Effectiveness of assistive technology in improving the safety of people with dementia: a systematic review and meta-analysis

Journal:	*Aging and Mental Health*
Manuscript ID	CAMH-2017-0575.R1
Manuscript Type:	Review
Keywords:	Dementia, Older People, Assistive Technology, Home Safety, Systematic Review

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Objectives: Assistive technology (AT) may enable people with dementia to live safely at home for longer, preventing care home admission. This systematic review assesses the effectiveness of AT in improving the safety of PwD living in the domestic setting, by searching for randomised controlled trials, non-randomised controlled trials and controlled before-after studies which compared safety AT with treatment as usual. Measures of safety include care home admission; risky behaviours, accidents and falls at home; and numbers of deaths. The review updates the safety aspect of Fleming and Sum's 2014 systematic review.

Method: Seven bibliographic databases, the Social Care Institute for Excellence website and the Alzheimer's Society website were searched for published and unpublished literature between 2011-2016. Search terms related to AT, dementia and older people. Common outcomes were meta-analysed.

Results: Three randomised controlled trials were identified, including 245 people with dementia. No significant differences were found between intervention and control groups in care home admission (risk ratio 0.85 95% CI [0.37, 1.97]; Z=0.37; p=0.71). The probability of a fall occurring was 50% lower in the intervention group (risk ratio 0.50 95% CI [0.32, 0.78]; Z=3.03; p=0.002). One included study found that a home safety package containing AT significantly reduced risky behaviour and accidents ($F(45)=4.504$, $p<0.001$). Limitations include the few studies found and the inclusion of studies in English only.

Conclusion: AT's effectiveness in decreasing care home admission is inconclusive. However, the AT items and packages tested improved safety through reducing falls risk, accidents and other risky behaviour.

Key Words: dementia, assistive technology, older people, home safety, systematic review

Background

The majority of older adults prefer to age at home and quality of life has been found to decrease following care home admission (Khosravi & Ghapanchi 2016; Scocco et al. 2006; Luppa et al. 2010). Maintaining normalcy and continuity is a core need expressed by people with dementia (PwD) (von Kutzleben, Schmid, Halek, Holle, & Bartholomeyczik, 2012), something the home environment can promote at a time of multiple losses in the cognitive, functional and social domains (Aminzadeh, Dalziel, Molnar, & Garcia, 2009). Care for PwD is a pressing global challenge with 47 million people currently estimated to live with dementia worldwide, projected to increase to more than 131 million by 2050, as populations age (Alzheimer's Disease International, 2016).

Maximising the time that PwD can remain at home or 'age in place' is the aim of health care policy around the world (von Kutzleben et al. 2012). It is also consistent with UK government aims for 2020 (Department of Health, 2016). Assistive technology (AT) has been proposed as a means of enabling PwD to age in place with improved safety and independence, thereby preventing unnecessary and costly hospital and care home admission (Cahilla, Macijauskiene, Nygårdc, Faulknera, & Hagend, 2007; Leroi et al., 2013). AT has garnered particular interest in the UK at a time of reduction in government funding to Adult Social Care departments (Leroi et al., 2013). In the context of dementia care, AT has been defined as '[…] a product, equipment or device, usually electronic or mechanical in nature, which helps people with disabilities to maintain their independence or improve their quality of life', including by assisting with daily living tasks, reducing risk of harm and enhancing communication (Fleming & Sum 2014: 15). This review focuses on AT designed to reduce risk of harm and therefore improve safety.

Dementia is the most common cause of care home admission (Luppa et al. 2010). Safety is a key reason why PwD enter care homes, due to concerns that PwD cannot live safely and independently due to their cognitive, and often functional, impairment (Gaugler et al. 2009). Accordingly, this review examines whether AT designed to improve safety reduces care home admission in PwD. Care home admission is therefore a primary outcome.

While some PwD and their caregivers perceive AT, including safety AT, to be beneficial (Bantry White, Montgomery, & McShane, 2010; Peek et al., 2014), others have highlighted disadvantages. Some older adults perceive it as stigmatising, expensive and intrusive (Peek et al., 2014; Zwijsen, Niemeijer, & Hertogh, 2011) and its management can be burdensome for caregivers (Bantry White et al. 2010).

Health and social care departments increasingly provide AT (Martin, Kelly, Kernohan, McCreight, & Nugent, 2008; Van Der Roest et al., 2012), despite its limited and inconclusive evidence base. (Horvath et al., 2013; Khosravi & Ghapanchi, 2016; Shaw, 2007; Van Der Roest, Wenborn, Dröes, & Orrell, 2012). This review therefore aims to synthesise recent research to increase understanding of the effectiveness of safety AT for PwD. This will enable users, practitioners and policy makers to better weigh up both its advantages and disadvantages.

This review updates and extends the safety aspect of Fleming and Sum's 2014 systematic review, which included studies from 1995-2011. Their review examined empirical support for AT in the care of PwD, focusing on its effectiveness in improving independence, safety, communication, wellbeing and caregiver support. Included studies were methodologically weak, meaning evidence of effectiveness was unclear. Another key finding was the frequency of usability and technical problems with AT. The current review aims to identify further effectiveness studies, which have increased in recent years, as noted by Khosravi and Ghapanchi (2016). Their systematic review into a broad range of AT concluded

that it is effective in assisting older adults, although they note the weakness of included studies. They included uncontrolled studies, excluded unpublished literature and their search terms did not relate to dementia. The current review searched for both published and unpublished literature for controlled studies and specifically investigates safety AT for PwD.

Objective

To assess the effectiveness of AT in improving the safety of PwD living in the domestic setting, by searching for randomised controlled trials (RCTs), non-randomised controlled trials (NRCTs) and controlled before-after studies (CBAs) which compared safety AT with treatment as usual. Measures of safety include number of care home admissions; risky behaviours, accidents and falls in the home; and numbers of deaths.

Methods

A systematic literature review and meta-analysis were undertaken. The methods of analysis and eligibility criteria outlined below were pre-specified in a protocol. The protocol was submitted internally as part of an MSc at the University of Oxford and is available on request. PRISMA guidelines were used to report the systemic review (Liberati et al., 2009).

Eligibility criteria

Types of studies: RCTs (individual and cluster), NRCTs and CBAs.

Types of participants: older people, (aged 65 and over), with a diagnosis of dementia (including Alzheimer's disease, vascular dementia and other types), living in the domestic setting. The domestic setting is defined as an individual's home and excludes people in

institutions receiving 24-hour care. Participants were not excluded according to geographical location or type or severity of the dementia.

Types of intervention: there is no consensus regarding the meaning of AT and related terms (Martin et al. 2009). It is defined here as a product, equipment or device which is usually electronic or mechanical in nature, and designed to improve independence, safety and/or quality of life (Fleming & Sum 2014). This review focuses on AT designed to improve safety, meaning AT which prevents harm or alerts support if harm occurs (Bantry White et al., 2010; Gibson et al., 2016; Orpwood et al., 2007). For example, a fall detector remotely monitors users and sends an alert if a fall occurs (Gibson et al., 2016). Aids used by PwD with a functional impairment to reduce risk of harm, such as grab rails, are included. Telehealth, a sub-type of AT, is excluded because it does not have the primary aim of improving safety and rather supports medical tasks (Gibson et al., 2016).

Comparison: treatment as usual, including psychosocial support without AT. For example, professional case management to coordinate support (Reilly et al., 2015), including daily home care visits and safety monitoring from paid or unpaid carers.

Types of outcomes:

[Table 1 near here]

Time: outcomes measured at short (less than 12 months), medium (12 months or more; less than 18 months) and long-term (18 months or more) are of interest.

These outcomes are adapted from published work in the field (for example, Leroi et al., 2013 and Reilly et al., 2015).

Information sources

The following bibliographic databases and websites were searched for published and unpublished literature in English in May and June 2016: MEDLINE, Embase, PsycINFO, CINAHL, Applied Social Sciences Index & Abstracts (ASSIA), ProQuest Dissertations & Theses Global, Cochrane (including Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, Cochrane Methodology Register, Health Technology Assessment Database and NHS Economic Evaluation Database), the Social Care Institute for Excellence (SCIE) website and the Alzheimer's Society website. Reference lists of included studies were handsearched. One study (Horvath et al., 2013) was gained from a brief scoping review undertaken by the first author prior to the systematic search. Ten experts in dementia and AT, including authors of included studies, were contacted to enquire about missing studies. Six responded, although no further studies were identified. An additional brief scoping search was undertaken in March 2018, prior to publication.

Search

Search terms were based on three categories: assistive technology, dementia and older people (see table 2). Dementia terms were based on the Cochrane Dementia and Cognitive Improvement Group terms (McShane & Marcus, 2010). Search techniques including Boolean and proximity operators, brackets, truncation, wildcards and controlled vocabulary were used. The draft search strategy was reviewed by systematic review and dementia experts. Searches were adapted for each database. All search strategies are available on request.

[Table 2 near here]

Study selection

The first author and another reviewer independently screened 130 studies on title and abstract and 5 studies on full text. Disagreement was resolved by discussion and ambiguities in eligibility criteria were resolved. The first author alone screened the remaining studies.

Data collection process

The first author alone extracted data using an extraction form based on the Cochrane characteristics of included studies tables (Higgins & Green 2011). The author of one included study (Wesson et al., 2013) was successfully contacted to obtain additional information regarding the AT provided in the intervention.

Data items

Data were extracted according to: study details (source of study, published or unpublished); methods (including design and objectives); participants (including age, type of dementia and setting); caregiver details (including relationship and other demographic information); intervention (including type of AT and other intervention components); comparison (details of it) and outcomes (including outcomes measured and measures used).

Risk of bias

Risk of bias was assessed using the suggested criteria for EPOC reviews (Effective Practice and Organisation of Care (EPOC), 2015). This assessed: generation of the allocation sequence; concealment of the allocation sequence; blinding of participants and personnel; baseline similarity of characteristics and outcome variables; treatment of incomplete outcome data; prevention of knowledge of the allocated interventions; contamination; selective outcome reporting and other bias. Both review authors assessed risk of bias independently and resolved disagreement by discussion. As all studies were judged to be at a similar risk of bias, it was considered appropriate to meta-analyse studies with shared outcomes.

