-July 2022 (Appendix 2). Key concepts (elderly; vulnerable; telecare; independent living) were used in conjunction with Boolean Operators. Searches were limited to systematic reviews (and meta-analyses). Grey literature was obtained through Google Scholar and ResearchGate. It was decided that grey literature would be included to reduce publication bias fostering a balanced picture of available evidence, and to increase comprehensiveness. The types of grey literature includes were evaluations and documentations. To identify further sources, the reference lists of included reviews were scanned. Authors were contacted to request articles with no access.

The search strategy and study selection were developed from the PICO (population, intervention, comparator, outcome) framework. The population comprised of adults (aged 50 and over) and/or their carer(s), both who provide informal care (friends/family) and paid care work (formal caregivers), to ensure a broader range of literature was captured. Although, the focus was mainly placed on elderly persons (aged 65 and above). Intervention included telecare services consisting of monitoring, diagnostics, communication, consultation, and training to maintain independent QoL for users (personal alarms, monitoring systems). The comparator was usual care or no telecare. However, the inclusion of a control group was not an eligibility requirement for this review. There was no specific outcome due to the limited amount of evidence on this topic. However, outcomes of interest generally included activities of daily living, level of dependency, clinical and care-related outcomes, perceived QoL and well-being, adverse events resulting from the use of telecare, as well as cost effectiveness, and effects of telecare on carers, family, friends.

The search was limited to post 2010 to ensure information was up to date. Technological advancements also played a role as the development of TEC has developed greatly in last 10 years.

Inclusion and exclusion criteria

To ensure a broad inclusion of published studies relevant to the research topic, the following criteria were adopted:

Inclusion Criteria	**Exclusion Criteria**
Type of studies	
• Date of publication – January 2010-July2022)	• Study protocols, nonempirical
• Systematic reviews using empirical methods (qualitative, quantitative, mixed)	• Articles were excluded if they focused solely on describing a telecare intervention or a technology.
• Grey literature	
• Publications in English, or translatable to English with full-text available	
Type of participants	
• Independent living older adults and/or caregivers of independent living older adults (formal or informal/paid or unpaid) • Vulnerable adults (18 or older who have the functional, mental, or physical inability to care for themselves).	• Children (under the age of 18)
• Adults with or without a disability/health condition	
Context	
• Persons generally living independently in a home-like/community setting (own home, nursing home, sheltered housing, residential care). • Technology use in home or supportive care environments (i.e., private residences, retirement villages, service-integrated housing, and independent living facilities)	
Type of interventions	
• Telecare defined as "continuous, automatic and remote monitoring of real time emergencies and lifestyle changes over time in order to manage the risks associated with independent living".	• Telehealth (technology used for the main purpose of monitoring health) • Assistive technology such as canes, walking sticks, chair lifts.

• Personal alarms, fall detectors, sensors, smart homes, wearables, monitors.	• Studies solely focussing on assistive devices such as canes, walkers, wheelchairs, and hearing aids. Nintendo Wii
	• Studies that were not health or care-related, focusing on home-based technology for other purposes such as energy efficiency or home security (e.g., sensors or cameras solely used to monitor either energy consumption or to detect intruders).
	• Interventions which require communication with healthcare professional
Outcomes	
• Main outcome focusses – health and social care. • 'Ageing in place' (supporting independence). • No specific outcome e.g., activities of daily living, quality of life, falls, hospital admissions, safety, acceptance, caregiver burden, benefits, challenges, costs, dependency, admission to long-term care.	

Study selection

Reviewer ran a search of systematic reviews according to the above search terms, identifying potential articles by screening titles and abstracts according to inclusion criteria. Main criteria of exclusion at the initial stage were technology interventions relating more to monitoring health conditions (telehealth), as opposed to telecare. Full texts were thereafter reviewed, whereby irrelevant studies were excluded. There was an initial difficulty of distinguishing between home telehealth/telemonitoring and telecare. However, this was resolved by focussing on independence and daily living as main outcomes. One reviewer consulted with a second reviewer when checking final articles, in relation to the research question and inclusion criteria.

Data extraction and quality assessment

Two reviewers extracted data from included systematic reviews using the JBI data extraction tool for Systematic Reviews and Research Syntheses. The objectives, participants (sample size, population demographics), setting, intervention, number of databases searched, date range of included studies, number of studies, type of studies, country of origin of included studies, appraisal instrument and rating, type of review, method of analysis, outcomes, and findings were extracted from each of the included studies.

Two reviewers independently assessed the methodological quality of included systematic reviews using the JBI critical appraisal instrument for Systematic Reviews and Research Synthesis (https://jbi.global/sites/default/files/2019-05/JBI_Critical_Appraisal-Checklist_for_Systematic_Reviews2017_0.pdf). This tool was chosen as it was deemed most suitable for a mix of qualitative and quantitative designs.

Analysis and synthesis

A meta-analysis was not appropriate due to heterogeneity of telecare interventions and possible overlap of primary studies. Results from the 29 included reviews are displayed narratively, and where appropriate tables are used for illustration. Three reviewers undertook analysis by extracting each review's background, findings, and discussion. Data was then thematically analysed through categorisation of key themes. Themes represented relevant outcomes and were merged accordingly. The review was supervised and assessed throughout by a clinical, research and programme lead, and then re-assessed by two other reviewers. All reviewers proofread the final manuscript as well as completing a final assessment of all data.

Results

The review selection process is summarised in Figure 1. PRISMA flow diagram. The search identified 606 reviews, from which 152 were examined as full texts. 29 studies were included in this umbrella review.

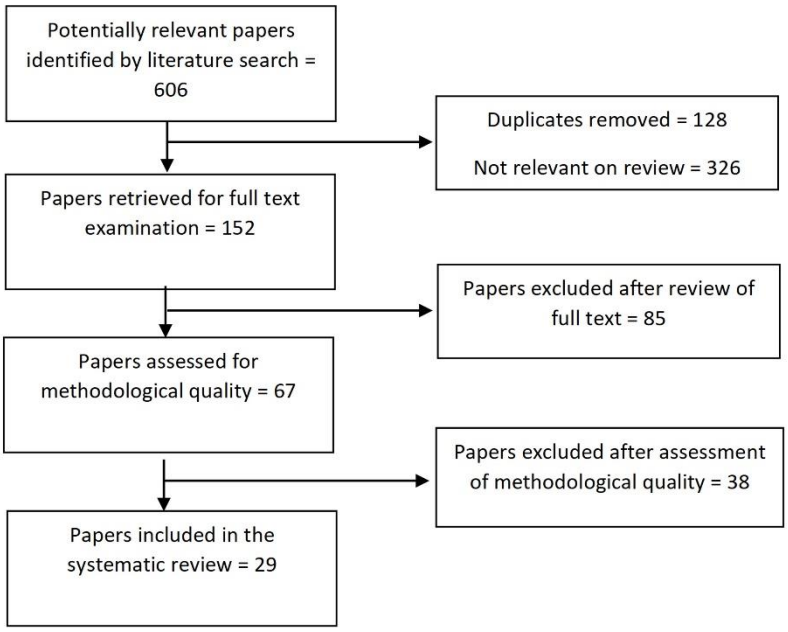

Figure 1: PRISMA Flow Diagram

Characteristics of included studies

The full characteristics of the 29 included reviews can be found in Appendix 3. The key characteristics are descriptively summarised below.

Outcomes of interest

Most reviews focussed on more than one outcome of interest and therefore overlap. Eight reviews focussed on user experience (acceptability, adoptability, usability) surrounding technology[3, 21, 4, 22, 23, 24, 25, 26]. Nine encompassed clinical outcomes such as frailty, well-being, QoL, falls, gait, sleep, agitation, depression [27, 28, 15, 29, 22, 30, 4, 31, 32]. 3 centred on ageing in place [12, 33, 10]. Three looked at safety alongside additional outcomes such as independence, communication, activity, wellbeing, and QoL[12, 31, 30]. Three were interested in ADLs[9, 34, 13]. Three were concerned with effects on carers[31, 4, 5]. Two highlighted cost outcomes[17, 2]. Two

reported effectiveness[26, 35]. Finally, technology being able to assess and aid with human loneliness or social isolation was the outcomes of 1 review[36].

Origin of primary studies in reviews

Of the 29 included reviews, the majority of primary studies within these were conducted in the US (68 studies), followed by the UK (21 studies) and Australia (20 studies). Some studies were conducted in multiple countries, making groupings complex. A full list of the remaining countries is displayed in the Appendix 4.

It is important to note that as many of the included reviews were conducted in the US, there may be contrasting uses, definitions and understandings of technology enabled care compared to UK context.

Description of telecare interventions

The types of technological interventions varied across each systematic review, with the majority combining multiple device types. Ten reviews predominantly incorporated sensor-based technology, encompassing active/passive systems including alarms and sensors, wearables, smart homes[3, 5, 32, 12, 33, 34, 13, 15, 14, 16].

Nine reviews covered a broad category of 'assistive technology'. This includes monitoring systems, medication dispensers, GPS tracking devices, camera-based technology, sensors, verbal prompts, computer systems, online platforms, wearable and portable monitoring[4, 30, 22, 9, 10, 35, 2, 25, 29].

Similarly, five focussed on monitoring technologies specifically aimed at improving safety such as nightlight paths, tracking devices, fall technology, illumination devices, home and environmental modifications[23, 17, 31, 11, 21].

Reviews also covered the use of technology to aid social interactions. This is important for the mental well-being of the individuals. Four reviews used IAT robotic technology. These robots

came in the form of companion styles, mental commitment, and assistive to help aid the individual[26, 27, 36, 24].

A final review looked at web-based and internet interventions alongside advanced technologies such as wearable devices[28].

Participant characteristics

Across the reviews selected, ages ranged from 30 – 98 years. Participants overwhelmingly represent independent living older adults (aged 60 and above). Independent living concerns those older adults who are still able to live independently but are close to access of assistance and support when required.

Ten reviews included participants with dementia, and four focussed on those receiving informal care (care provided by the older adults friends and family) Three centred on independent living older adults, those in assisted living, and those receiving formal care (paid care provided via healthcare institutions). A further three looked at either continuous care (package of care provided in that individuals own home or care home, funded via the NHS), independent living, or those who wished to age in place.

The participant characteristics were determined by the included reviews. The authors of the current review are aware that differing populations groups will have differing needs for technology enabled care.

Methodological quality of included systematic reviews

Overall, 67 reviews were assessed for methodological quality. 38 of these were excluded mainly due to an absence of critical appraisal or because they were irrelevant to the reviews PICOs. Papers removed after critical appraisal were mostly due to methodological issues including the use of low-quality studies and unclear outcomes. Furthermore, a large number of reviews contained possibilities of bias which should be taken into consideration. Full appraisal results can be found in Appendix 5. Whilst bias cannot be entirely eliminated, to

ensure the best possible use of evidence, only methodologically robust reviews which undertook critical appraisal themselves were included for analysis. This provides readers with transparency in relation to the methodological strength of results.