Summary measures

Meta-analysis of shared outcomes was undertaken when appropriate, as outlined below. Only dichotomous data were available for meta-analysis and risk ratios with 95% confidence intervals (CIs) were calculated. Risk ratios are easier to interpret than odds ratios and evidence suggests that, as relative effect measures, they are more consistent (Higgins & Green, 2011). Results were re-expressed as risk differences, which are again easier to interpret (Higgins & Green, 2011). As data were sparse and the interventions were not identical, the Mantel-Haenszel method and a random effects model were chosen (Borenstein, Hedges, Higgins, & Rothstein, 2009; Higgins & Green, 2011).

Synthesis of results

Meta-analysis was undertaken using RevMan for the outcomes of care home admission and falls in the home. Although clinical heterogeneity existed between interventions, meta-analysis was considered meaningful as all studies were RCTs containing only PwD who lived at home and other elements of the research question aligned for each outcome. All studies

were also approximately within the 'short term' time frame specified. Statistical heterogeneity was assessed according to the Tau^2, Chi^2 and its significance level, and the I^2. A meta-analysis was not completed for attrition and caregiver outcomes, even though multiple studies reported these outcomes. This was due to the heterogeneity in reasons reported for attrition and the measurement of distinct caregiver constructs.

Risk of bias across studies

It was not possible to assess publication bias via a funnel plot due to the low number of included studies (Borenstein et al., 2009). Selective outcome reporting was assessed in included studies by comparing the outcomes listed in the methods and results sections.

Results

Study selection

The literature search retrieved 6742 records. After de-duplication, 5461 were screened on title and abstract. Forty-two were screened on full text and 3 studies were included in the review, all sourced from database searching (1 from the prior scoping review). Figure 1 shows the selection process and reasons for exclusions at each stage. The scoping search in March 2018 found no additional studies.

[Figure 1 near here]

Study characteristics

All 3 studies used an RCT design. Two studies measured outcomes approximately 3 months post-baseline (Horvath et al., 2013 at 3 months and Wesson et al., 2013 at 12 weeks). The final study measured outcomes 12 months post-baseline (Tchalla et al., 2013). Across the studies, 245 PwD were randomised, 130 to the intervention group. AT diverged in number and type between studies. Packages of relatively low-cost AT and other home safety items were provided in two studies (Horvath et al., 2013; Wesson et al., 2013). The third study (Tchalla et al., 2013) tested an item of AT designed to reduce falls, the HBTec-TS, which consists of a nightlight path and electronic support bracelet. The standard care falls reduction programme was provided to both intervention and control groups in the Tchalla study. The control groups in the other studies received 'usual care' which included home safety literature. All studies reported some of the review's primary and secondary outcomes, as outlined under 'effects of interventions' below. Table 3 outlines detailed study characteristics. Full data extraction forms and risk of bias scoring are available on request.

[Table 3 near here]

Risk of bias within studies

[Table 4 near here]

In the Horvath study, bias relating to blinding was scored as unclear risk as participants and caregivers were blind but research assistants were not. However, this is not considered to cause high risk of bias as the blinded caregivers reported key outcomes. This study was judged to be at low risk of bias overall. The Wesson study was scored as low risk of bias overall, reflecting its score for each of the domains. The Tchalla study was scored as unclear

risk of bias relating to allocation concealment and blinding as the relevant information was not provided. Bias relating to baseline characteristics was scored as low because, although there were significant differences on one variable (comorbidities), comorbidities were not found to be significantly associated with falls (the primary outcome) in the analysis. Therefore, it is considered unlikely to have biased results. However, the study was judged to be at unclear risk of bias overall.

Effects of interventions

This section is arranged according to primary and secondary outcomes. Review outcomes not included here were not reported in the studies. Note that the outcomes of 'number of deaths' and 'improved safety of PwD in the home measured by hospital care or medical care' are excluded because insufficient detail regarding cause of incidents was reported.

Primary outcomes

Care home admission (institutionalisation): Two studies reported the number of participants admitted to a care home versus those not admitted (Horvath et al., 2013; Tchalla et al., 2013). Although it was not a specified outcome in the Horvath study, the information was available in the participant flow diagram. No significant differences were found between intervention and control groups (risk ratio 0.85, 95% CI [0.37, 1.97]; Z=0.37; p=0.71). The heterogeneity statistics indicate that the two studies are not statistically heterogeneous (Tau^2=0.00; Chi^2=0.14, df=1 p=0.71; I^2=0%). The absolute value of risk difference also demonstrates an insignificant difference in probability of care home admission between groups (risk difference -0.02 95% CI [-0.09, 0.05]).

[Figure 2 near here]

Improved safety of PwD in the home: falls (number of people who fell): Two studies reported the number of people who fell in the home versus the number of people who did not (Tchalla et al., 2013; Wesson et al., 2013). The probability of a fall occurring was 50% lower in the AT group compared to the control group (risk ratio 0.50, 95% CI [0.32, 0.78]). The overall effect of the intervention was significant (Z=3.03; p=0.002). However, the CI is relatively wide, indicating an imprecise risk ratio. The statistics indicate that the two studies are not statistically heterogeneous (Tau^2=0.00; Chi^2=0.16, df=1 p=0.69; I^2=0%). The absolute value of risk difference demonstrates that the probability of an individual experiencing a fall is 28% less in the intervention group (risk difference -0.28 95% CI [-0.44, -0.11]).

[Figure 3 near here]

The data used to generate the risk ratio for the Tchalla study was used by Tchalla et al. (2013) to calculate the cumulative incidence of falls at home in each group: 32.7% 95% CI [21.2, 46.6%] in the intervention group and 63.8% 95% CI [49.5–76.0%] in the control group. They note that the HBTec-TS was significantly associated with a decreased risk of falling at home (p=0.0028).

Improved safety of PwD in the home: falls (number of falls): Wesson et al. (2013) found fewer falls in the intervention (n=5) than the control (n=11) group (Incident Rate Ratio (IRR)=0.34 95% CI [0.06, 1.91]). However, the result was not significant and the study was underpowered.

Improved safety of PwD in the home: Risky behaviours and accidents: The Horvath study demonstrated a significant difference between the means of the intervention and control groups in risky behaviour and accidents, measured on the Risky Behaviour Questionnaire (Horvath, Harvey, & Trudeau, 2007), after controlling for relevant variables ($F(45)=4.504$, $p<0.001$).

Wesson et al. (2013) measured the Physiological Profile Assessment (PPA) (Lord, Menz, & Tiedemann, 2003) which contains a measure of falls risk (Wesson et al., 2013). This measure showed no improvement post intervention (intervention M=1.42 (SD=1.63); control M=2.65 (SD=1.83); p=0.82).

Secondary outcomes

Adoption of AT: The Horvath study reported that caregivers in the intervention group had significantly improved home environmental safety ($F(45)=2.537$, $p<0.001$) which indicates that AT items were adopted (see attrition data below also). Wesson study notes that 50% of participants implemented 50% or more of the home hazard reduction recommendations.

Wellbeing / quality of life: The Wesson study found no significant differences between groups on the depression scale (Alexopoulos, Abrams, Young, & Shamoian, 1988) (intervention M=8.10 (SD=7.27); control M=6.32 (SD=4.83); p=0.29) or the agitated behaviour scale (Logsdon et al., 1999) (intervention M=12.29 (SD=13.49); control M=14.66 (SD=15.67); p=0.58).

Change in level of care needs: The Wesson study measured daily functioning using the Interview for Deterioration of Daily Activities in Dementia (IDDD) (Teunisse, Derix, &

Crevel, 1991). There was no significant difference between groups at post intervention (intervention M=49.9 (SD=11.6); control M=53.7 (SD=15.9); p=0.40).

Experienced usefulness and user-friendliness of AT: Horvath et al. (2013) note that 18 of the 38 dyads that did not enrol did so due to refusal to participate. Of those that did not complete the study, withdrawal was through changed circumstances rather than choice (see attrition below). In the Tchalla study, the rate of acceptance of the device in the intervention group was 95.9%. Two of 49 withdrew because of concerns regarding privacy.

Caregiver burden; caregiver mood; caregiver perception of ability to cope: The Wesson study found no significant difference between groups on caregiver burden (intervention M=19.14 (SD=12.27); control M=11.64 (SD=11.48) p=0.77). Caregiver strain in the Horvath study was significantly lower in the intervention group (F(45)=2.976, p<0.001).

Attrition: A variety of reasons were presented for attrition, including care home admission, hospital admission, refusal to complete certain outcomes measures and death. In the Horvath study, 10/70 in the intervention group and 9/57 in the control group attrited. In the Wesson study, 1/11 in the intervention group and 0/11 in the control group did not provide 12-week falls data. In the Tchalla study, 2/49 in the intervention group withdrew and 2 participants died. One participant died in the control group out of 47.

Adverse effects (user wellbeing; clinical; care; informal carer): Tchalla et al. (2013) and Wesson et al. (2013) report no serious adverse effects associated with the intervention.

Risk of bias across studies

As noted, a funnel plot could not be completed to assess publication bias. All studies were assessed to be at low risk of bias for selective outcome reporting specifically.

Discussion

Summary of evidence

The review aimed to test the effectiveness of AT in improving the safety of PwD living in the domestic setting, including examining whether AT delays or prevents care home admission.

The results show no significant differences between intervention and control groups in care home admission (Horvath et al., 2013; Tchalla et al., 2013). None of the studies included care home admission as a primary outcome and the length of follow-up (3-12 months) may have been insufficient to detect differences. Follow-ups of 24-36 months are typical in studies examining care home admission as a primary outcome (Reilly et al. 2015; Leroi et al. 2013).

The probability of a fall occurring was 50% lower in the AT group compared to the control group and the overall effect of the intervention was significant (Tchalla et al., 2013; Wesson et al., 2013). Horvath et al. (2013) found that significantly fewer accidents and risky behaviours occurred in the intervention group. These limited results suggest that AT, either as a particular device or as part of a home safety package, improves safety from falls, accidents and risky behaviour. As falls are a strong predictor of care home admission (Tinetti & Williams, 1997; World Health Organisation, 2012) it is plausible that reduced care home admission would be a long-term outcome of AT interventions.