Findings

Clinical outcomes

Daily functioning. This is defined as daily responsibilities that a person must be able to carry out to function independently e.g., dressing and moving with ease. This is why it is one objective telecare promotes, to aid with an individual's functional health status and QoL at home[3]. There is a recognition among the included reviews that technology within a home environment can assist with older adults' functional capabilities[13, 9, 34]. Sensor technology can be useful for "tracking functional status and successful ageing in place" by measuring daily functioning, such as activities of daily living (ADLs)[34]. Two reviews suggest sensor technology can effectively measure ADLs and recognise variations in activity patterns, thereby offering a promising solution to supporting older adults' daily functioning at home[34, 13]. Sensor monitoring may ultimately support declining functionality by assisting with routine tasks of elderly persons. This in turn may impact clinical outcomes such as mobility and falls[13]. However, as too much focus is placed on technical usefulness, clinical applicability cannot be confirmed yet. Actual use within daily practice requires further investigation to assess practicality[34].

Frailty. Frailty enforces higher susceptibility to poor homeostasis recovery after stress, and among older adults is associated with higher adverse outcomes, such as mortality and hospitalization therefore measuring frailty is vital to reducing adverse outcomes[37]. Wearable sensor technology is one way to measure and monitor frailty, with one review highlighting the success of using this technology in evaluating frailty in older adults[32]. 29 studies were included within this review and all but one established that wearable sensors were able to detect a relationship between physical activity and frailty in older adults. Therefore, by measuring physical activity with wearable sensors, frailty can be assessed. Pendant accelerometer devices in the home setting are sensitive to identifying pre-frailty, however further research is required to determine a "feasible, user-friendly device and body-location that can be used to independently identify

and objectively measure signs of pre-frailty in independent living older adults"[32]. This highlights the significance of utilising technologies which monitor older adults' functional abilities, allowing them to be well supported. However, the use of biometric data alone has shown no significant impact on frailty[12]. Measures of frailty can also include gait and falls, both of which are explained in more detail below. Similarly, another review indicates how an accelerometer device in the home setting can provide health benefits to users through detection of falls[16]. Frail older adults are at higher risk of falls, injury, and decreased functional ability therefore telecare may be highly beneficial for this population[38]. As telecare is largely reactive, working by generating alerts when someone encounters a problem, an integrated device combining telehealth and telecare technologies may be useful to comprehensively address functional capabilities while assisting with prevention of frailty and associated adverse outcomes. A mix of telehealth and telecare technologies would hopefully provide more proactive support by identifying indicators of pre-frailty (gait speed, exhaustion) alongside managing risky circumstances (falls).

Gait. Another review found wearable sensor-based devices highly effective in measuring gait activity among people with dementia in controlled and real-life settings[15]. This is meaningful given the association between frailty and gait, and the link between frailty and dementia[32]. The sheer importance of wearable devices for elderly persons living independently is emphasised here, particularly for someone living with frailty and/or cognitive impairment. As gait detection is an indicator of fall risk, sensor-based devices are likely essential to minimising injuries among independent living older adults[29]. However, standardised evaluation is required[16].

Falls. Accuracy of fall detection devices is difficult to identify despite them being commercially accessible and further research is required to ensure clinical effectiveness in prediction of falls[29, 12, 16, 11]. However, fear of falling is a serious and widespread problem among older adults which can negatively impact mobility, daily functioning, and independence[16]. Thus, prevention of falls is crucial to sustaining a high QoL for elderly persons[29]. Numerous reviews highlighted significance for the overall effect of technology interventions on fall reduction in independent living older adults[11, 29, 16]. One review determined a statistically significant decrease in the number of fallers, suggesting effectiveness for smart home systems improving the safety of independent living older adults[2 29]. As, night-time systems are

effective in managing sleep disturbances in older adults, they are in turn a potential solution to reducing the risk of falls by increasing safety[9, 29, 28]. Additionally, AT was found to "improve safety from falls, accidents and risky behaviour" by reducing the probability of a fall[11]. Conversely, one review found no evidence that smart homes are effective for fall prevention, encompassed by a lack of RCT's surrounding this topic[12]. Overall, there is promising evidence that sensors are an effective fall prevention initiative. It should be noted that evidence suggest a combination of smart home systems and exercise provides the most effectiveness for a reduction of falls in independent living older adults[29.]

Hospital/care home admissions. Potential reductions in accidents and risky behaviour alongside falls being a strong forecast of care home/hospital admission, AT has the potential to provide long-term effects [11, 4]. However, current evidence is lacking; no significant evidence supports a reduction in care home/hospital admission as a longer-term outcome of telecare[11, 4, 12]. These difficulties to obtain evidence of impact are due to a lack of collaboration across health and social care. Further research is required to reduce the inconclusiveness of these findings.

Health, well-being, and quality of life. Despite some reviews finding no impact on health-related quality of life (HRQOL) when using e-intervnetions[12,29], AT at home has the potential to positively impact the health and well-being of older adults and their caregivers, thereby improving QoL[5, 3, 22, 9]. Much of the evidence surrounding AT within the home and improvements to health and well-being provide an improvement to the mental health of independent living older adults. One review highlights a positive impact on mental health from the use of a telecare pendant for 12 months. However, whilst important, additional health-related outcomes were not attained[10]. A further review evidences a reduction in symptoms of depression using home health monitoring[12] Artificial intelligence systems may have the potential to contribute to improvements in agitation, anxiety, depression for people with dementia ([27]). However, not significant enough to improve QoL[27, 5,s 31, 14, 4]. Perceived improvements in QoL for people with dementia and their carers through AT was stated in another review ([22]). Alongside this, Maia[9] suggests a variety of AT (monitoring, GPS, robots, verbal prompts) can improve the QoL of older adults with dementia through assisting with ADL, minimising risk and ultimately allowing older adults to move independently. However, validated health-related measures were not used. To find out if telecare 'works' in improving

health outcomes, high-quality methods such as RCT's are needed. Furthermore, user experiences are also critical to understand the value of telecare and its impact. [30]. Both qualitative and quantitative measures are important when evaluating telecare.

Sleep. Sleep/insomnia is a significant problem to address due to its problematic impact on older adults' health, which include feelings of fatigue, trouble concentrating and irritability. Additionally, insomnia in older adults produces a higher risk of accidents.[39] One review highlights effectiveness of ICT interventions in managing older adults' sleep disturbances[28]. Strengthening this, another review found good evidence that technology is providing periods of high-intensity lighting assists with behavioural disturbances and betters sleep among people with dementia[31]. Other evidence found mixed results in relation to sleep quality[26]. More research is needed to highlight technologies impact on older adults' sleep[28, 31, 26]. Nonetheless, older adults may be more accepting of interventions which allow them to manage their insomnia[12]. There is importance therefore in tailoring technology to users' health interests/concerns[12, 21].

Ageing in place

Likewise, 'ageing in place' is an important desire for many older adults and therefore an important need to fulfil[35, 12]. The phrase 'ageing in place' is defined as older adults being able to comfortably live independently in their own homes, regardless of ability. Ageing in place highlights a gap for technology enabled care to support older adults in preserving their independence within their own homes. One review provides evidence that sensor-based technology, utilised to monitor activity and functioning, can support ageing in place[33]. The strongest evidence was found when combining multiple technology components: activity sensing in combination with fall detection, medication reminders, and bed occupancy, may effectively support ageing in place. However, research limitations exist questioning external validity of findings[33]. Technology at home is highlighted as a promising resource to support ageing in place by another review; the use of an accessible communication platform, which provides resources for easier communication between older adults and their families, was found particularly effective in promoting ageing in place. This underscores the importance of an interaction element for older adults[10]. Despite this, evidence concerning technologies at home which permit communication are lacking. Remote communication is important to

safeguarding older adults' general well-being by supporting ageing in place related concerns such as isolation and loneliness[33, 10]. Evidence from one review suggested an emergency assistance device alone was insufficient for augmenting ageing in place[33]. This likely emphasises the value and need for a reliable system which encompasses communication to enhance ageing in place, further supporting social networking[31]. While there are clearly benefits for the use of technology enabled care to support ageing in place, implications for older adults should be considered whilst using the resources such as the cost of devices and their ability to communicate with the devices successfully.

Loneliness and social isolation. Despite many older adults wanting to remain independent at home, some report conflicting fears surrounding loneliness and isolation[3]. This raises a difficulty for technology use as older adults' perceptions of 'ageing in place' may differ. This also highlights the importance of subjective feelings[30]. Nonetheless, one review indicates that smart homes can identify and predict social isolation and loneliness, and robotics can aid in alleviating loneliness. Thus, concluding that although physical information and communication technologies (ICTs) are not able to eradicate social isolation and loneliness, they do provide some promise due to the increased social interaction opportunities they provide.[36]. An important recurring finding that complements older adults' views is that technology should be tailored to individual needs and preferences, as their experiences aid in evaluation. A person-centred approach promotes ageing in place by ensuring outcomes concentrate on QoL and well-being[10, 33, 30].

Independence, safety, and security. Maintenance of independence is cited as an expectation and key reason for engagement/acceptance of telecare[23, 21, 16]. Telecare offers independence for older adults in the sense of managing everyday tasks and therefore may assist with fears surrounding loss of independence[3, 9]. One review emphasises a positive impact on caregivers as AT provides an alternative solution to offering people with dementia increased independence, which in turn, may relieve some pressure from caregivers [9]. GPS/tracking devices along with telecare were found to provide reassurance and enhanced independence for users, carers, and people with dementia[4, 3]. Although these tracking devices enhance reassurance, it should be considered from a moral viewpoint, how ethical are they? Despite this reflection, in aid of promoting independence, AT is recommended to be introduced in the developing stages of dementia to enhance QoL[9]. Safety provided by AT is

associated with independence (due to daily tasks) and improvements in mental well-being (worries and burden)[4, 13]. Sensors and monitoring technology at home provided safety for older adults relative to independent functioning[13]. Users report a sense of security/safety provided by fall alarms/detectors, allowing more risks to be taken at home[16, 23]. However, while users feel safer, participating in riskier behaviours may not be encouraged for the long-term, acknowledging ethical concern over how far users can change their lifestyle and still remain safe despite feeling it. Similarly, GPS technology increases older adults' ability to move independently, highlighting the practicality of this type of technology in supporting independence[9, 4, 13]. To strengthen this, fall detectors offered older adults a larger sense of security[16]. Overall, independence and the ability to age in place are valuable for acceptance[16].

Difficulties, ageing in place & technology. Despite effectiveness, difficulties have been noted whereby some technologies struggle to work outside of the home, limiting patient independence[31]. Geographical limitations are an important consideration e.g., difficulties exist for users suffering with cognitive impairments who may be mobile and still wishing to maintain independence[3]. Conflicting opinions from users have emerged e.g., worries surrounding loss of social network and independence due to lack of contact[21]. Users reported that they would not use the technologies if it meant they could not use it in their own home, to age in place[12]. While there is evidence to suggest technology may support ageing in place, it is important to understand older adults' experiences[21, 3].

User experience

Technology acceptance, perceived usefulness, and usability. Findings overwhelmingly suggest that technology must meet the needs of users to be accepted [21, 4, 25, 24, 34]. Understanding and accepting the need for technology is important[23]. Thus, technology must fulfil older adults' goals e.g., desire to age in place[25, 12]. This is especially important for users with cognitive impairments, whereby meeting specific capacities is required to attain acceptance[25, 4]. Sensor technology (monitor activities) achieved acceptance by cognitively impaired older adults in one review[34]. This shows that technology can still be suitable and acceptable for older adults with cognitive difficulties. Likewise, perceived usefulness of technology relates to perceived personal need for technology and was found to positively influence acceptance[21, 12, 23, 4, 24]. However, establishing what constitutes perceived usefulness

is noted a difficulty[21]. Users must consider themselves in need of technology to perceive it as valuable[24,3]. One review suggests usefulness and usability depend on whether technology is tailored to the user and perceived as user-friendly[23]. This highlights a gap in the literature and research reviewed as showing that other reviews have not identified the importance of the technology being tailored to the user. Despite challenges, it is vital to include users and carers within the development processes to aid with user experience. Co-design is a prominent theme which ensures the needs of service users are met[4, 9]. However as only one review highlights higher acceptability when technology is tailored to the user, a change in approach should be considered when developing telecare.

Factors which influence acceptance of technology vary over time and differ depending on the type of technology, and according to individual characteristics[21, 26, 3, 30]. Social influence is noted as an important consideration, alongside processes such as integration into the home[26, 30, 21, 23, 33]. Motivation to use technology was found to be driven by attitudes and perceptions of older adults (perceived need, control, independence, safety). Ease of use (usability), feedback and cost, are additional elements to consider[23, 24]. The way older adults perceive themselves seems crucial to acceptance e.g., subjective health (healthy and independent, or frail and in need)[21]. Furthermore, it may be found that as the population begins to age, the acceptance for technology in care increases, as the cohort under speculation is more familiar with technology use. Additionally, as developments in technology improve over-time, adoption may evolve. Existing technologies (smart phones/speakers, interactive doorbells) could have also contributed to the limited acceptability of smart technologies for care, where the current cohort is not familiar with these and is therefore put-off from using those similar technologies for their care.

Overall, robots which are programmed to aid patients to life safely, were perceived as useful by older adults for communication purposes. These robots are concerned with utilising communication for fall detection to prevent falls and alarm systems, this also includes social robots to aid companionship[2326]. High acceptability was found among 2nd and 3rd generation technology in one review which may have been associated with ease of use / lack of user initiation[24]. Ease of use may well influence technology acceptance[21, 25, 23; 24, 26]**.** Ease of use was reported from the use of personal alarms and fall detectors[3, 23]. Usability and differing individual characteristics should be a consideration for developers e.g., immobility/dementia

and simplicity/limited ability[19, 22]. It is important to adopt user-friendly devices in this sense to ensure that there is a universal experience for all users[25]. Acceptability was also found to be high for HHMT as it allowed users to manage their own health[21]. However, important factors will vary depending on each individual, creating complexities for developers. Despite acceptability being high, cultural factors should be considered for the use of robots where intervention processes in healthcare systems are delt with differently, based on differences in treatment processes [41.]

Perceived benefits of technology. Perceived benefits of technology vary, emphasising that 'one size' does not fit all[4, 31, 23]. Technology acceptance links to perceived benefits such as safety, independence, ageing in place. These were said to have a positive influence on acceptability[21, 12, 22, 12, 24]. Thus, perceived benefits motivate users, however users and carers also need to be motivated to use technology thus benefits need to be made clear so technology can be understood and accepted[4, 21, 23, 24]. How benefits are communicated and promoted are important to acceptance – users need to perceive an instant benefit from technology for it to be perceived as valuable[24, 4, 23]. Although the wish to age in place may influence technology acceptance for some older adults[12], available alternatives to technology such as carer/family support may also impact older adults' acceptance/decision[21].

Satisfaction. One review discovered an overall high satisfaction with telecare services and equipment[19]. This is strengthened by general positive opinions regarding technology, experienced by users[11, 31]. This is important as satisfaction may influence acceptance, as highlighted in Peek et al. [21]. Hawley-Hauge[23] suggests a link between satisfaction and usability as users who required little help were more likely to report satisfaction. This suggests the need to adapt technology according to individual abilities, alongside addressing additional concerns held by users. Satisfaction, alongside effectiveness and efficiency are crucial to ensuring continued use of technology[4].

Technology concerns. Unfortunately, acceptance does not always result in compliance[24, 34]. There are a handful of technology concerns prevalent among users which require attention. False alarms are a frequently reported concern of sensor-based technology which impacts use and uptake[21, 22, 23, 16, 3, 33]. Although this may also provide reassurance, the power to cancel false alarms seems crucial[23]. Associated with this is the consequence of alarms e.g., older adults do not want to place burden on others or quicken care home

admission[31, 21]. Privacy is another prominent concern mentioned across reviews in relation to camera-based technology and relates to adoption[3, 12, 26, 21, 22, 34, 16]. Although, it is noted that privacy concerns may be outweighed if the technology provides benefits to the individual e.g., live safely in own home[3, 21, 11]. On the other hand, some older adults do not accept visual surveillance in any format[23]. Thus, choice and control are significant in relation to privacy, highlighting the importance of ethical considerations to preserve older adults' confidentiality[23, 21, 22]. On the other hand, surveillance technology such as safety/tracking devices could be useful for concerns surrounding the potential of elderly people wandering or getting lost. [4]. Similarly, tracking devices could be especially useful for adults with dementia due to this. One review highlights the value of GPS technology in locating wandering older adults with dementia[31].

However, wearables may not be suitable for all older adults, particularly those with cognitive/visual impairments as they do present concern in terms of forgetfulness, acceptance, comfort, usability[21, 16, 31, 3]. Technology design and effects should fulfil people with CI and their caregivers expectations[24, 25, 3]. Additionally, technology appearance may hamper use as it is associated with user stigmatisation and perceived use. [25, 21, 24]. Another notable concern is cost, which negatively influenced acceptance in four reviews[21, 22, 23, 24]. However, cost concerns were overpowered by technology's ability to assist with ageing in place for people with dementia in another review[4]. Lack of understanding and knowledge surrounding devices may impair uptake of technology e.g., worries about operating technology[3, 21]. Ease of use is important to address[21, 25]. Likewise, poor functioning, system instability, and technical malfunctions are reported barriers[31, 11, 12, 9]. Ultimately, when the aim is to alleviate the barriers surrounding the uptake and use of technologies, it is critical to consider user specific perceptions and preferences[31].

Identity & stigma

Technology acceptance and uptake correlates with perceived need for technology as some users negatively associate telecare with old age, frailty, dependency, poor health, which can lead to lack of use[21, 3, 24, 25]. The importance of involving older adults within the development process is thus championed to assist with stigma concerns e.g., creating discrete systems[3]. As culture and cultural values can affect a person's belief and understanding about disability,

incorporating cultural considerations into the development process will aid in meeting need needs of the individual and beliefs about identity. [30]. Drawing on benefits of technology is important as older adults may be less motivated if they perceive themselves not in need, and ultimately hesitant[25, 36]. Reassurance around stigmatisation is required whereby autonomy remains essential[4, 19, 25]. Availability of telecare to all older adults in aim of alleviating stigmatisation concerns is suggested in one review[33].

Implementation

Enablers. Obtaining an understanding of older adults' experiences of technology enables increased understanding of their needs[3]. Introduction and support surrounding technologies before and during the implementation stage is highly relevant for the acceptance and utilization of AT as a lack of knowledge on functions leads to an increase in errors which, in turn, causes a decrease in the use of AT[24]. The inclusion of older adults in the implementation process provides a sense of control due to the direct involvement in the decision to use technologies. This is essential as a sense of control from a user perspective links to acceptance[3]. Regular feedback and motivation support this. The needs of all stakeholders involved (especially older adults themselves, carers, and family members) in development of technology is reported as essential[33, 26, 30 9, 24, 25]. Feasibility is limited when stakeholders find technology difficult to use or lack understanding for smooth use. Guidance, training, and follow-up of users are needed when developing and evaluating technology to ensure patient-centeredness[10, 35, 24].

Barriers. Lack of understanding may lead to lack of use, suggesting training and support are important enablers[3, 27, 35, 10]. The reported difficulty of technology application into daily routine strengthens this[9]. System improvements are needed to assist with technology flaws (e.g., false alarms). For successful application of technology, environment and duration of intervention are important considerations[27, 31]. As caregivers express that AT would to help assist them within in their role and reduce the stress they experience, the barriers surrounding the cost of AT should be addressed through policies and grants.[22]. Due to the progressive nature of dementia, difficulties relating to prolonged use of AT are emphasised[27]. Perceived value and acceptability from users' perspective are thus important.

Impact on carers, friends, family

Positive experiences have been encountered by caregivers from the use of AT, including increased job satisfaction and perceived quality of care[11, 31, 25]. As the safety of older adults is of critical importance to both formal and informal carers, monitoring technologies at home may alleviate safety concerns[31]. Two reviews found positive evidence for the use of technology in reducing caregivers', both relatives and those paid, concerns around safety[9, 26]. Strengthening this, AT was recommended by carers, notably when safety and security of people with dementia was addressed[4]. This emphasises usefulness of AT for carers of people with dementia and those formal carers, providing a sense of relief[22, 4, 35]. Linked to this, one review concluded a significant decrease in caregiver burden resulting from the use of monitoring technology, facilitating improvements in care[9]. Despite perceived benefits, there is uncertain evidence that telecare has a positive effect on the well-being of carers[5, 4, 14]. One review found no improvements for the working conditions or health of formal caregivers[35]. However, findings support want for AT from caregivers[22]. Due to a general lack of awareness surrounding AT, more of an effort should be made to increase knowledge and provide caregivers with support[22, 4]. One review found no evidence to support workplace productivity despite telecare freeing up time for carers and being a recommended alternative[5]. A prominent overall finding is that caregiver inclusion (both formal and informal) in research adds value to interventions by providing benefits to the patient, both caregiver types, and researcher[9, 4, 34]. Adaptation to needs of caregivers is also important to alleviate abandonment of technology[4].

Cost

Through provision of safety and enhancement of one's QoL, monitoring technologies may offer a cost-efficient approach[12, 14]. Supporting this notion, *estimated* cost savings of allowing older adults to age in place opposed to institutionalised care are noted, highlighting potential[33]. One review demonstrates cost savings in favour of electronic health technologies at home for older adults[2]. Another suggests assisted living technologies may provide cost savings, though this is based off low quality scarce evidence[17]. There is no other evidence of cost-effectiveness provided by reviews. Thus, a robust conclusion is unfeasible. Even so, there

is promising evidence for policymakers[2]. More high-quality studies assessing cost-effectiveness are needed as it is vital for widespread scalability[11, 12, 9, 13, 14]. As highlighted, cost is a barrier to adoption hence an important factor to address[21, 22, 23]. Cost and sustainable reimbursement models are evidently neglected within research which limits long-term application[21,12, 33, 23]. If minimising cost of care services is the central purpose, evidence needs to show that telecare is as effective as usual care. High-quality assessments and evaluation studies required[14].

Discussion

This overview of systematic reviews collects and synthesises the best available evidence surrounding *telecare* for older adults at home. Most studies reviewed diverse outcomes, which were challenging to synthesise in a meaningful manner and made a meta-analysis unfeasible. Thus, taking into consideration the difficulty surrounding the synthesisation of study outcomes, awareness should be shone on a potential inaccurate reflection regarding the effectiveness of findings[31, 5, 11, 31, 17, 13, 4].