Caregiver strain in the Horvath study was significantly lower in the intervention group. The results relating to adoption of AT, usefulness of AT, user-friendliness of AT and attrition reflect no major concerns about acceptability and feasibility. Attrition was relatively

low overall and largely due to changed circumstances. No adverse effects were reported as a result of AT. No significant differences were found in number of falls, participant wellbeing, level of care needs or caregiver burden. However, the single study contributing data to these four outcomes was underpowered. Other outcomes were not reported.

Applicability and limitations

This review includes 3 RCTs including 245 PwD in 3 countries. One ongoing RCT was identified (Leroi et al., 2013). However, it was excluded as the study was incomplete. This review applies to AT designed to improve safety. All included studies took place in high income countries. Aside from gender, demographic information was limited, so generalisability is unclear. The participants' health and settings across the studies were relatively homogenous, although severity and possibly type of dementia varied. The heterogeneous interventions and outcomes and the small number of studies means that our understanding of the effects of AT remains limited.

A relatively low number of AT items were tested and, while interpretation of the effectiveness of these AT items or packages is possible, the results may not generalise to other items. In addition, it is possible that the control group received AT items in the Tchalla study (although distinct items from the intervention group). Causality could be inferred between AT (the HBTec-TS) specifically and the outcomes in the Tchalla study, as the HBTec-TS was isolated as the independent variable. Causal inference of the AT intervention is strong (but not conclusive) in the Horvath study, in which the home safety kit predominantly contained AT items, but also included other items such as a medicine case. As the Wesson study was multifactorial, we cannot be confident in a causal link between AT

specifically and the outcome. Nevertheless, this review offers important findings regarding the current state of evidence in relation to AT items and packages for this population.

The risk of bias in included studies, especially compared to other recent AT systematic reviews, is relatively low. All studies were RCTs, with two scoring as low risk of bias and the other (Tchalla et al., 2013) scoring as unclear risk. Strengths of this review include a comprehensive search, using a large number of search terms. Limitations include that the search was limited to studies in English and that only a sample of studies were jointly screened for inclusion. The meta-analyses should be interpreted with caution due to the heterogeneous interventions and the combining of only two studies. The Wesson study was underpowered and it is notable that the meta-analysis for number of participants experiencing falls at home, which includes the Wesson study, is heavily dominated by the Tchalla study. Therefore, its overall significance is not particularly informative and further trials are needed to support conclusions regarding a total effect size.

Minor changes were made to the protocol. In particular, the definition of one of the outcomes was extended following joint screening. Such post hoc decisions can introduce bias. However, the revised safety outcome (which included risky behaviour and wandering) is consistent with the review's original rationale and objectives.

Agreements and disagreements with other studies and reviews

This review updated Fleming and Sum's 2014 review, which found no studies relating to the safety and security of PwD in the domestic setting which had a control group. Most were feasibility studies with very small sample sizes. The current review therefore extends our knowledge and provides stronger evidence for safety AT. Fleming and Sum's main finding was the weakness of available evidence and the common difficulties with usability and acceptability of AT. For example, they refer to Miskelly (2005) who conducted a feasibility

study into a tracking device for PwD and found that the GPS equipped mobile phone was able to accurately identify the location of PwD but that 5 of the 11 participants dropped out due to usability or comfort issues. They also refer to a large, cross national, pre-post study (Gilliard & Hagen, 2004; Topo & Saarikalle, 2004) which found widespread technical and usability problems. However, technology has developed since these studies and technical problems were not prominent in this review's findings, albeit that some of the AT examined was lower-tech. Fleming and Sum refer to a study in a residential setting (Engström, Lindqvist, Ljunggren, & Carlsson, 2005, 2006), which is worth mentioning as it had a control group and involved similar AT items to those identified in the current review. It tested general and individualised passage alarms, sensor-activated night-time illumination, fall detectors and internet communication. Results showed that staff members' perceived quality of care and job satisfaction improved and relatives' opinions of the AT were positive.

The systematic review by Khosravi and Ghapanchi (2016) is relevant, although it included a wider range of technology, participants and settings than the current review. It concluded that sensor technologies and general ICT have a positive impact by assisting seniors throughout the cognitive decline process. Most of the studies relevant to safety and/or dementia were at high risk of bias, largely with small sample sizes and no control group. For example, Lancioni et al. (2013) found that technology was effective in supporting activity and travel among 4 patients with moderate Alzheimer's disease attending a day centre.

A number of recent systematic reviews and scoping reviews found limited research relating to home safety and falls interventions for older people, sometimes including PwD. Although they answer different questions to the current review, some are outlined next as they relate to safety interventions for older people, and therefore provide a picture of the broader literature. Booth et al. (2015) systematically reviewed falls prevention interventions, including home hazard reduction interventions, in older adults with cognitive impairment but

not necessarily dementia. They found that multifactorial falls prevention interventions (which may include AT) provide promising but statistically insignificant results across living settings, including care homes, hospitals and the domestic setting. However, they concluded that the evidence is insufficient to make clear recommendations for practice. Struckmeyer & Pickens (2016) also found no systematic reviews specific to home modifications for people with Alzheimer's disease when researching the topic prior to their scoping review. They summarise several individual studies in their scoping review, demonstrating the importance and effectiveness of a range of environmental modifications in improving safety or function. Winter et al. (2013) found inconclusive evidence relating to falls interventions generally (including AT interventions) for people with a cognitive impairment, but not necessarily dementia, living at home. They highlighted the need for controlled studies.

At the individual study level, the Whole Systems Demonstrator RCT, the largest trial of telehealth and telecare in the world (Department of Health, 2011), is important to the AT field. PwD were eligible but not specifically included (Leroi et al., 2013). Steventon et al. (2013) report that telecare tested in this RCT was not found to lead to significant reductions in health and social care service use over a 12-month period. They found no impact on care home admission and note that longer time periods may be required to detect impact.

Overall, recent studies demonstrate uncertainty regarding the effectiveness of AT and other home safety interventions in improving user safety, with predominantly inconclusive results, some positive results and some results of no impact. The current review into safety AT for PwD is therefore more positive than many recent studies, although it is inconclusive about AT's impact on care home admission.

User values and preferences

Concern regarding invasion of privacy is mentioned in the Tchalla study, which is a common theme in qualitative research with users of AT (Hamblin, 2014; Ward, Holliday, Fielden, & Williams, 2012). It is important to consider the perceptions and preferences of users alongside impact evaluations to elucidate barriers to the essential first step of AT being adopted. For example, some older people report avoiding using telecare as they find the process of being monitored intrusive or they fear that alerting caregivers to accidents will accelerate care home admission (Ward et al., 2012; Zwijsen et al., 2011). This highlights the importance of ethical considerations and assumptions to the adoption of AT. For example, whether users seek privacy and autonomy or instead view themselves as social and dependent, may affect the perceived acceptability of AT (Zwijsen et al., 2011).

Authors' Conclusions

Implications for practice

Limited evidence is available regarding the effectiveness of AT in improving the safety of PwD in the domestic setting. The available data were not conclusive about whether AT is effective in decreasing care home admission. The follow-up time periods and studies' power may have been insufficient to detect differences in this longer-term outcome. The items of AT tested, and home safety packages involving AT, were found to be effective in improving safety through reducing falls risk, accidents and other risky behaviour. Studies tested a range of AT but all 3 included sensor lights and electronic alarms to alert support. Two contained additional relatively low cost home safety items, such as grab rails. The results allow the preliminary conclusion that such AT improves safety in PwD.

Therefore, current evidence supports the use of such safety AT by PwD living in the community, particularly if they are concerned about falls and other accidents. Similarly,

practitioners working with PwD in such a situation, such as occupational therapists, social workers and doctors, should consider providing or referring for the safety AT items or packages tested in this review. Current evidence supports the policy of commissioning such AT in dementia care. Detailed information regarding cost effectiveness is likely to be of interest to policy makers, which is beyond the scope of this review. Further, the decision to commission or install AT should involve consideration of ethical issues and service user values and preferences, such as those mentioned above. Practitioners, users and policy makers should also note that the available evidence is limited and its generalisability to items or packages of AT not tested in this review is unknown.

Implications for research

Further research is needed which isolates AT as the independent variable, in order to infer causality. Detailed reporting of the intervention components in multifactorial interventions is recommended. More studies which are adequately powered to provide conclusive results, and are of adequate length to test long-term outcomes, are also needed. In addition, cost effectiveness studies are recommended, to support policy maker and provider decisions.

Disclosure of interest

The authors report no conflicts of interest.

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Table 1: Primary and secondary outcomes

Primary outcomes	Secondary outcomes
• Care home admission (number of people admitted to residential or nursing homes, sometimes called 'institutionalisation'). • Time to care home admission, defined as the permanent transition of PwD to a care home or admission to an acute care facility that results in permanent placement in a care home. • Improved safety of PwD in the home, defined by reduction in harm or risk of harm. Harm is measured by number of serious adverse events requiring hospital care or medical care in the community (for example, mean number of nights in hospital or number of hospital admissions). Risky behaviours and accidents, including falls (for example, number of participants who fell; number of falls; time to first fall) and wandering (increase or decrease in wandering), are also measures of safety. • Number of deaths that occur as a consequence of an identified risk that the AT might have affected.	• Adoption of AT • Wellbeing / quality of life • Change in level of care needs • Experienced usefulness and user-friendliness of AT • Caregiver burden; caregiver mood; caregiver perception of ability to cope • Attrition • Adverse effects (user wellbeing; clinical; care; informal carer)

Table 2: Search terms

Search term category	Dementia	Assistive Technology	Older People
Examples	• Dementia • Alzheimer's Disease • Dementia, Vascular • Cognition Disorders • Creutzfeldt Jakob disease • Lewy Bodies • Mental Disorders	• Assistive technology • Telecare • Self help device • Occupational therapy • Electronic sensor • Alarm • Disability aid • Daily living equipment • Home safety intervention	• Older people • Elderly care • Aged • Aging • Senior • Very aged