Nonetheless, this review highlights the importance that technologies within a home environment can play by enhancing the safety and functioning of older adults [34, 13, 15, 10]. Through measurement and support of daily functioning, sensor-based technology at home delivers promising effectiveness for increasing older adults' independence[13, 34, 33, 9]. Evidence on smart home systems complement this, providing good effectiveness surrounding safety and falls[29]. Effectiveness is also demonstrated for multiple technology components (e.g., sensors, alarms, reminders, communication) in successfully supporting ageing in place[10, 33]. Ultimately, telecare encompassing sensors and combined with other types of technology provide the best opportunity to increase safety and security through minimisation of risk and injury, assisting with functional abilities[29, 12]. This may provide an improvement in long-term health outcomes in the future but further research in everyday practice is needed[32, 13].

Alternatively, findings offer insufficient evidence that telecare or AT at home improves the health and well-being of users or carers[5, 14, 11; 31, 4, 29, 27]. Research examining the impact on health and well-being of both carers/family and users is recommended to assess efficiency[33, 4, 17]. Overall, there is not enough evidence to support improvements in QoL using telecare/AT,

including robots[27, 5, 31, 14, 4, 12]. However, investigating the impact of telecare on older adults' sleep is important for acceptance[12, 21].

Furthermore, there is little acknowledgement across the papers regarding gender and cultural differences as well as effects of inequalities. These points should be explored in telecare literature, as digital exclusions may be often presented across differing socio-economic backgrounds and across cultures with poorer access.

Ageing in place/independence, QoL, and perceived usefulness are important factors which influence older adults' intention to use. It is highly evident that not 'one size' fits all; what is useful to one individual may not be the same for another due to differences in individual needs and preferences[3, 11, 4, 30]. Determining the value of technology to an individual is essential by meeting the needs of users and involving carers/family in the production process (co-design) for successful implementation and uptake[21, 33, 34, 21, 24, 9, 10]. Motivation for continued use through feedback and communication is vital[23, 30, 10]. Perceived benefits of technology from a user perspective are required to be met[24, 4, 31, 22]. High acceptability was reported among automatic systems (2nd and 3rd generation) as well as technologies which allowed management of one's health. Despite positive opinions regarding telecare/AT, privacy and economic concerns require addressing[24, 34, 12, 36]. Moreover, autonomy is essential to tackling stigma[4,19,25].

Due to inconsistencies with results, it was difficult to compare the effectiveness of devices, which was complicated by a lack of clear definition. Overall, reviews suggest inadequate evidence surrounding the complete effectiveness of AT/telecare, making it challenging to make solid conclusions on the actual impact of devices[35, 11, 5, 17]. This finding supports previous research that highlights the need for stronger ecological validity within AT research, which can be achieved through natural settings. This will also provide a standardisation of evaluation. Effectiveness is evidently important to underline despite limited evidence surrounding this[25, 23, 4]. To accelerate the growth of telecare, more evidence on effectiveness and cost-effectiveness is needed, alongside education and awareness for all[22, 4, 9, 10].

Implications for policy & practice

Most reviews reference weak evidence encompassed by numerous methodological issues, questioning validity and reliability of data[5, 31, 34, 13]. There is a great need for better designed methodologically robust studies encompassing larger samples[10, 15, 16, 15, 12, 17]. Longer duration interventions are desired, especially for people with dementia due to disease progression and potential fluctuations in usability and acceptability[25, 27, 33]. Ethical considerations require examination to adhere to users' privacy and confidentiality[33, 11, 12, 4, 22, 25].

Encouragement of technology use among independent living older adults involves identifying and addressing specific needs. Thus, all stakeholders need to be mindful that acceptance is dependent upon multiple factors which vary according to each individual[21, 11, 23]. Aiming to reduce technology-related concerns by utilising reliable and relevant instruments to assess needs is recommended[4, 24, 30, 14]. Future research should thus involve all key players to enhance acceptability and usability, alongside provision of training and support to assure long-term adherence[25, 22, 36, 12, 24, 21].

Applying technologies within a home environment will be most useful as context has shown important[9, 23, 33, 26, 27]. More Randomised Controlled Trials would be beneficial to assess effect and impact of telecare interventions as they provide the highest quality evidence[12, 21, 35]. However, this is a medical view, and should be remembered that some RCT results only relate to the sample selected, and in some cases cannot apply to a wider population to which the sample belongs. However, RCTs are becoming increasingly popular in social research, which includes the context of telecare.

Ethical issues regarding informed consent among older adults should also be considered, where they may lack decision capacity. Cost effectiveness studies are still rare which limits widespread uptake [12, 11]. Lastly, research centring on the use of multiple technologies in combination e.g., how they work together or could complement each other, may be ideal[4, 29].

Strengths & limitations

This review utilised a wide range of databases, thereby providing an extensive search strategy. It also included a wide range of research designs - qualitative, quantitative, and mixed

methods, allowing for strengths and weaknesses of data to accompany each other. As the purpose of this review was to present and describe the current body of systematic review evidence surrounding telecare, the results of all relevant systematic reviews were included regardless of topic overlap. Although incorporating overlapping reviews may present bias, it was considered unfeasible to contain only Cochrane Reviews due to scarcity of research. Moreover, the lack of consistent definition surrounding the term telecare makes it difficult to search and select suitable studies. As such, there is an increased risk of missing relevant research relating to telecare. Likewise, this review only included methodologically robust publications, therefore it does not capture all potentially relevant data. Nonetheless, it aims to offer reliable and valid evidence surrounding telecare.

Conclusion

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Research into the effectiveness of telecare is inconspicuous, as noted by the lack of robust research surrounding the topic. Despite this, significant benefits for users and carers have been emphasised, predominately in relation to functioning and safety. Telecare may offer a promising solution to supporting ageing in place. It is evident that telecare provides use to independent living older adults and their carers; telecare is generally considered useful and acceptable among users and carers. However, barriers exist in relation to application and use. Ensuring telecare meets the needs of older adults will eliminate barriers to long-term adoption. As technology develops rapidly, more research within a home environment is needed so that effectiveness can be determined. Future research involving larger representative samples is required for greater generalisability and technology readiness. Inclusion of all stakeholders is recommended within development and evaluation to underscore widespread benefits. This is particularly important for users with cognitive disabilities so they can achieve maximum support from telecare/AT.

What was already known	What this study has added

• Limited research surrounding telecare. • Studies assessing effectiveness of telecare are scarce.	• Weak data encompassed by methodological issues. • Telecare is highly beneficial for providing safety and functioning, thus a useful tool for ageing in place. • User needs are most important.

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Appendices

Appendix 1: Search Strategy and Strings

Activities of Daily Living (ADL) OR Quality of life OR safety OR well-being OR risk OR hospital admissions OR cost
AND
Telecare OR remote care OR assistive technology OR self-help device OR monitoring elderly OR falls detection OR smart home OR wearable technology
AND
Living independent* OR homecare OR community-dwelling OR ageing in place
AND
Elderly OR age* OR old OR vulnerable

Databases searched with search strings:

Google scholar – 17,900 – 15/03/2022
(“telecare” OR “assistive technology” OR “information and communications technology” OR “monitoring device”) AND (“elderly” OR “ageing” OR “older adults”) AND (“quality of life” OR “well-being” OR “risk” OR “daily living”)

Cochrane reviews – 39 - 15/03/2022
telecare OR "assistive technology" OR information and communications technology OR monitoring device in Title Abstract Keyword AND elderly OR ageing OR older adults in Title Abstract Keyword AND "quality of life" OR well-being OR risk OR daily living in Title Abstract Keyword - with Cochrane Library publication date Between Jan 2010 and Mar 2022, in Cochrane Reviews (Word variations have been searched)

EBSCO – 39

Ovid – 10

Pub med – 49 (5 results for systematic review) 22/03/2022
(("telecare"[Title/Abstract] OR "assistive technology"[Title/Abstract] OR "fall detector"[Title/Abstract] OR "sensor"[Title/Abstract] OR "monitoring"[Title/Abstract] OR "gerontechnology"[Title/Abstract]) AND ("home"[Title/Abstract] OR "homecare"[Title/Abstract] OR "independent living"[Title/Abstract] OR "community-dwelling"[Title/Abstract]) AND ("elderly"[Title/Abstract] OR "aged"[Title/Abstract] OR "aging"[Title/Abstract] OR "older adults"[Title/Abstract]) AND ("activities of daily living"[Title/Abstract] OR "quality of life"[Title/Abstract] OR "falls"[Title/Abstract] OR "well-being"[Title/Abstract]) AND "systematic review"[Title/Abstract]) AND (2010:3000/12/12[pdat])

Web of science – 642 - 22/03/2022

Science direct – 583 - 22/03/2022
“(telecare OR "assistive technology" OR gerontechnology) AND (elderly OR aging) AND (home) AND "systematic review"

Scopus – 7 – 22/03/2022

Epistemonikos – 7 results (04/04/2022)

Health systems evidence – 110 results - 05/03/2022

MEDLINE – 242 results - 08/04/2022
("systematic review") AND (telecare OR "remote care" OR "assistive technology" OR "technology enabled care" OR "smart home")

Google scholar – 2,280 results ("systematic review") AND (telecare OR "remote care" OR "assistive technology" OR "technology enabled care" OR "wearable device") AND ("ageing in place" OR "community-dwelling" OR homecare) AND ("older adults" OR elderly).

Prospero – 16 results - 08/04/2022
(telecare OR assistive technology OR remote care OR technology enabled care OR wearable device) AND (ageing in place OR community-dwelling OR homecare OR living independently) AND (older adults OR elderly).

Pubmed, CINAHL, Web of Science, Cochrane Library, Global health, Psyc**ARTICLES,** PsychBOOKS, EBSCOhost, Google Scholar, Medline, Embase.

Example strings used:

("telecare" OR "telehealth" OR "telemonitoring" OR "digital technology" OR "telenursing" OR "remote monitoring" OR "sensor" OR "assistive technology") AND ("homecare" OR "home" OR "home care services" OR "community health care") AND ("patient risk" OR "patient safety"

OR "quality of life" OR "health outcome" OR "quality" OR "patient harm" OR "user" OR "clinical outcome" OR "carer burden" OR "client satisfaction" OR "benefit" OR "cost")

Telecare OR assistive technology OR sensor technologies AND home AND information AND communication technology

Control unit OR alarm button OR fall detector OR gas detector OR door exit sensor OR temperature sensor OR flood detector OR bed sensor OR chair sensor OR smoke alarm OR pressure mat OR alarm pill dispenser OR pull cord alarm OR button and box

Abstract: "systematic review" AND Abstract: telecare OR Abstract: "remote monitoring" OR Abstract: "digital technology" OR Abstract: telehealth OR Abstract: telemonitoring OR Abstract: telenursing OR Abstract: "assistive technology" OR Abstract: alarm OR Abstract: sensor OR Abstract: device AND Abstract: home OR Abstract: homecare OR Abstract: "community health care" OR Abstract: "independent living" OR Abstract: "living independently" AND Year: 2010 To 2022

((AB=(“self-help devices” OR “selfhelp devices” OR “self help devices” OR “assistive technology” OR “telemonitoring” OR “tele-monitoring” telemedicine)) AND AB=("systematic review")) AND AB=(Home OR homecare OR community health care OR independent living OR living independently)

“self-help devices” OR “selfhelp devices” OR “self help devices” OR “assistive technology” OR “telemonitoring” OR “tele-monitoring” telemedicine

Appendix 2: Updated Search Strings

Embase – 15/06/2022.