Table 3: Summary of studies

Reference and study design	Objective	Participant sample size, characteristics and country	Intervention	Results of review's primary outcomes	Overall risk of bias
Horvath et al. (2013) RCT, blocked design, stratified by recruitment site	To test an educational intervention to improve caregiver competence in creating a safer home environment for PwD	• N = 127 • 70 in intervention (M age = 80.4, SD = 6.7, 86.7% male) • 57 in control (M age = 80.9, SD = 7.2, 87.5% male) • Dementia of the Alzheimer's type, range of severity levels • USA	A caregiver led home safety toolkit including: • AT items such as a grab rail and a sensor night light • A supporting advice booklet	• Intervention participants had significantly fewer risky behaviours and accidents ($F(45) = 4.504$, $p < 0.001$) • Admissions to care homes were not significantly different between groups (see figure 2)	Low
Wesson et al. (2013) RCT, pilot trial	To explore the design and feasibility of a caregiver supported fall prevention programme for PwD	• N = 22 • 11 in intervention (M age = 78.7, SD = 4.2, 54.5% male) • 11 in control (M age = 80.9, SD = 5.0, 63.6% male) • Mild dementia (type unstated) • Australia	A caregiver supported fall prevention programme including: • A home hazard reduction programme including AT items such as a grab rail and sensor lights • A supporting advice booklet • Physiotherapist prescribed exercises	• No significant difference in falls between intervention and control groups	Low
Tchalla et al. (2013) RCT, dynamic random allocation using a minimisation	To evaluate the effectiveness and acceptability of a nightlight path and electronic	• N = 96 • 49 in intervention (M age = 87.8, SD = 6.5, 22.5% male) • 47 in control (M age = 85.3, SD = 6.3,	• A nightlight path (sensor light, the HBTec-TS) • Teleassistance service involving a remote intercom, an electronic bracelet and a	• The use of the nightlight and teleassistance was significantly associated with a decreased risk of falling at home (OR =	Unclear

method	bracelet coupled with a teleassistance service for preventing indoor falls in PwD	23.4% male) • Mild to moderate dementia of the Alzheimer's type • France	teleassistance support centre • All participants (intervention and control) undertook a standard care falls reduction programme	0.37, 95% CI = 0.15 – 0.88, p = 0.0245) • Admissions to care homes were not significantly different	

Table 4: Risk of bias summary: review authors' judgement about risk of bias in each study

	Horvath et al. (2013)	**Wesson et al. (2013)**	**Tchalla et al. (2013)**
Allocation sequence generation	Low risk	Low risk	Low risk
Allocation concealment	Low risk	Low risk	Unclear risk
Blinding of participants and personnel	Unclear risk	Low risk	Unclear risk
Baseline outcomes	Low risk	Low risk	Low risk
Baseline characteristics	Low risk	Low risk	Low risk
Incomplete outcome data	Low risk	Low risk	Low risk
Contamination	Low risk	Low risk	Low risk
Selective outcome reporting	Low risk	Low risk	Low risk
Other bias	Low risk	Low risk	Low risk

Figure Captions

Figure 1: Study flow diagram

Figure 2: Forest plot of number of participants admitted to care homes

Figure 3: Forest plot of number of participants experiencing falls at home

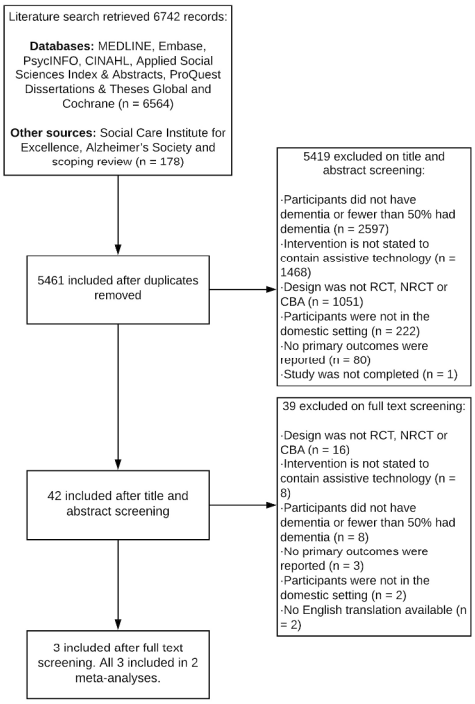

Figure 1: Study flow diagram

279x215mm (300 x 300 DPI)

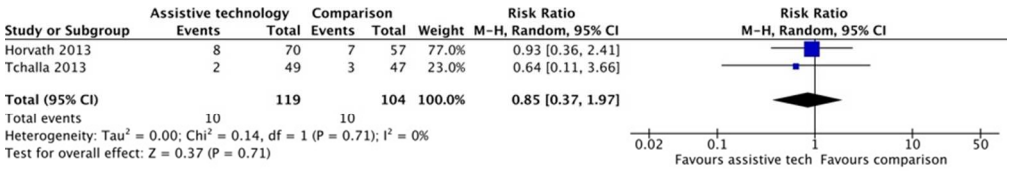

Figure 2: Forest plot of number of participants admitted to care homes

159x34mm (150 x 150 DPI)

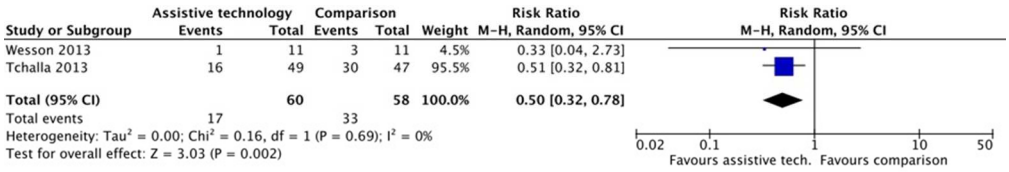

Figure 3: Forest plot of number of participants experiencing falls at home

159x34mm (150 x 150 DPI)

Supplementary material

Search Strategies

Source	Search Strategy	Hits Retrieved
Embase	1. assistive technology/ 2. assistive technology device/ 3. self help device/ 4. self help/ 5. rehabilitation/ 6. occupational therapy/ 7. ambulatory monitoring/ 8. patient monitoring/ 9. information technology/ 10. alarm monitoring/ 11. sensor/ or electronic sensor/ 12. assis* technolog*.mp. 13. Telecare.mp. 14. Self help device*.mp. 15. assis* device*.mp. 16. electronic tag*.mp. 17. electronic track*.mp. 18. Track* device*.mp. 19. Tag* device*.mp. 20. ubiquitous comput*.mp. 21. pervasive comput*.mp.	3675

	22. ICT.mp. 23. smart home.mp. 24. community alarm system*.mp. 25. intercom$1.mp. 26. carbon monoxide sensor*.mp. 27. fall detector*.mp. 28. pager*.mp. 29. alarm bracelet*.mp. 30. bed alarm*.mp. 31. alarm*.mp. 32. rehabilitation equipment/ or walking aid/ or wheelchair/ 33. occupational therapy equipment.mp. 34. care equipment.mp. 35. special equipment.mp. 36. disability equipment.mp. 37. adapt* equipment.mp. 38. community equipment.mp. 39. exp walking aid/ 40. mobility aid*.mp. 41. aid* for daily living.mp. 42. disability aid*.mp. 43. disability product*.mp. 44. daily living equipment.mp. 45. daily living item*.mp.	

	46. daily living product*.mp. 47. aid* for personal care.mp. 48. aid* for mobility.mp. 49. aid* for protection.mp. 50. aid* for signalling.mp. 51. tool* for living.mp. 52. modification* to the home.mp. 53. home modification*.mp. 54. home safe* assess*.mp. 55. modification intervention*.mp. 56. home safety intervention*.mp. 57. environment* modif*.mp. 58. home occupational therapy.mp. 59. home accident/ 60. accident prevention/ 61. walking aid*.mp. 62. (grab rail* or grab bar* or hand rail* or grab bar*).mp. 63. bed rail*.mp. 64. home safety/ 65. falling/ 66. global positioning system/ 67. memory assist*.mp. 68. multi?factor* interven*.mp. 69. home hazard.mp. 70. cognition.ti.	

	71. dement*.mp. 72. alzheimer*.mp. 73. lewy* bod*.mp. 74. deliri*.mp. 75. ((cognit* or memory* or mental*) adj3 (declin* or impair* or los* or deteriorat*)).mp. 76. (chronic adj4 cerebrovascular).mp. 77. ("organic brain disease" or "organic brain syndrome").mp. 78. ("supra nuclear palsy" or "ischemic white matter" or "multiple infarcts").mp. 79. ("normal pressure hydrocephalus" and shunt$).mp. 80. "benign senescent forgetfulness".mp. 81. (cerebr$ adj3 deteriorat$).mp. 82. (pick$ adj2 disease).mp. 83. (creutzfeldt or JCD or CJD).mp. 84. huntington$.mp. 85. binswanger$.mp. 86. korsako$.mp. 87. exp dementia/ 88. exp multiinfarct dementia/ 89. exp Dementia, Vascular/ 90. exp Delirium, Dementia, Amnestic, Cognitive Disorders/ 91. exp Cognition Disorders/ 92. exp Alzheimer Disease/	

	93. exp Creutzfeldt Jakob disease/ 94. "Pick Disease of the Brain"/ 95. Supranuclear Palsy, Progressive/ 96. Lewy Bodies/ 97. Huntington Disease/ 98. Mental Disorders/ 99. Wernicke Encephalopathy/ 100. Korsakoff Syndrome/ 101. Ischemic Attack, Transient/ 102. Delirium/ 103. exp CADASIL/ or exp Cerebrovascular Disorders/ 104. (Parkinson* disease dementia or PDD).mp. 105. ("limited cognitive disturbance*" or "mild cognitive disorder*").mp. 106. wandering behavior/ 107. elderly care/ or geriatric care/ 108. aged/ 109. exp aging/ 110. old* people.mp. 111. old* person*.mp. 112. elder*.mp. 113. old* adult*.mp. 114. very aged.mp. 115. senior*.mp. 116. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or	

	20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 117. 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88 or 89 or 90 or 91 or 92 or 93 or 94 or 95 or 96 or 97 or 98 or 99 or 100 or 101 or 102 or 103 or 104 or 105 or 106 118. 107 or 108 or 109 or 110 or 111 or 112 or 113 or 114 or 115 119. 116 and 117 and 118 120. limit 119 to yr="2011 -Current"	
PsycINFO	1. assistive technology/ 2. self help/ 3. rehabilitation/ 4. occupational therapy/ 5. information technology/ 6. assis* technolog*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 7. Telecare.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 8. Self help device*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 9. assis* device*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 10. electronic tag*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	492