('digital technology':ti,ab,kw OR 'telecare':ti,ab,kw OR 'assistive technology':ti,ab,kw) AND ('social care':ti,ab,kw OR 'home care':ti,ab,kw) AND [systematic review]/lim AND [2010-2022]/py

= 7 results.

('community alarm':ti,ab,kw OR 'telecare':ti,ab,kw OR 'lifestyle monitoring':ti,ab,kw OR 'stand-alone device':ti,ab,kw OR 'response service':ti,ab,kw OR 'consumer technology':ti,ab,kw OR 'environmental monitor':ti,ab,kw OR 'property sensor':ti,ab,kw OR 'personal monitor':ti,ab,kw OR 'gps monitor':ti,ab,kw OR 'bed monitor':ti,ab,kw OR 'movement detector':ti,ab,kw OR 'falls detector':ti,ab,kw OR 'co detector':ti,ab,kw OR 'heat detector':ti,ab,kw OR 'smoke detector':ti,ab,kw) AND [systematic review]/lim AND [2010-2022]/py

= 45 results.

"community alarm" OR "telecare" OR "lifestyle monitoring" OR "stand-alone device" OR "response service" OR "consumer technology" OR "environmental monitor" OR "property

sensor" OR "personal monitor" OR "GPS monitor" OR "bed monitor" OR "movement detector" OR "falls detector" OR "CO detector" OR "heat detector" OR "smoke detector"

Web of science - 06/07/2022

(AB=("community alarm" OR "telecare" OR "lifestyle monitoring" OR "stand-alone device" OR "response service" OR "consumer technology" OR "environmental monitor" OR "property sensor" OR "personal monitor" OR "GPS monitor" OR "bed monitor" OR "movement detector" OR "falls detector" OR "CO detector" OR "heat detector" OR "smoke detector")) AND AB=("systematic review")

= 12 results.

((AB=("social care" OR "home care")) AND AB=("digital technology" OR "telecare" OR "assistive technology")) AND AB=("systematic review")

= 5 results.

((AB=("care")) AND AB=("digital technology" OR "telecare" OR "assistive technology" OR "technology" OR "alarm" OR "device" OR "wearable" OR "detector")) AND AB=("systematic review")

= 1003 results.

Ovid – 12/07/2022

(('digital technology' or 'telecare' or 'assistive technology') and ('social care' or 'home care') and "systematic review").mp. [mp=ti, ab, tx, ct, ot, hw]

= 275 results

PubMed - 13/07/2022

("community alarm" OR "telecare" OR "lifestyle monitoring" OR "stand-alone device" OR "response service" OR "consumer technology" OR "environmental monitor" OR "property sensor" OR "personal monitor" OR "GPS monitor" OR "bed monitor" OR "movement detector" OR "falls detector" OR "CO detector" OR "heat detector" OR "smoke detector") AND ("systematic review"[Title/Abstract])

= 214 results

EBSCO - 13/07/2022

AND "systematic review" Abstract AND "community alarm" OR "telecare" OR "lifestyle monitoring" OR "stand-alone device" OR "response service" OR "consumer technology" Abstract

=24 results.

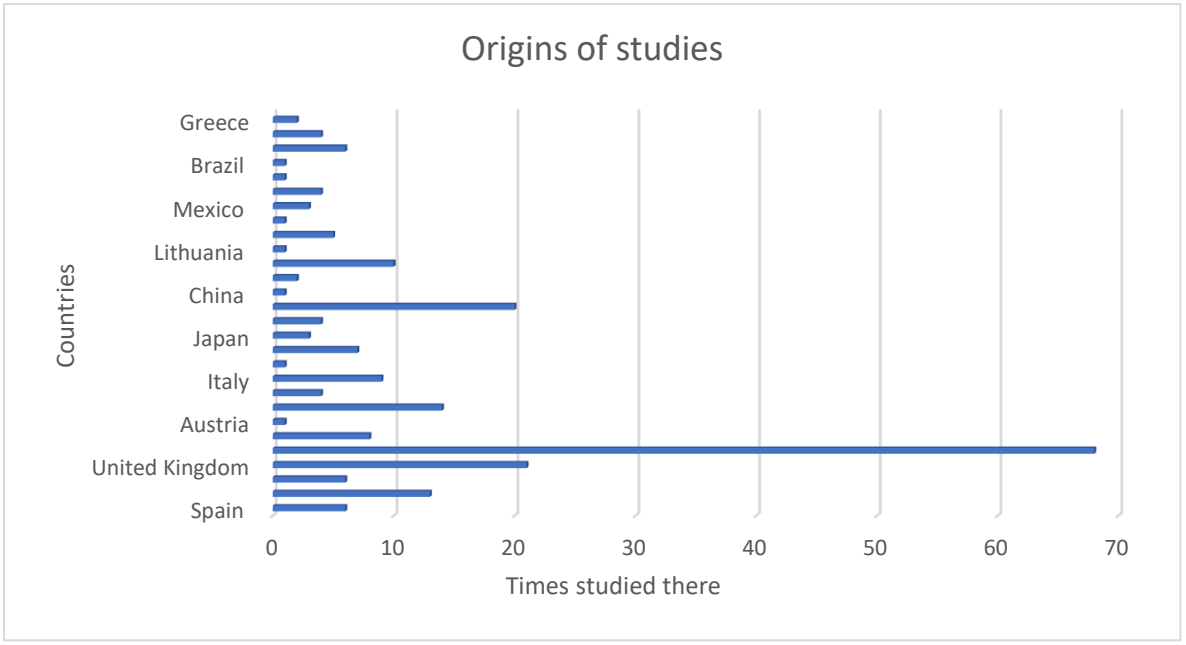
Appendix 3: Characteristics of Included Studies

Ref	Objective(s)	Participants of included studies	Setting	Interventions/phenomena of interest	No. databases searched	Date range of included studies	No. of studies	Type of Studies included	Country of Origin of Included Studies	Appraisal instrument & rating	Type of review	Method of analysis	Outcome(s) of interest	Results
3	community-dwelling older adults' experience with the use of telecare in home care services.	T= 99 participants (55-98 yrs old).	community-dwelling	Active & passive systems which use pendant alarms and sensors.	4	2005-2015	11	ethnographic interpretative; phenomenological; evaluation; single group pre-post design, integrated theoretical; argumentative analysis & a material-semiotic approach.	Spain, Netherlands, Sweden, England, USA.	Joanna Briggs Institute Qualitative Assessment & Review Instrument. Incl. studies overall high quality.	Qual SR	Meta-synthesis. Primary open coding.	User experiences	Telecare systems can promote safety & security to age in place. Telecare systems must fit individual needs & be supported by service providers.
5	effect of telecare interventions for individuals with social care needs on well-being & functioning of informal carers.	3 = carers of PWD. 1 = carers of older people (over 65) with at least 1 health/social care need. 2 = not specific. T = 1091 (30-83 yrs old).	Home/community	Passive sensors, medication dispensers & calendar clocks.	5	2004-2009	7	Controlled trial (1), cross-sectional design (2), before-and-after design (2), retrospective cohort study (1), Unclear (1).	USA, UK, Norway.	(Effective Public Health Practice 1998) - adapted. Incl. evaluations rated as weak quality, indicating risk of bias.	Quant SR	Narrative synthesis.	psychological outcomes for the carer, carer functioning, carer relationships & perceptions of telecare.	telecare tentatively exerts a positive effect on carer stress and strain. No evidence to indicate benefits on burden/QoL. Conflicting evidence about effects of telecare on carers' time, & relationships. Good-quality evaluations req. to establish effects of telecare on informal carer outcomes.
5	How wearable sensors have been used to assess frailty in older adults	community-dwelling older adults (63–90 yrs).	home =14, laboratory =8, in-patient =2, out-patient =2, community	body-worn sensors.	4	2011-2020	29	Validation (< 25%) or observational cross-section design.	not stated	Appraisal Tool for Cross-sectional Studies. 1 study scored 12. Methodological quality of remaining studies = minimum	SR	Narrative synthesis	frailty	Wearable sensors successfully evaluate frailty in older adults. Further research needed to identify a feasible, user-friendly device and body-location to identify signs of pre-frailty in community-dwelling older adults. Aids with facilitation of early identification & targeted
32	How wearable sensors have been used to assess frailty in older adults	community-dwelling older adults (63–90 yrs).	home =14, laboratory =8, in-patient =2, out-patient =2, community centre =1, not specified =4.	body-worn sensors.	4	2011-2020	29	Validation (< 25%) or observational cross-section design.	not stated	Appraisal Tool for Cross-sectional Studies. 1 study scored 12. Methodological quality of remaining studies = minimum result of 70% (14 out of a possible 20. range 14–20).	SR	Narrative synthesis	frailty	Wearable sensors successfully evaluate frailty in older adults. Further research needed to identify a feasible, user-friendly device and body-location to identify signs of pre-frailty in community-dwelling older adults. Aids with facilitation of early identification & targeted intervention to reduce burden of frailty in an ageing population
12	Technology readiness among older adults & evidence for SH & home-based health-monitoring technologies that support aging in place.	mean age = 75.40 yrs. Age range = 60 - 96 yrs. T = 11,282.	home, private dwellings or independent retirement facilities (87.5%); 6.25% - assisted living facilities	Smart homes & home health technologies utilising sensors, cameras, mobile technologies, web applications.	6	2010-2014	48	60.41% = quantitative experimental design, 35.42% = qualitative experimental design, 4.17% = mixed methods.	Developed counties (not specified).	Physiotherapy Evidence Database (PEDro) scale. Results not clean	SR	Descriptive analysis	aging in place; level of technology readiness.	Technology readiness level for SH & HMMT is low. SH & HMMT used to monitor activities of daily living, cognitive decline & mental health, & heart conditions in older adults with complex needs. No evidence that SH/HMMT help address disability prediction & HRQOL, or fall prevention. Conflicting evidence SH/HMMT help address COPD.
33	How health smart homes (HSH) & home-based consumer health (HCH) technologies might support aging in place.	Age range of participants in each study not presented. T = 2554.	Residential	Integrated monitoring system: smart home technology; sensing system for activity & environmental monitoring; ambient technologies	5	1998-2011	31	Technology trials, descriptive studies, one-group pretest-posttests, RCTs, RCTs, non-equivalent control group pretest-posttests, one-group posttest repeated measures, longitudinal community cohort study, descriptive study.	Austria, Canada, Finland, Italy, Luxembourg, Spain, Netherlands, Korea, UK, France, Japan, USA.	STARE-HI guidelines. 28/31 studies = emerging/promising. 3/31 = effective (first tier) but limitations e.g., participant dropout rates.	SR	Descriptive analysis	independent aging.	Almost all studies inc. activity sensing component & most used passive infrared motion sensors. 3 effective studies used a multicomponent technology approach. Future research should explore use of technology for self-management of health by older adults; social support; & self-reported health measures.
21	Acceptance of electronic technologies that support aging in place by community-dwelling older adults.	T =2123. Community-dwelling older adults 60 yrs+	Community-dwelling	Technology for safety & social interaction.	7	1999-2011	16	qualitative, quantitative, and mixed methods studies	USA, The Netherlands, China, Australia, England, Japan	Critical Appraisal Skills Program (CASP) & Mixed Methods Appraisal tool (MMA).	SR	thematic synthesis & coding	Acceptance and / or concerns	Acceptance divided into six themes: concerns; expected benefits; need; alternatives to technology; social influence; characteristics of older adults. Acceptance of technology in pre-implementation stage influenced by multiple factors.
11	Effectiveness of AT in improving safety of PWD living in domestic setting.	People aged 65 & over with a diagnosis of dementia. T = 245 across three studies	domestic	AT designed to improve safety. Nightlight path and electronic support bracelet.	11	2013	3	RCTs & a pilot trial	USA, Australia and France	Protocol for eligibility was submitted internally as part of MSc @ University of Oxford. Available on request.	SR	meta-analysis using revman protocol	safety	AT's effectiveness in decreasing care home admission inconclusive. AT items and packages tested improved safety through reducing falls risk, accidents & other risky behaviour.
31	Use of AT in the care of people with dementia.	people w/ dementia aged 50+ yrs. Caregivers & patients with moderate to severe dementia or mild to moderate Alzheimer's disease.	Community	electronic memory aids: safety technologies such as tracking devices, alarms, illumination devices and fall detectors; telecare and telehealth interventions; increased lighting; multi-sensory stimulation; and simulated presence therapy.	8	?	41	RCTs (n = 12), (n = 5) quasi-experimental time series with nonequivalent control group, cluster randomized trial, case-control–matched design, case cohort, & a retrospective analysis assessing	Not stated	Forbes approach. 7 = strong, 10 = moderate, 24 = weak.	SR	narrative synthesis	independence, safety, communication, wellbeing, carer support	General use of AT did not establish a positive difference to the lives of PWD.
4	types & uses of AT in dementia; effectiveness of AT for burden, well-being & QoL of carers of PWD living at home; carers' experiences of AT use in dementia; valued aspects of AT.	Carers' age ranged from 19 - 91 years, with 13 publications not reporting an age range.	home	Assitive technology: sensors and alarms, GPS tracker, Automatic night and day calendar; lost item locator; automatic night lamp; gas cooker device; picture button telephone, stove timer, night-time monitoring system, pill dispenser, cameras, robots.	11	2000-2018	56	Quantitative (n=17), qualitative (n= 30) and mixed method (n=9) study designs. 2 RCT's & 1 CCT	USA, Ireland, Sweden, France, Israel, England, The Netherlands, Finland, Germany, Norway, Scotland, Canada, Lithuania, Taiwan, Austrtralia, Poland, Spain, Japan, Mexico, Belgium	Cochrane handbook for systematic reviews of interventions	SR	narrative synthesis & descriptive summary	Carer burden; quality of life; well-being. Experiences of usefulness; benefits & disadvantages; relationship.	Qual. of research focussing on AT use in dementia continues to be low. AT solutions help improve carers' experience. AT would support PWD & carers in the community. researchers, healthcare professionals & technology developers should adopt a family centred model.
30	Individual aspects of welfare technology from perspectives of independence, safety, activity, & participation.	Varied from < 10 participants to > 100. 2 studies had in total > 1000 participants. 8 studies = men were the majority.	Community	assistive and welfare technology - sensors, cameras, information and communication technology platforms, smartphone applications, digital security alarms, and robots.	5	?	31	?	21 = Europe 10 = USA.	CASP assessment tools for cohort studies & qualitative research - modified	SR	Studies categorized into groups based on the areas of focus.	independence, safety, activity & participation, & quality of life.	The integration of digital assistive & welfare technology should be based on needs of older persons, and those needs must be assessed using reliable and relevant instruments. The heterogeneity of the target group, i.e., older persons, together with the fact that assessments must give consideration to identifying goals, obstacles, and risks as well as users' preferences, implies a person-centred approach.
	Facilitators & barriers to adoption of, & medical outcomes commensurate with, use of AT by PWD & their carers to perform ADLs independently.	Participants diagnosed with dementia or their caregivers.	?	Assistive technology; cognitive stimulators; socially assistive robots; sensor-based technology; wearable cameras.	4	?	48	?	AT: 3 = UK, 2 = Norway, 2 = Netherlands, remaining = Greece, US, Pakistan, Finland, Australia, UK/Italy/Malaysia, Canada, Sweden, Taiwan. Cognitive stimulation: 4 = UK, remaining = France, Scotland, Saudi Arabia, Canada, Netherlands/Germany/Belgium. Socially assistive robots =	JHNEBP. Most prev. assessment in the strength of evidence (panel a) was level III. then I, II, & IV. Qual. of evidence (panel b), most freq. assessed level was level B. then A.	SR	narrative synthesis	facilitators to adoption, barriers to adoption, & medical outcomes	Positive relations occur when PWD & caregivers use AT. Majority of the literature shows a positive effect of its use. Strong support for AT by caregivers due to many positive medical outcomes, but also a reticence to adopt by PWD. Barriers of cost & complexity need to be addressed through health policy or grants.