	11. electronic track*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 12. Track* device*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 13. Tag* device*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 14. ubiquitous comput*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 15. pervasive comput*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 16. ICT.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 17. smart home.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 18. intercom$1.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 19. fall detector*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 20. pager*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 21. bed alarm*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 22. alarm*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 23. rehabilitation equipment/ or walking aid/ or	

	wheelchair/ 24. care equipment.mp. 25. special equipment.mp. 26. adapt* equipment.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 27. community equipment.mp. 28. mobility aid*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 29. aid* for daily living.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 30. disability aid*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 31. disability product*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 32. daily living equipment.mp. 33. daily living item*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 34. daily living product*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 35. aid* for personal care.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 36. aid* for mobility.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 37. aid* for protection.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	

	38. aid* for signalling.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 39. tool* for living.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 40. modification* to the home.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 41. home modification*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 42. home safe* assess*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 43. modification intervention*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 44. home safety intervention*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 45. environment* modif*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 46. home occupational therapy.mp. 47. home accident/ 48. accident prevention/ 49. walking aid*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 50. (grab rail* or grab bar* or hand rail* or grab bar*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 51. bed rail*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	

	52. memory assist*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 53. multi?factor* interven*.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 54. home hazard.mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures] 55. aged/ 56. exp aging/ 57. old* people.mp. 58. old* person*.mp. 59. elder*.mp. 60. old* adult*.mp. 61. very aged.mp. 62. senior*.mp. 63. dement$.mp. 64. alzheimer$.mp. 65. (lewy$ and bod$).mp. 66. deliri$.mp. 67. ((cognit$ or memory$ or mental$) and (declin$ or impair$ or los$ or deteriorat$)).mp. 68. (chronic and cerebrovascular).mp. 69. ("organic brain disease" or "organic brain syndrome").mp. 70. "supra nuclear palsy".mp. 71. ("normal pressure hydrocephalus" and shunt$).mp.	

	72. "benign senescent forgetfulness".mp. 73. (cerebr$ and deteriorat$).mp. 74. (cerebr$ and insufficien$).mp. 75. (pick$ and disease).mp. 76. (creutzfeldt or JCD or CJD).mp. 77. huntington$.mp. 78. binswanger$.mp. 79. korsako$.mp. 80. presenile dementia/ 81. exp senile dementia/ 82. exp Vascular Dementia/ 83. exp Huntingtons Disease/ 84. exp Wernicke's Syndrome/ 85. exp Korsakoffs Psychosis/ 86. exp Alzheimer's Disease/ 87. exp Progressive Supranuclear Palsy/ 88. wernicke encephalopathy/ 89. wandering behavior/ 90. ((cognit$ adj5 declin$) or (cognit$ adj5 deficit$)).mp. 91. sensor.mp. 92. safety devices/ 93. exp Falls/ 94. apparatus/ 95. mobility aids/ 96. global positioning system.mp.	

	97. elder care/ or aging in place/ 98. aged.mp. 99. 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 97 or 98 100. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 91 or 92 or 93 or 94 or 95 or 96 101. 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88 or 89 or 90 102. 99 and 100 and 101 103. limit 102 to yr="2011 -Current"	
MEDLINE	1. assistive technology/ 2. self help device/ 3. rehabilitation/ 4. occupational therapy/ 5. ambulatory monitoring/ 6. patient monitoring/ 7. information technology/ 8. assis* technolog*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 9. Telecare.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept	1328

	word, unique identifier] 10. Self help device*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 11. assis* device*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 12. electronic tag*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 13. electronic track*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 14. Track* device*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 15. Tag* device*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 16. ubiquitous comput*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 17. pervasive comput*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	

	18. ICT.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 19. smart home.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 20. community alarm system*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 21. intercom$1.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 22. carbon monoxide sensor*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 23. fall detector*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 24. pager*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 25. alarm bracelet*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 26. bed alarm*.mp. [mp=title, abstract, original title, name of substance word, subject heading	

	word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 27. alarm*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 28. rehabilitation equipment/ or walking aid/ or wheelchair/ 29. occupational therapy equipment.mp. 30. care equipment.mp. 31. special equipment.mp. 32. adapt* equipment.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 33. community equipment.mp. 34. aid* for daily living.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 35. disability aid*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 36. disability product*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 37. daily living equipment.mp. 38. daily living item*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol	

	supplementary concept word, rare disease supplementary concept word, unique identifier] 39. daily living product*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 40. aid* for personal care.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 41. aid* for mobility.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 42. aid* for protection.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 43. aid* for signalling.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 44. tool* for living.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 45. modification* to the home.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 46. home modification*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	

	47. home safe* assess*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 48. modification intervention*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 49. home safety intervention*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 50. environment* modif*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 51. home occupational therapy.mp. 52. home accident/ 53. accident prevention/ 54. walking aid*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 55. (grab rail* or grab bar* or hand rail* or grab bar*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 56. bed rail*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	

	57. falling/ 58. global positioning system/ 59. memory assist*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 60. multi?factor* interven*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 61. home hazard.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 62. cognition.ti. 63. dement*.mp. 64. alzheimer*.mp. 65. lewy* bod*.mp. 66. deliri*.mp. 67. ((cognit* or memory* or mental*) adj3 (declin* or impair* or los* or deteriorat*)).mp. 68. (chronic adj4 cerebrovascular).mp. 69. ("organic brain disease" or "organic brain syndrome").mp. 70. ("supra nuclear palsy" or "ischemic white matter" or "multiple infarcts").mp. 71. ("normal pressure hydrocephalus" and shunt$).mp. 72. "benign senescent forgetfulness".mp. 73. (cerebr$ adj3 deteriorat$).mp.	

	74. (pick$ adj2 disease).mp. 75. (creutzfeldt or JCD or CJD).mp. 76. huntington$.mp. 77. binswanger$.mp. 78. korsako$.mp. 79. exp dementia/ 80. exp multiinfarct dementia/ 81. exp Dementia, Vascular/ 82. exp Delirium, Dementia, Amnestic, Cognitive Disorders/ 83. exp Cognition Disorders/ 84. exp Alzheimer Disease/ 85. exp Creutzfeldt Jakob disease/ 86. "Pick Disease of the Brain"/ 87. Supranuclear Palsy, Progressive/ 88. Lewy Bodies/ 89. Huntington Disease/ 90. Mental Disorders/ 91. Wernicke Encephalopathy/ 92. Korsakoff Syndrome/ 93. Ischemic Attack, Transient/ 94. Delirium/ 95. exp CADASIL/ or exp Cerebrovascular Disorders/ 96. (Parkinson* disease dementia or PDD).mp. 97. ("limited cognitive disturbance*" or "mild cognitive disorder*").mp.	

	98. wandering behavior/ 99. aged/ 100. exp aging/ 101. old* people.mp. 102. old* person*.mp. 103. elder*.mp. 104. old* adult*.mp. 105. very aged.mp. 106. senior*.mp. 107. alarm monitor*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] 108. electronic sensor.mp. 109. Accidents, Home/ 110. Geriatrics/ 111. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 107 or 108 112. 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88 or 89 or 90 or 91 or 92 or 93 or 94 or 95 or 96 or 97 or 98 113. 99 or 100 or 101 or 102 or 103 or 104 or 105 or 106 or 110 114. 111 and 112 and 113	

	115. limit 114 to yr="2011 -Current"	
CINAHL	S1 TX cognit* N2 declin* OR TX cognit* N2 deficit* OR TX cognit* N2 deteriorat* OR TX cognit* N2 fail* OR TX cognit* N2 los* OR ?mild cognitive impairment*? OR TX ("mild neurocognitive disorder*" OR MNCD) OR TX ("limited cognitive disturbance" OR LCD) OR TX ("questionable dementia" OR QD) OR TX ("benign senescent forgetfulness" OR BSF) OR TX ("cognitive impairment no* dementia" OR CIND) OR TX ("mild cognitive disorder*" OR MCD) S2 TX ("nonamnestic mild cognitive impairment*" OR "N-MCI") OR TX ("multiple mild cognitive impairment" OR "M-MCI") OR TX dement* OR TX alzheimer* OR TX "lewy* bod*" OR TX deliri* OR TX chronic N2 cerebrovascular OR TX cerebr* N2 insufficien* OR TX cerebr* N2 deteriorat* OR TX ("organic brain disease*" or "organic brain syndrome") OR TX ("supranuclear palsy" OR "supra nuclear palsy") OR TX "ischemic white matter" S3 TX "multiple infarcts" OR TX ("normal pressure hydrocephalus" and shunt*) OR TX pick* N2 disease OR TX (creutzfeldt OR CJD OR JCD) OR TX huntington* OR TX binswanger* OR TX korsako* OR TX wernicke* OR TX ("parkinson* disease dement*" OR PDD) OR TX ("cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy" OR CADASIL) S4 MH "Dementia+" OR MH "Dementia, Vascular+" OR MH "Delirium, Dementia, Amnestic, Cognitive Disorders+" OR MH "Dementia, Multi-Infarct" OR MH "Dementia, Presenile" OR MH "Dementia, Senile" OR MH "Alzheimer's Disease" OR MH "Cognition Disorders+" OR MM "Cognition" OR MH "Huntington's Disease" OR MM "Nootropic Agents" OR MH "Wernicke's Encephalopathy" S5 MH Cerebrovascular Disorders+ OR MH wandering behavior	811

	S6 MH Assistive technology OR MH Assistive Technology Services OR MH Assistive Technology Devices OR MM ambulation aids OR MM Wheelchairs OR MM Rehabilitation OR MM Home Rehabilitation OR MM Occupational Therapy OR MM Rehabilitation, Geriatric OR AB "ambulatory monitoring" OR AB "patient monitoring" OR MM Information Technology S7 MM Protective Devices OR MM Equipment Alarm Systems OR assis* technolog OR TX telecare OR TX "self help device*" OR MM Accidents, Home OR MM Home Safety OR MH Accidental Falls OR AB "assis* device*" OR "electronic tag*" OR "electronic track*" OR "Track* device*" S8 "Tag* device*" OR "ubiquitous comput*" OR "pervasive comput*" OR ICT OR "smart home" OR "community alarm system" OR intercom$1 OR "carbon monoxide sensor*" OR "fall detector" OR pager* OR "alarm bracelet*" OR "bed alarm*" S9 alarm* OR "occupational therapy equipment" OR "care equipment" OR "special equipment" OR "disability equipment" OR "adapt* equipment" OR "community equipment" OR "mobility aid*" OR "aid* for daily living" OR "disability aid*" OR "disability product*" OR "daily living equipment" S10 "daily living item*" OR "daily living product*" OR "aid* for personal care" OR "aid* for mobility" OR "aid* for protection" OR "aid* for signalling" OR "tool* for living" OR "modification* to the home" OR "home modification*" OR "home safe* assess*" OR "modification intervention*" OR "home safety intervention*" S11 "environment* modif*" OR "home occupational therapy" OR "walking aid*" OR (("grab rail*" or "grab bar*" or "hand rail*" or "grab bar*")) OR "bed rail*" OR "global position* system*" OR "memory assist*" OR "multi factor* interven*" OR "home hazard"	

	S12 ((MH "Aged") OR (MH "Aged, 80 and Over") OR (MH "Frail Elderly")) OR MH "Aging" OR MH "Gerontologic Care" OR ("old people" or "elderly" or "old age" or "senior" or "aged") OR "old* people" OR "old* person*" OR elder* OR "old* adult*" OR "very aged" OR senior* S13 S1 OR S2 OR S3 OR S4 OR S5 S14 S6 OR S7 OR S8 OR S9 OR S10 OR S11 S15 S12 AND S13 AND S14 S16 S12 AND S13 AND S14 Limiters - Published Date: 20110101-20161231	
Applied Social Sciences Index & Abstracts (ASSIA)	((SU.EXACT("Alcoholic dementia" OR "Alzheimer's disease" OR "Dementia" OR "Lewy body dementia" OR "Multi-infarct dementia" OR "Presenile Alzheimer's disease" OR "Presenile dementia" OR "Semantic dementia" OR "Senile dementia" OR "Subcortical dementia" OR "Vascular dementia") OR (SU.EXACT("Mild cognitive disorders") OR SU.EXACT("Cognitive disorders")) OR ti(cognition) OR (dement* OR alzheimer*) OR (lewy* NEAR/1 bod* OR deliri*) OR SU.EXACT("Organic brain syndrome") OR ("supra nuclear palsy" OR "ischemic white matter") OR (("normal pressure hydrocephalus" and shunt$) OR "benign senescent forgetfulness") OR (cerebr$ NEAR/3 deteriorat$ OR pick$ NEAR/2 disease) OR (creutzfeldt or JCD or CJD OR huntington$)) OR (binswanger OR (korsako$ OR "progressive supra nuclear palsy") OR ("Huntington Disease" OR "wernicke encephalopathy") OR ("Korsakoff Syndrome" OR Ischemic Attack, NEAR/1Transient) OR SU.EXACT("Delirium") OR SU.EXACT("Cerebrovascular diseases") OR ("Parkinson* disease dementia" or PDD OR ("limited cognitive disturbance*" or "mild cognitive disorder*")) OR SU.EXACT("Wandering"))) AND (((pervasive NEAR/1 comput*) OR (ICT OR "smart home") OR ("community alarm system*" OR intercom$1)	67

	OR ("carbon monoxide sensor*" OR fall N/2 detector*) OR (pager* OR alarm NEAR/2 bracelet*) OR SU.EXACT("Community alarms") OR ab((alarm* OR occupational NEAR/1 therapy NEAR/1 equipment)) OR SU.EXACT("Selfpropelled wheelchairs" OR "Wheelchairs")) OR ((care NEAR/1 equipment) OR (special NEAR/1 equipment OR disability NEAR/1 equipment) OR (adapt* NEAR/1 equipment OR community NEAR/1 equipment) OR (mobility NEAR/1 aid OR aid* NEAR/1 daily NEAR/1 living) OR (disability NEAR/1 aid OR disability NEAR/1 product) OR (daily NEAR/1 living NEAR/1equipment OR daily NEAR/1 living NEAR/1 item*) OR (daily NEAR/1 living NEAR/1 product* OR aid* NEAR/1 personal NEAR/1 care) OR (aid* NEAR/1 mobility OR aid* NEAR/1 protection) OR (aid* NEAR/1 signalling OR tool* NEAR/1 living) OR (modification* NEAR/2 home OR home NEAR/1 safe* NEAR/1 assess*)) OR ((modification NEAR/2 intervention) OR SU.EXACT("Accidents") OR (("grab rail*" or "grab bar*" or "hand rail*" or "grab bar*") OR "bed rail*") OR SU.EXACT("Falls") OR ("global positioning system" OR gps) OR (memory NEAR/1 assist* OR multi-factor* NEAR/1 interven*) OR (home NEAR/1 hazard)) OR ((SU.EXACT("Walking aids") OR SU.EXACT("Technical aids") OR SU.EXACT("Environmental control systems")) OR (SU.EXACT("Rehabilitation") OR SU.EXACT("Computer assisted rehabilitation")) OR (SU.EXACT("Occupational therapy") OR SU.EXACT("Community occupational therapy")) OR ("ambulatory monitoring" OR "alarm monitoring") OR SU.EXACT("Information technology") OR SU.EXACT("Electronic monitoring") OR ("electronic sensor" OR assis* NEAR/3 technolog*) OR (telecare OR Self-help device*) OR (assis* NEAR/2 device* OR electronic NEAR/2 track*) OR (Track* NEAR/2 device* OR ubiquitous NEAR/2 comput*))) AND ((SU.EXACT("Age") OR SU.EXACT("Gerontology")) OR SU.EXACT("Elderly people") OR SU.EXACT("Ageing") OR (old* NEAR/2 person* OR old* NEAR/2 people*) OR (old* NEAR/2 adult* OR elder*) OR ("very aged" OR senior*)) AND pd(20110101-20161231)	

ProQuest Dissertations & Theses Global	(SU.EXACT("Alcoholic dementia" OR "Alzheimer's disease" OR "Dementia" OR "Lewy body dementia" OR "Multi-infarct dementia" OR "Presenile Alzheimer's disease" OR "Presenile dementia" OR "Semantic dementia" OR "Senile dementia" OR "Subcortical dementia" OR "Vascular dementia") OR (SU.EXACT("Mild cognitive disorders") OR SU.EXACT("Cognitive disorders")) OR all(cognition) OR all((dement* OR alzheimer*)) OR all((lewy* NEAR/1 bod* OR deliri*)) OR SU.EXACT("Organic brain syndrome") OR all(("supra nuclear palsy" OR "ischemic white matter")) OR all((("normal pressure hydrocephalus" AND shunt) OR "benign senescent forgetfulness")) OR all((cerebr NEAR/3 deteriorat OR pick NEAR/2 disease)) OR all((creutzfeldt OR JCD OR CJD OR huntington)) OR all(binswanger) OR all((korsako OR "progressive supra nuclear palsy")) OR all(("Huntington Disease" OR "wernicke encephalopathy")) OR all(("Korsakoff Syndrome" OR Ischemic Attack, NEAR/1Transient)) OR SU.EXACT("Delirium") OR SU.EXACT("Cerebrovascular diseases") OR all(("Parkinson* disease dementia" OR PDD OR ("limited cognitive disturbance*" OR "mild cognitive disorder*"))) OR SU.EXACT("Wandering")) AND ((all(modification NEAR/2 intervention) OR SU.EXACT("Accidents") OR all((("grab rail*" or "grab bar*" or "hand rail*" or "grab bar*") OR "bed rail*")) OR SU.EXACT("Falls") OR all(("global positioning system" OR gps)) OR all((memory NEAR/1 assist* OR multi-factor* NEAR/1 interven*)) OR all(home NEAR/1 hazard)) OR (all(care NEAR/1 equipment) OR all((special NEAR/1 equipment OR disability NEAR/1 equipment)) OR all((adapt* NEAR/1 equipment OR community NEAR/1 equipment)) OR all((mobility NEAR/1 aid OR aid* NEAR/1 daily NEAR/1 living)) OR all((disability NEAR/1 aid OR disability NEAR/1 product)) OR all((daily NEAR/1 living NEAR/1equipment OR daily NEAR/1 living NEAR/1 item*)) OR all((daily NEAR/1 living NEAR/1 product* OR aid* NEAR/1 personal NEAR/1 care)) OR all((aid* NEAR/1 mobility OR aid* NEAR/1 protection)) OR all((aid* NEAR/1 signalling OR tool* NEAR/1 living)) OR all((modification* NEAR/2 home OR home NEAR/1 safe* NEAR/1 assess*))) OR	8

	(all(pervasive NEAR/1 comput*) OR all((ICT OR "smart home")) OR all(("community alarm system*" OR intercom$1)) OR all(("carbon monoxide sensor*" OR fall N/2 detector*)) OR all((pager* OR alarm NEAR/2 bracelet*)) OR SU.EXACT("Community alarms") OR all((alarm* OR occupational NEAR/1 therapy NEAR/1 equipment)) OR SU.EXACT("Selfpropelled wheelchairs" OR "Wheelchairs")) OR ((SU.EXACT("Walking aids") OR SU.EXACT("Technical aids") OR SU.EXACT("Environmental control systems")) OR (SU.EXACT("Rehabilitation") OR SU.EXACT("Computer assisted rehabilitation")) OR (SU.EXACT("Occupational therapy") OR SU.EXACT("Community occupational therapy")) OR all(("ambulatory monitoring" OR "alarm monitoring")) OR SU.EXACT("Information technology") OR SU.EXACT("Electronic monitoring") OR all(("electronic sensor" OR assis* NEAR/3 technolog*)) OR all((telecare OR Self-help device*)) OR all((assis* NEAR/2 device* OR electronic NEAR/2 track*)) OR all((Track* NEAR/2 device* OR ubiquitous NEAR/2 comput*)))) AND ((SU.EXACT("Age") OR SU.EXACT("Gerontology")) OR SU.EXACT("Elderly people") OR SU.EXACT("Ageing") OR all((old* NEAR/2 person* OR old* NEAR/2 people*)) OR all((old* NEAR/2 adult* OR elder*)) OR all(("very aged" OR senior*))) AND pd(20110101-20161231)	
Cochrane	#1 MeSH descriptor: [Alzheimer Disease] explode all trees #2 MeSH descriptor: [Creutzfeldt-Jakob Syndrome] explode all trees #3 MeSH descriptor: [Dementia, Vascular] explode all trees #4 MeSH descriptor: [Kluver-Bucy Syndrome] explode all trees #5 MeSH descriptor: [Lewy Bodies] explode all trees #6 MeSH descriptor: [Lewy Body Disease] explode all trees #7 MeSH descriptor: [Niemann-Pick Disease, Type A] explode all trees #8 MeSH descriptor: [Pick Disease of the Brain] explode all trees #9 MeSH descriptor: [Dementia, Multi-Infarct]	183 (Cochrane Reviews (including reviews and protocols) (132) Other Reviews (6) Trials (44) Methods Studies (0) Technology Assessments (0) Economic Evaluations