9	Analyse intervention studies using AT's to help demented elderly with execution of Basic & Instrumental ADL's.	Demented elderly and/or their carers. 2936 across 4 studies with variable ages for both. Experimental group = 977. Control group = 1959.	home	assistive technologies: monitoring systems, verbal prompts, robotic navigation.	7	2009-2018	4	clinical trials	US (2), Holland, Belgium, Germany (1). Germany (1)	(PEDro) tool for evaluation of clinical trials. A1 - 6 points. A2 - 5 points. A3 - 6 points and A4 - 6 points, classified as low - moderate quality & compromised internal validity.	SR	narrative synethsis	Basic & Instrumental ADL's	Positive results to support elderly people and caregivers in performing their daily activities. Use of simple voice prompts is cheaper, easier to manage & more efficient for demented elderly to perform Instrumental Activities of Daily Living
10	Effectiveness of technologies used at home by healthy older adults who are ageing in place.	T = 1904 participants (sample range, 30–1189). Participants were mostly women. Av age for all included RCT's = 68 years.	home	Accessible computer system: emergency assistance technology (alarms, pendant, wearables), wristband with a pedometer, online platform, neurofeedback headband and electroencephalogram (EEG) with iPod-supported mindfulness training.	7	2014-2019	7	RCT or CCT.	USA , the UK, the Netherlands	"Risk of bias tool" of the Cochrane Collaboration	SR	narritive synthesis	Ageing in place	Most technologies showed significant markers for effectiveness w/ regard to ageing in place compared to CG. Accessible communication platform, online video platform, neurofeedback headband & biofeedback showed significant results related to ageing in place in healthy older adults. Underlines the positive attitude older adults have towards technology.
29	Effectiveness of e-interventions on fall, neuromuscular functions & QoL in community-dwelling older adults.	4,877 older adults aged 50+. Sample sizes ranged from 12 to 523 participants. T = 4,613 across studies. Av age = 77.7 yrs.	Community or home	Exergaming, exercise with virtual reality or interactive components, mobile applications, visual computer feedback, home-based technology, tele-rehabilitation, telehealth coaching and counselling, computerized cognitive-behavioural training, activity-tracking fitness devices and computerized balance training.	9	2009-2019	31	RCT'S	US (8), Australia (7), Italy (4), Switzerland (4), France (2), Germany (2), South Korea (2), Spain (2), United Kingdom (2), Belgium (1), Canada (1), Greece (1), Israel (1), Netherlands (1), New Zealand (1), Norway (1), and Serbia (1). Some studies were conducted in multiple countries.	RoB Cochrane Collaboration. low (74.7%). Qual of evidence for executive function - TMT B-A & HRQOL assessed by EQ VAS. Rated high. Qual of evidence for proportion of fallers & HRQOL - EQ-5D = moderate. Qual of evidence for LES - SPPB & cognitive measures (TMT A and B) = moderate. Qual of evidence for fall efficacy = moderate. Qual of evidence for balance = low.	SR & meta-analysis	narrative synthesis & quantitative data synthesis.	fall, neuromuscular functions & quality of life	Telehealth combined with exercise & SH systems demonstrated the best evidence of effectiveness in reduction of falls in community-dwelling older adults. Future research should focus on forecasting falls using SH tech & AI, testing promising e-interventions on larger samples to improve strength of evidence.
34	Applicability & effectiveness of sensor networks in measuring & supporting ADLs among non-demented older adults.	65 years+, living independently. T = 227 subjects, ranging between 1 & 62 participants	experimental labs & independent living in the community	sensor technology	5	2013-2016	13	10 case studies. 3 case control studies	Not specified	Newcastle-Ottawa 9 scale - the Rob. Case studies deemed lowest on hierachy in terms of RoB. 3 case control studies - moderate.	SR	descriptive analusis	ADL's	Wireless sensor networks appear to be developing into an effective solution for measuring ADLs & identifying changes in their patterns. Sensors offer a promising solution to support older adults living independently at home. Too much focus on technology. Practical usefulness needs further elaboration.
13	Sensor monitoring as a method to measure & support daily functioning for older people living independently at home.	Community-dwelling individuals aged 65+, varied 1 - 52. 7 studies = mean age not specified. Weighted mean age = 82.6 in 8 studies. 10 did not report. 4 = participants without any reported diseases. Most had 1 or more chronic diseases.	Senior houses or assisted living settings, smart home apartments. Independent living setting in the community.	sensor monitoring to measure and support the daily functioning of older people living independently at home.	5	2002-2011	17	3 case–control studies, 1 mixed-methods study, 1 longitudinal pilot study, 1 single-group pre–post design study, 3 multiple-case studies, 7 case studies, and 1 experiment.	Not specified	Newcastle-Ottawa Scale14 -RoB. 3 = low quality; 2 = moderate quality	SR	Descriptive approach	ADL's; IADL's	Studies on effectiveness of sensor monitoring to support people in daily functioning remain scarce. A road map for further development proposed.
17	Review cost, cost-minimization & cost-effectiveness studies for ALTs that specifically enable older people to 'age in place'.	Mean population = 65+. Overall mean population age = 72 yrs. intervention group mean 68 years - 81 years. Newly diagnosed pt's w/ wide range of complex co-morbidities (4). home-based frail older people (1). patient population of veterans living at home with complex co morbidities and dementia (1). live-in' caregivers (2).	remote rural, rural, and urban locations.	Home and Environmental Modifications. Telemedicine.	2	?	8	5 = formal economic evaluations. 3 = cost-minimisation analyses. 5 = part of RCTs, 2 = part of quasi-experimental studies.	7 = USA. 1 = Canada.	Drummond et al. (2005) checklist to assess validity of results. all studies= low methodological quality	SR	narrative synthesis	Costs	ALTs may be an innovative solution to the problems posed by aging populations, but morereserach concerning their cost-effectiveness is required.
23	Guidance related to the attractiveness of specific ICT interventions & monitoring equipment, which is directly related to falls prevention & detection.	older adults aged 50 +. Healthy, community-based older adults. Over representation of women.	home environment and in focus group sessions	falls prevention, detection or monitoring technologies. Personal emergency alarms or wearable "falls detectors" (8), home automation systems (9); portable computers & communication systems (2); robotics (1); game consoles (2).	6	2004-2012	21	Observational cross-sectional studies (n=6). 1 Controlled Clinical Trial and 1 cohort study (pre and post). 12 qualitative. 3 quantitative studies & 6 mixed methods studies	?	JBI tool for qualitative research. Quality Assessment Tool for Quantitative Studies by (EPHPP) for quantitative studies. Weak or moderate quality.	SR	narrative synthesis using thematic analysis	older adults' attitudes & perspectives	Positive messages regarding benefits of falls technologies for promoting healthy active ageing & independence are critical. Ensuring technologies are simple, reliable & effective & tailored to individual need. Technologies need to be clearly described in research & older peoples' attitudes towards different sorts of technologies must be clarified if specific recommendations are to be made.
15	Provide updated overview & explore opportunities in current research on wearable sensors for gait analysis in adults over 60 living w/ dementia.	60+, with existing dementia. Total population sample size = 40 - 85 participants age ranged from 60 - 88 years old. Mixed genders & selection criteria based on initial cognitive & gait evaluation.	clinical or community-based setting or in a "real life" environment	IMU sensors attached to the body around the trunk.	3	2012 - 2021	6	?	UK = 3. Germany = 2. Netherlands = 1.	Custom quality assessment worksheet.	SR	descriptive	gait	Sensor-derived data are successful in their respective objectives & goals. use of IMUs provides a fertile ground for countless prospective gait performance assessments in PWD. Body-worn devices are highly effective in measuring levels of gait activity in & out of laboratory environments. Additional studies utilising standardized protocols should be conducted in the future to explore impact & usefulness of wearable devices in gait-related characteristics.
14	"How does nocturnal digital surveillance affect health, welfare & social care provision in aged populations compared to SC? "	50+ yrs residing in the home or nonpenal care institutions. in OECD countries or those of an equivalent level of development. T = 227 participants.	home or nonpenal care settings	Digital cameras, sensors, alarms, or other place-based, non-physiological monitoring devices that were used specifically during the night.	12	2007-2016	5	2 = RCTs. 1 = variant of a cluster randomized trial. 2 = non-randomized, mixed methods designs.	Not stated	RoB 2.0 & ROBINS-I tools for randomized studies. For non-randomized studies, the ROBINS-I tool.	SR	not stated	health, welfare, social care provision	Health-related outcomes & social care outcomes did not differ between interventions & SC. QoL & affect showed improvement with some interventions, as did economic outcomes in 1 setting. Qual of studies was low, with a serious to critical RoB. Little evidence for the benefits of digital surveillance interventions compared to SC in several key outcomes. Higher qual intervention studies should be prioritized in future research.
24	facilitators & barriers to IAT use among older people with CI & their informal & formal caregivers	1655. Diagnosed w/ MCI, or advanced or severe dementia or AD. formal and/or informal caregivers.	own home, formal residence. day-care centre, Living Lab.	social robots. 1st, 2nd, or 3rd, 4th generation IAT.	4	2007-2017	30	1 RCT. 3 non RCT, 11 observational studies using quant measures only. 7 mixed methods.	Europe = 22. USA/Canada = 5. Australia = 2. Asia = 1.	Mixed Methods Appraisal Tool (MMAT). 10 = high-quality studies (+++++). 11 = four stars (++++). 3 (+++). 2 (++). 3 (+). 1 = no star.	SR	narrative synthesis	acceptance & use	IAT-based interventions can be accepted & used by people with CI & their caregivers. Potential to compensate for functional decline. Given possible impact of impairment on QoL & health, results are promising. Tech design & effects need to satisfy expectations of people with CI & their caregivers. Need for more individually designed IAT. People with CI & their formal & informal caregivers need to be motivated to use IAT.
25	Technologies for older adults with MCI/D. current knowledge on usability & acceptability. & how people with MCI/D & family carers were involved in studies.	65+ yrs. 665 people w/ dementia and 83 people with MCI. T = 248 PCs. 55 staff members & 23 others.	Community-dwelling	GPS. monitoring systems, tablets, touch-screen computers with calendar, clock and task reminders, verbal instruction technology, robot technology.	5	2009-2017	29	qual, quant RCT, quant non RCT, quant descriptive studies, 2 mixed methods.	Australia, Brazil, Canada, Finland, France, Germany, The Netherlands, Norway, Italy, Sweden, Taiwan, UK, USA.	Mixed Methods Appraisal Tool. 6/29 papers = high-quality studies (four stars); 11 = three stars; 7 = two stars; 5 = one star.	SR	narrative synthesis	usability & acceptability	Research regarding technologies to support people w/ MCI/D optimistic. A wide range of technologies have been evaluated in homes w/ people with MCI/D & their PCs. Importance of including people with MCI/D & their PCs in research, to enhance usability & acceptability. Very few studies reported on the consequences of technology use with regard to QoL, occupational performance, human dignity.
	examine effectiveness of information & communication technologies (ICT) interventions in managing sleep	elderly aged 60 years or older. Overall not stated.	not stated	web-based & use the Internet. combined advanced technologies (mobile applications, smartwatches, wearable devices).	3	2015-2021	9	RCTs, quasi-experimental studies, retrospective study.	United States = 10. Sweden = 2. South Korea, Australia, New Zealand, the Netherlands, Taiwan = 1 each.	Cochrane RoB for RCTs. Low risk of attrition & reporting bias but high risk of performance & detection bias. Selection bias - random sequence generation	SR & meta-analysis	Statistical analysis	sleep disturbances	Interventions effectively improve qual of sleep & reduce sleep disturbances in elderly. Internet-based CBT, AVS, or automated guiding light can be applied for treatment of insomnia. Internet-based CBT has a positive effect on indirect factors such as depression, QoL, physical activity, sleep-related outcomes. Nursing education & practices in