	explode all trees #10 MeSH descriptor: [Cerebrovascular Disorders] explode all trees #11 MeSH descriptor: [Huntington Disease] explode all trees #12 MeSH descriptor: [Neurocognitive Disorders] explode all trees #13 MeSH descriptor: [Delirium] explode all trees #14 MeSH descriptor: [Wernicke Encephalopathy] explode all trees #15 MeSH descriptor: [Korsakoff Syndrome] explode all trees #16 dement* or alzheimer* #17 lewy* and bod* #18 deliri* #19 cadasil or "cerebral autosomal dominant arteriopathy" #20 (cognit* or memory* or mental*) and (declin* or impair* or los* or deteriorat*) #21 (chronic and cerebrovascular) or ?ischemic white matter? or ?multiple infarcts? #22 MeSH descriptor: [Supranuclear Palsy, Progressive] explode all trees #23 MeSH descriptor: [Hydrocephalus, Normal Pressure] explode all trees #24 (benign next senescent next forgetfulness) #25 (cerebr* and deteriorat*) #26 (cerebr* and insufficien*) #27 (pick* next disease:ti) or (pick* next disease:ab) #28 creutzfeldt:ti or creutzfeldt:ab or jcd:ti or jcd:ab or cjd:ti or cjd:ab #29 (Huntington*:ti or Huntington*:ab) #30 (binswanger:ti or binswanger:ab) #31 (korsakof*:ti or korsakof*:ab) #32 (Wernicke* next syndrome:ti) or (Wernicke* next encephalopathy:ti) or (Wernicke* next syndrome:ab) or (Wernicke* next encephalopathy:ab) #33 epilep*:ti or schizophre*:ti or child*:ti or Parkinson*:ti or HIV*:ti or aids:ti or stroke:ti or diabet*:ti or heart:ti #34 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 #35 #34 not #33 #36 MeSH descriptor: [Self-Help Devices] this	(1)

	term only #37 MeSH descriptor: [Occupational Therapy] explode all trees #38 MeSH descriptor: [Telerehabilitation] explode all trees #39 MeSH descriptor: [Self Care] this term only #40 MeSH descriptor: [Monitoring, Ambulatory] this term only #41 "assis* technolog*" #42 "patient monitoring" #43 "information technol*" #44 "alarm monitor*" #45 "electronic sensor" #46 telecare #47 "Self help device*" #48 "assis* device*" #49 "electronic tag*" #50 "electronic track*" #51 "Track* device*" #52 "Tag* device*" #53 "ubiquitous comput*" #54 "pervasive comput*" #55 ICT #56 "smart home" #57 intercom* #58 "fall detector*" #59 pager* #60 "bed alarm*" #61 alarm* #62 MeSH descriptor: [Canes] this term only #63 MeSH descriptor: [Walkers] this term only #64 "care equipment" #65 "special equipment" #66 "disability equipment" #67 "adapt* equipment" #68 "mobility aid*" #69 "aid* for daily living" #70 "disability aid*" #71 "disability product*" #72 "daily living equipment" #73 "daily living item*" #74 "aid* for personal care" #75 "aid* for mobility" #76 "aid* for signalling" #77 "modification* to the home" #78 "home modification*" #79 "home safe* assess*" #80 "modification intervention*" #81 "home safety intervention*" #82 "environment* modif*"	

	#83 "home occupational therapy" #84 MeSH descriptor: [Accidents, Home] this term only #85 MeSH descriptor: [Accident Prevention] this term only #86 MeSH descriptor: [Accidental Falls] this term only #87 ("grab rail*" or "grab bar*" or "hand rail*" or "grab bar*") #88 "bed rail*" #89 ("global positioning system" or GPS) #90 "memory assist*" #91 "multi* factor* interven*" #92 "home hazard" #93 #36 or #37 or #38 or #39 or #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 or #65 or #66 or #67 or #68 or #69 or #70 or #71 or #72 or #73 or #74 or #75 or #76 or #77 or #78 or #79 or #80 or #81 or #82 or #83 or #84 or #85 or #86 or #87 or #88 or #89 or #90 or #91 or #92 #94 MeSH descriptor: [Aged] this term only #95 MeSH descriptor: [Geriatrics] this term only #96 MeSH descriptor: [Aging] this term only #97 "elderly care" #98 "old* person" #99 "old* people" #100 "old* adult" #101 senior* #102 "very aged" #103 #94 or #95 or #96 or #97 or #98 or #99 or #100 or #101 or #102 #104 #35 and #93 and #103 Publication Year from 2011 to 2016	
Social Care Institute for Excellence (SCIE)	SubjectTerms:'"dementia"' including **narrower terms** - AND SubjectTerms:'"older people"' including **narrower terms** - AND SubjectTerms:'"assistive technology"' including **narrower terms** - OR SubjectTerms:'"telecare"' including **this term only** - OR SubjectTerms:'"home improvements"' including **narrower terms** - OR AbstractOmitNorms:'"fall detector"']	154

	(Exportation limited to years 2011 – 2016)	
Alzheimer's Society	Dementia "assistive technology" "older people" (Final hits limited to years 2011 – 2016) (Searched in the 'with all the words' option)	23

Characteristics of Included Studies with Risk of Bias Scoring

Horvath et al. (2013)

Reference	**Author:** Horvath et al. **Date:** 2013 **Journal**: International Journal of Alzheimer's Disease
Methods	**Study design:** randomised controlled trial, randomisation at level of patient-caregiver dyad, blocked design, stratified by setting (in order to achieve a balanced representation of each site in both the intervention and control conditions). **Study duration**: 3 months
Participants	*Person with dementia* **Number:** randomised: 127 (70 in intervention; 57 in control) **Cognitive status**: all participants had a progressive dementia of the Alzheimer's type or a related disorder. **Age:** average age in control: 80.9 (SD = 7.2); average age in intervention: 80.4 (SD = 6.7) **Sex:** male participants: 87.5% in control; 86.7% in intervention **Caucasian participants:** Caucasian: 92.7% control; 88.3% intervention **Setting:** living in the community **Country**: United States (Massachusetts) *Caregiver* **Relation to PwD**: not stated, but noted that some caregivers were adult children **Living arrangement** (with or external to PwD): all lived at home with the PwD **Age:** average age in control: 69.4 (12.9); average age in intervention: 70.6 (11.4) **Other demographic information** female participants in control: 79.2%; female participants in intervention: 81.7%
Intervention	*Treatment Group* **Type(s) of assistive technology (AT)**: home safety items including both telecare and environmental aids. **Sub type(s) of AT (specific items(s)):** the following items are listed in the study (not clear if this is complete): Motion sensor with battery; Canvas bag; Smoke alarm; Colored duct tape (2 inch); Night lights (with photo sensor); Stove knob covers; Grab bar (18 inch); Slide bolt lock; Medicine case; Keyed doorknob; Surge protector; Carbon monoxide alarm; Flashlight with batteries; Hand-held shower; Rubber bath mat (machine washable); Cabinet slide lock (p.3) **Aim of AT**: To reduce accidents and risky behaviour including

	reducing falls; alerting if fire or carbon monoxide is detected; reducing unsafe/ unsupervised cooking; reducing electrical accidents. **Whether AT is designed specifically for people with dementia or not**: Designed specifically for people with memory loss. **Description of intervention:** • Intervention group – received the home safety tool kit, which has 2 components (1) The booklet 'Keep the Home Safe for a Person with Memory Loss' and (2) A number of low-cost sample items that have been found to be acceptable and effective in reducing risky behaviours and accidents. The kit included some items of assistive technology, such as a grab bar, night lights (with photo sensor) and a motion sensor (see below for other components). Carers were given the opportunity to practise using the home safety items, which was designed to increase self-efficacy. **Additional intervention components (if any):** a home safety workbook and a number of other non-AT items, including telehelath such as a medicine case. The booklet was learner verified to provide a persuasive and comprehensive advice regarding home safety and conformed to health literacy principles. *Control Group* • Dyads received the 'Worksheet to Make the Home Safer,' a patient information sheet that is commonly used in clinical practice. 'The worksheet has accurate and practical recommendations for home safety in dementia of the Alzheimer's type with a reading level of 5th to 6th grade; however, it is in a conventional format using words only and does not conform fully to the principles of health literacy.' (p.4)
Outcomes	*Outcomes measured* Caregiver self-efficacy, Caregiver strain, Home safety, Risky behaviours and accidents. *Time points measured:* Baseline and at 3 months. In addition, during the study period, the caregivers in both the intervention and control groups were called biweekly by the project director or research assistant to collect information on the Risky Behavior Questionnaire.
Notes	**Statistical analysis summary**: • Descriptive statistics were first gained for all data collected • All data was tested to check it met the assumptions required for Multivariate Analysis of Covariance (MANCOVA). • Hypotheses were tested using MANCOVA in order to test all outcome variables and covariates simultaneously. • In the MANCOVA model, tests of between subject effects were

	gained (covariates include baseline measures of outcome variables and age of caregiver.) • Effect sizes were calculated via cohen's d **Funding of study:** Not clear. The research was supported by Department of Veterans Affairs Health Services Research and Development, Boston University Alzheimer's Disease Core Center and the Department of Veterans Affairs, New England Geriatric Research Education & Clinical Center.