28	technologies (ICT) interventions in managing sleep disturbances in the elderly	older. Overall not stated.	not stated	(mobile applications, smartwatches, wearable devices).	3	2015-2021	9	studies, retrospective study.	Taiwan = 1 each.	Selection bias - random sequence generation low, but 3/10 showed high allocation concealment.	meta-analysis	analysis	sleep disturbances	QoL, physical activity, sleep-related outcomes. Nursing education & practices in community-based environments should be adjusted to allow nurses to play a pivotal role in evidence-based ICT interventions promoting better health behaviors.
36	how technology can help overcome loneliness & social isolation other than by fostering social communication with people & what the main open-ended challenges are	Older adults were considered eligible (people over 50 years old). Roughly T = (n=946+), with more participants included but not listed.	Homes, different forms of care facilities, sensor-enabled houses and apartments, hospitals	VRe systems, smart homes, various alleviation robots, pet robots.	7	2006 - 2021	23	Explorative pilot studies to randomized controlled experiments. Longitudinal design, randomized controlled trial protocol.	United States = 10. Germany = 2. Singapore =2. Australia, Canada, Ireland, Mexico, the Netherlands, New Zealand, and Taiwan, 2 = cross-national data, 1 = participants from the United Kingdom, Italy, Ireland, & 1 = England and Japan.	Selective analysis based on self-defined categories. Limited number of papers limited use of tools.	SR	descriptive overview of open ended coded analysis & content analysis	human lonliness/social isolation	Issues of loneliness & social isolation among older adults cannot be eliminated using physical ICTs, but are used to help detect & predict, or alleviate such circumstances. SH's can help predict & detect loneliness & social isolation, & robotic pets & other social robots can help alleviate loneliness to some extent. More robust study samples & study designs. Studies reported some technology- and topic-specific open-ended challenges.
35	effectiveness of ATs on relevant outcomes with a focus on frail older adults.	T = 1768 participants, mean age= 65 years or higher; with mean ages of study populations in individual studies ranging from 68.9 years - 87.8 years. Sample sizes varied from (n=16) to (n=203)	participants' homes	nightlight path; Home automatization; mobile safety alarm; gait-speed monitoring & feedback device; metronome; tablet computer connected to a patient scale; reminder device; medical alert protection system; tablet computer–based self-monitoring system; environmentally embedded sensor system; tablet-based app for medication; telemedical medication reminders; multimedia device; portable electronic vision enhancement system.	6	2009 - 2019	trials includ	Confirmatory RCTs & pilot or feasibility RCTs.	Europe = 10. US = 5.	Cochrane RoB tool.	SR	qualitative synthesis & narrative review	effectiveness	Analysis did not provide strong confirmation for the overall effectiveness of AT in older adults. Personal disease management apps seem to be promising. Personal disease management devices seem to be most effective. 4/6 studies showing significant improvement of disease-related outcomes. Frailty could only be assessed for 7 trials. Studies including participants with significant or severe impairment showed no effectiveness.
2	evaluate economic impact of eHealth interventions in older persons' care	Older people (aged 65 years or older) with a need to long-term care in a nursing home, hospital, or their own home were included in the study. >310 participants. 2 papers not stating population size.	Home settings (n=3), geriatric hospital visit	Electronic health interventions - combining medication management, independence, mobility, cognitive impairment, falls. Mobile phone & web-based technologies & servies, sensor based, virtual reality & robotic, wearable & portable monitoring	7	2011-2017	3	cohort & randomized clinical trial studies regarding the economic evaluation of these interventions including cost-effectiveness analysis, cost–benefit studies, and cost–utility.	Not stated	CHEERS checklist for appraisal	SR	Qualitative narrative synthesis	cost	In all studies included, there is cost savings in favor of using electronic health intervention as an alternative care approach.
16	Assess current state of design & implementation of fall detection devices. Extent to which devices have been tested in real world & acceptability of devices to older adults.	Overall not provided	controlled environment & real world settings.	Wearable systems (accelerometer). Non-wearable systems include cameras, acoustic sensors, pressure sensors for falls.	4	2004-2013	74	experimental - not stated	not stated	Statement on Reporting of Evaluation Studies in Health Informatics (STARE-HI)	SR	narrative synthesis	detection of falls	There exists a large body of work describing various fall-detection devices. Challenge in this area - to create highly accurate unobtrusive devices. Appears that the technology is becoming more able to accomplish such a task. There is a need now for more real-world tests as well as standardization of the evaluation of these devices.
27	effect of the duration of exposure to socially assistive robots in older adults w/ dementia.	older adults with dementia. Most of the participants were women:	long-term care facilities, 2 dementia units, 1 psychogeriatric care unit, and 1 hospital and rest home areas	interactive autonomous robots. artificial intelligence systems, social commitment robots, mental commitment robots, companion robots, assistive robots.	7	2013-2019	7	RCTs	Australia = 4. Norway = 2. New Zealand = 2. Denmark = 2. Us = 1. Netherlands = 1. Spain = 1.	Cochrane Collaboration tool for RoB. 6 = high quality, others = low quality;All enrolled studies = high quality (a score of >3).	SR & meta-analysis	statistical analysis - meta regression	agitation, depression, & quality of life	Pet-type robot systems - potential activity in LTC facilities for dementia care. Further research warranted to establish comprehensive intervention plan related to use of pet-type robots.
26	Synthesize acceptability & effectiveness of AI-enhanced interventions for older people receiving LTC services.	Most studies had a small sample size, ranging from four - 490 (mean 70-8; SD 111-4).	nursing homes, assisted living facilities, or dementia units, home-based LTC	AI-enhanced social robots (n=22), environmental sensors (n=6), and wearable sensors (n=5) w	5	2004-2021	31	15 controlled trials & 14 non-controlled trials	North America, Australasia, Europe.	RoB 2, RoB 2 CRT, & ROBINS-I tools. Included studies = high risk of bias.	SR	narrative synthesis	acceptability & effectiveness	AI-enhanced interventions are promising innovations that could reshape the landscape of LTC globally. More trials required to support widespread implementation. Pathways needed to support more high-quality trials, including in low-income & middle-income countries

Appendix 4: Origin of Primary Studies



Appendix 5: Appraisal Results

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Overall appraisal	Comments
Verberk et al. 2011	Unclear	Unclear	Unclear	Y	N	N	N	Unclear/Y	Unclear/Y	Y	unclear	Exclude	unclear PICO & search strategy. Not relevant. No QA.
Karlsen et al. 2017	Y	Y	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Include	High quality systematic review with thorough recommendations for policy and practice.
Davies et al. 2013	Y	Y	Unclear	Y	Y	Y	Y	Y	N/A	Y/Unclear	Y	Include	Includes low quality studies. Unclear evidence of search strategy. No study excluded based on methodological score.
Saeed et al. 2020	Y	Y	Y	Y	Y	N	Unclear					Exclude	Not empirical
Santana et al. 2018	Y	Y	Unclear	Y	N	N	N		N/A	N	Unclear	Exclude	No quality assessment
Sapci & Sapci. 2019	Unclear	Y	Y	Y	N	N	N	Unclear	N/A	unclear	Unclear	Exclude	No quality assessment
Baig et al. 2019	Y	Y	Y	Y	N	N/A	Unclear	Y	Y	Y	Y	Exclude	No quality assessment
Vavasour et al. 2021	Y	Y	Y	Y	Y	Unclear	Unclear	Y	Y	Y	Y	Include	No studies excluded based on quality. Unclear whether QA / data extraction undertaking by reviewers independently and in duplicate.
Zhang et al. 2021	Y	Y	Y	Y	N	N	Unclear	Unclear	Unclear	N	Y	Exclude	No quality assessment
Marikyan et al. 2019	Y	Unclear	Y	N	N	Unclear	Y	Y	N/A	Y	Y	Exclude	Only searched 1 database (Scopus). No quality assessment. Mainly theoretical studies.
Liu et al. 2016	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Include	
Reeder et al. 2013	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	
Peek et al. 2014	Y	Y	Y	Y	Y	Unclear	Y	Y	Y	Y	Y	Include	strategies to minimise bias unclear.
Madara 2016	Y	Y	Y	Y	N	N	N	Y	N/A	unclear	Y	Exclude	No quality assessment
Brims et al. 2019	Y	Y	Unclear	Y	Unclear	Y	Y	Y	Y	Y	Y	Include	
Fleming & Sum 2014	Y	Y	Y	Y	Y	Y	Unclear	Unclear	Unclear	N	Y	Include	Includes many poor quality studies.
Sriram et al. 2019	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Include	Potential for bias - reviewers did not critically appraise studies independently although was carried out by more than one.
Abou Allban et al. 2020	Y	Y	Y	N	N	N/A	Unclear	Unclear	?	Y	Y	Exclude	No critical appraisal - possibilities of biases impacting method.
Zander et al. 2020	Y	Y	Y	Y	Unclear	N	Unclear	Y	Y	Y	Y	Include	Possibility of bias. Studies were not excluded based on quality. No QA results.
Rondon-Sulbaran et al. 2019	Y	Y	Y	Y	N	N	Unclear	Y	Unclear	N	Y	Exclude	Quality of studies not determined as purpose was to provide overview. Possibility of bias in data extraction, screening, reviewing.
D'Onofrio et al. 2017	Y	Y	Y	Y	Y	N	Unclear	Y	Unclear	Y	Y	Exclude	Full - text requested from authors as current review "uncorrected author proof". No summary of findings or results from QA.
Kruse et al. 2020	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	Possible bias as unclear whether reviewers worked independently.
Peeters et al. 2011	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Exclude	Telehealth (video consulting) related as opposed to telecare.
Zamiri et al. 2021	Y	Unclear	Y	Y	N	N/A	Unclear	Unclear	Unclear	Y	Unclear	Exclude	No QA. Included websites. Use of key words only - not a comprehensive search strategy.
Penteridis et al. 2017	Y	Y	Unclear	Y	N	N	N	Unclear	Unclear	Y	Unclear	Exclude	Possibilities of bias / no quality assessment.
Maskeliunas et al. 2019	Y	Y	Unclear	N	N	N	Unclear	Unclear	Unclear	?	?	Exclude	Not relevant. Poor quality.
Van der Roest et al. 2017	Y	Y	Y	Y	N/A	N/A	Y	N/A	Y	N/A	N/A	Exclude	No studies included as did not meet inclusion criteria.
Maia et al. 2018	Y	Y	Y	Y	Y	N	Unclear	Y	Unclear	Y	Y	Include	Possibilities of bias - lack of independent reviewing
Ollevier et al. 2020	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	Followed a strict methodology

Morris et al. 2014	Y	Y	Y	Y	Y	Unclear	Y	Y	Y	Y	Y	Exclude	E-health rather than telecare
Dahler et al. 2016	Y	Y	Y	Y	N	N	N	Y	N/A	Y	Y	Exclude	No QA. Risk of bias.
Chan et al. 2021	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	
Lenouvel et al. 2020	Y	Y	Y	Y	Y	N	Unclear	Y	Y	Y	Y	Include	Possibility of bias - reviewers not working independently.
Song & Van der Cammen. 2019	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	Exclude	Search strategy not comprehensive. No quality assessment. No minimisation of bias through independent working.
Pol et al. 2013	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	High quality systematic review with thorough recommendations for policy, practice & research.
Pal et al. 2017	Y	Y	Y	Y	Y	Unclear	Y	Y	Unclear	N/A	N/A	Exclude	No relevant outcomes. Simply assesses the literature to collect evidence regarding studies on smart home monitoring technology implantation.
Graybill et al. 2014	Y	Y	Y	Y	Y	Y	Y	Unclear	Y	Y	Y	Include	Limited number of large databases
Hawley-Hague et al. 2014	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	
Husebo et al. 2020	Y	Y	Y	Y	N	N/A	Unclear	Unclear	N	N/A	N/A	Exclude	No QA or clear recommendations justified by evidence.
Weizman et al. 2021	Y	Y	Y	Y	Y	Y	Y	Y	Unclear	Y	Y	Include	results of the quality assessment based on subjective judgment of 2 interpretations of the authors - bias cannot be alleviated. Search strategy may be limited.
[illegible]													No quality assessment. Possibilities of bias impacting data
2021	Y	Y	Y	Y	Y	Y	Y	Y	Unclear	Y	Y	Include	[illegible] alleviated. Search strategy may be limited.
Klimova et al. 2018	Y	Y	Y	Y	N	N/A	N	Unclear	N	Y	N/unclear	Exclude	No quality assessment. Possibilities of bias impacting data extraction. Not very comprehensive search strategy.
Richardson et al. 2021	Y	Y	Y	Y	Y	Y	Y	Y	Unclear	Y	Y	Include	Low quality studies
Choukou et al. 2021	Y	Y	Y	Y	N	N/A	Y	Unclear	Unclear	Y	Unclear	Exclude	No quality assessment therefore do not know level of evidence.
Job et al. 2020	Y	Y	Y	Y	Y	Y	Y	Unclear	Unclear	Y	Unclear	Exclude	No statistical tests or mention of heterogeniety. Not relevant outcomes.
Gochoo et al. 2021	Y	Y	Y	Y	N	N/A	N	Unclear	Unclear	unclear	Unclear	Exclude	No quality assessment. Purpose was to provide an overview of current technologies available. Unclear whether statements are backed up by robust evidence.
Lussier et al. 2018	Y	Y	Y	Y	N	N/A	Y	Y	Y	unclear	Unclear	Exclude	No quality assessment.
sen et al. 2021	Y	Y	Y	Y	Y	Unclear	Unclear	Y	Y	Y	Y	Exclude	Cell phone/computer/internet - not telecare.
Thordardottir et al. 2019	Y	Y	Y	Y	Y	Y	Unclear	Y	Y	Y	Y	Include	the aim was to obtain an overview of what technologies have been explored among people with MCI/D and their FCs. Therefore, no studies were excluded based on quality.
Holthe et al. 2018	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	No exclusion based on quality.
Dequanter et al. 2021	Y	Y	Y	Y	Y	Unclear	Unclear	Y	Unclear	Y	Y	Exclude	Does not mention bias or how it was alleviated. E-health (Exergames and cognitive training) rather than telecare.
De joode et al. 2010	Y	Y	Y	Y	N	N	N	Unclear	Unclear	unclear	Y	Exclude	No QA. Not reviewed independently. Risk of bias.
Marasinghe 2016	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Exclude	Not relevant to RQ/PICOs.
Lee & Yu. 2021	Y	Y	Y	Y	Y (RoB)	Y	Y	Y	N	Y	Y	Include	Cannot disregard publication bias
Behera et al. 2021	Unclear	Unclear	Y	Y	N	N/A	Y	Y	Unclear	Y	Y	Exclude	No QA. No data on included studies e.g., characteristics.
Latikka et al. 2021	Y	Y	Y	Y	Y	Y	Y	Y	Unclear	Y	Y	Include	Search strategy limited. Subjective quality assessment, possibility of bias.
Lynn et al. 2017	Y	Y	Y	Y	N	N/A	Unclear	Y	Unclear	Y	Y	Exclude	Quality of studies retrieved not determined as purpose was to obtain an overview of the type of research, range of interventions, involvement of people living with dementia in the studies. Possibility of bias - not stated whether done independently. Use of tools not specified.
Khosravi & Ghapanchi. 2016	Y	Y	Y	Y	N	N/A	Y	Y	Y	Y	Y	Exclude	No quality assessment
Fotteler et al. 2022	Y	Y	Y	Y	Y	Y	Y	Y	Unclear	Y	Y	Include	Could have provided more info around search strategy.
Rezapour et al. 2021	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	
Chaudhuri et al. 2014	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	
Lu et al 2021	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include	
Lima et al. 2017	Y	Y	Y	N	N	N	Unclear	Y	Unclear	Y	Y	Exclude	Studies not quality assesed. not clear whether recommendations made are supported by strong or weak evidence. Possibilities of bias.
[illegible]													evidence. Possibilities of bias.
Loveys et al. 2022	Y	Y	Y	Y	Y (RoB)	Y	Y	Y	Y	Y	Y	Include	
Vedel et al. 2013	Y	Y	Unclear	Y	Y	Y	Y	Y	Unclear	unclear	Unclear	Exclude	Uses term telecare but e-health
Barr et al. 2017	Y	Y	Y	Y	Y	Y	Y	Y	Unclear	Y	Y	Exclude	Not relevant to PICOs. Only searched 2 databases
Mortenson et al. (2012)	Y	Y	Y	Y	Y	Unclear	Y	Y	Y	Y	Y	Exclude	Not fully relevant to PICOs - includes AT such as wheelchairs, canes. Difficult to determine impact of AT by device due to large differences.
Gordon et al. (2018)	Y	Y	Y	Y	Y	Unclear	N	Unclear	Unclear	Y	Y	Exclude	No QA results. Not just telecare related. Possible biases