Risk of bias tool for studies with a separate control group: Randomised controlled trials; Non-randomised contolled trials; Controlled before-after (EPOC 2015)

Criteria	**Score**	**Evidence for author's judgement**
Was the allocation sequence adequately generated?	Low risk	'Computer-generated random numbers were used by the statistician to allocate group assignment (p.3)
Was the allocation adequately concealed?	Low risk	Group assignment was by 'the sealed envelope method', and completed by the statistician (p.3)
Were baseline outcome measurements similar?[1,2]	Low risk	'After informed consent but before random assignment, the project director (PD) or research assistant (RA) collected demographic and baseline data on the outcome variables and covariates' (p.3) All time 1 baseline measures of outcomes variables were set as covariates in the MANCOVA model (p.6-7) Comment: Outcome variables were collected at baseline but they were not reported. However, all baseline measures were controlled for in the MANCOVA model, demonstrating appropriate adjusted analysis.
Were baseline characteristics similar?	Low risk	The primary authors report no significant differences between the intervention and control groups on the demographic and disease severity measured: Caregiver age; Care recipient age; Mini-Mental State Examination; Physical self-maintenance scale; Functional activities questionnaire; Gender of caregiver; Gender of care receiver; Married; Caucasian (p.6)
Were incomplete	Low risk	'We examined baseline characteristics …. between the

outcome data adequately addressed?[1]		dropouts and completers using the appropriate statistics (chi-square for nominal data and *t*-tests with adjustments for type 1 error for continuous data) revealing no significant differences between the groups' (p.6) Authors completed analysis on the final sample (= 60 in intervention and 48 in control). (p.6) Authors report that attrition was dispersed evenly across intervention and control groups (p.6) Comment: analysis was not by intention to treat. However, attrition was spread evenly across groups and the characteristics of drop outs and completers were not significantly different. Therefore, incomplete outcome data is considered to be adequately addressed.
Was knowledge of the allocated interventions adequately prevented during the study?[1]	Unclear risk	'The study design was single blinded in that the subjects did not know which group they had been assigned to randomly, but the project director and research assistants were aware of group assignment…..Thus, there may have been bias in the data collection following randomization.' (p. 9) Comment: project staff who were collecting data were aware of group assignment. However, this is not considered to cause high risk of bias as the caregiver, who was blinded, reported key outcomes.
Was the study adequately protected against contamination?	Low risk	The intervention was a number of low-cost sample items in a canvas bag (p.4) The control group received the "Worksheet to Make the Home Safer," a patient information sheet that is commonly used in clinical practice. The worksheet had accurate and practical recommendations for home safety in dementia of the Alzheimer's type (DAT) with a reading level of 5th to 6th grade; however, it was in a conventional format using words only and does not conform fully to the principles of health literacy. (p.3) The control group had a statistically significantly lower home safety score (p.7) Comment: Given the nature of the intervention, contamination was low risk as the items were not given out to the control group. However, contamination could have occurred as the control group may have obtained safety items independently if recommended in their information sheet. However, the control group did have

		a statistically significantly lower home safety score, indicating that any contamination did not undermine the intervention.
Was the study free from selective outcome reporting?	Low risk	They reported the 4 outcomes pertinent to the hypotheses: caregiver self-efficacy, caregiver strain, home safety, risky behaviours and accidents (p.7) Comment: no important outcomes were subsequently omitted from the results.
Was the study free from other risks of bias?	Low risk	

Tchalla et al. (2013)

Reference	**Author:** Tchalla et al. **Date:** 2013 **Journal:** Dementia & Geriatric Cognitive Disorders
Methods	**Study design:** 'experimental prospective study that involved dynamic random allocation using a minimization (criteria: age, sex, fall history in previous 12 months and MMSE scale) method to identify participants for intervention and a control group meeting necessary criteria' (p.252) **Duration of the study:** 12 months
Participants	*Persons with dementia* **Number:** 96 (49 intervention; 47 control) Cognitive status: all had Alzheimer's Disease **Age:** Average age in control: 85.3 (SD = 6.3); average age in intervention: 87.8 (SD = 6.5) Average age of all participants: 86.6 (SD = 6.5) All aged 65 years and older **Setting:** 'living at home' (p.253) **Sex:** Male participants: 23.4% control (N = 11); 22.5% intervention (N = 11) Female participants: 76.6% control (N = 36); 77.6% intervention (N = 38) **Country:** France *Information regarding Caregivers* **Presence of caregiver** = 90.6% **Lives alone** 70.8% **Lives with other**s 29.2%
Intervention	*Treatment:* **Type(s) of assistive technology (AT)** telecare **Sub type(s) of AT (specific items(s)):** Home-based technologies coupled with teleassistance service (HBTec-TS). Part 1. The HBtec in this study was a nightlight path, which is installed near the bed and illuminates a path from the bed. It is designed to prevent falls at home when someone gets up at night for personal needs. It turns on automatically when the person steps on the ground. The primary authors note that it is beneficial for preventing falls at night but also during the day because it clearly improves the vision of elderly people and makes them feel confident moving in the house. Part 2. The teleassistance service involves a remote intercom,

	an electronic bracelet and a teleassistance centre which is functional 24/7. If an alarm is sent due to someone falling, the centre helps to coordinate support by, for example, calling a nominated caregiver or the emergency services. This is designed to enable early management of falls. **Aim of AT**: to reduce falls risk and ensure that assistance is gained if a fall occurs **Whether AT is designed specifically for people with dementia or not**: author's judgement is not; it is for anyone at risk of falls. Primary authors comment that it is beneficial for the elderly and, in particular, those with neurological frailty. **Additional intervention components** (if any): All participants undertook a fall reduction program following the initial Comprehensive Gerontological Assessment according to current guidelines (This reference is an article with a number of recommendations to prevent falls. It includes assistive devices such as bed alarms, walking aids and hip protectors, as well as a number of other interventions, such as medication based and exercise) *Control:* The comparison group, like the intervention group, undertook a fall reduction program following the initial Comprehensive Gerontological Assessment according to current guidelines.
Outcomes	Primary outcome: • Incidence of benign and serious falls at home during the 12-month period (Number of participants falling in each group) Secondary outcomes: • Number of participants falling once • Number of participants falling twice • Number of participants falling three or more times • Number of admissions to care home • Number of deaths Time points for data collection: at baseline, data for number of falls in previous 12 months was collected. outcomes were examined after 12 months, for the 12-month period. However, data was collected each month to enable this (via a regular monthly telephone call to the GP of each participant).
Notes	**Summary of statistical analysis:** • Descriptive statistics were gained and expressed as mean ± SE. • Student's t test was used to compare the means of continuous variables and normal distribution data in factors associated with falls. • Odds ratio reported for the intervention

	• Categorical data were tested using χ^2 analysis. • A multivariate analysis was performed by applying a multiple logistic stepwise regression procedure to obtain variables that independently correlated to falls. • All statistical tests were two-tailed, and a significance level of p = 0.05 or less was used. **Funding of study** Unclear. They thank a number of people and organisations. All authors declare that they have no financial or personal conflicts in terms of grants / funds.

Risk of bias tool for studies with a separate control group: Randomised controlled trials; Non-randomised contolled trials; Controlled before-after (EPOC 2015)

Criteria	**Score**	**Evidence for author's judgement**
Was the allocation sequence adequately generated?	Low risk	The study involved dynamic random allocation using a minimization method (p.252)
Was the allocation adequately concealed?	Unclear risk	The unit of allocation was by patient. However, the randomisation scheme was not specified.
Were baseline outcome measurements similar?[1,2]	Low risk	Falls in the previous 12 months (0, 1 or ≥ 2) were measured at baseline and there were no significant difference between groups (p.256)
Were baseline characteristics similar?	Unclear risk	'The baseline characteristics of the participants were similar between the two groups except for comorbidities. In the intervention group, 43 (87.8%) had two or more comorbidities. This was significantly (p = 0.0155) higher than in the control group 33 (70.2%; table 1)' (p.254). Primary author notes that comorbidities could be a confounding variable (p. 254). However, comorbidities were not found to be significantly associated with falls in the univariate analysis (p.257). Comment: there was a difference between control and intervention groups. However, this is unlikely to have introduced bias as reflected in the univariate analysis.
Were incomplete outcome data adequately	Low risk	Outcome data for the study objective (to test the interventions impact on indoor falls) was

addressed?[1]		reported completely (p.255-6). Intention to treat analysis was performed (p.254).
Was knowledge of the allocated interventions adequately prevented during the study?[1]	Unclear risk	No information regarding blinding is included.
Was the study adequately protected against contamination?	Low risk	The intervention was a piece of equipment (p.252) which was only provided to one group. Comment: Given the nature of the intervention, contamination was low risk as the item was not given out to the control group. However, in relation to AT generally, contamination is likely, as assistive devices may be provided as standard practice, which was provided to the control group.
Was the study free from selective outcome reporting?	Low risk	All outcomes related to the stated purpose of the study are reported (p.255 – 256).
Was the study free from other risks of bias?	Low risk	Collection of falls data was 'declarative by GPs and caregivers, and therefore subject to recall bias – especially in this population with dementia. This reporting bias might lead to underestimation of the rate of falls, particularly those which do not cause injury or need GP or emergency room intervention.' (p.257) –as stated by primary authors. Comment: however, this would have applied to both intervention and control groups, so is not considered to undermine internal validity.

Wesson et al. (2013)

Reference	**Author**: Wesson et al. **Date**: 2013 **Journal:** BMC Geriatrics
Methods	**Study design:** randomised pilot trial **Duration of the study:** 12 weeks
Participants	**Number:** 22 (intervention = 11; control = 11); follow up assessment on 21 (one in hospital) **Cognitive status**: All have dementia, type of dementia not stated **Age** average age control: 80.9 (SD = 5.0); average age intervention: 78.7 (SD = 4.2) **Setting:** Living at home **Sex:** Women = 5 (45.5%) intervention; women = 4 (36.4%) control **Country:** Australia
Intervention	*Treatment:* **Type(s) of assistive technology (AT):** Telecare and environmental aids **Sub type(s) of AT** (specific items(s)): Primary author advised via personal correspondence that all participants received some form of assistive technology in the study. This included bedrail, shower chairs/ stools, lever taps, grab rails, hand held showers, commode chair, sensor lights, signage to cue appliance use, and personal alarms. Primary author did not have a breakdown of how many participants had what type of intervention (i.e. % issued personal alarms). **Aim of AT**: reduce falls risk; alert support as required; use appliances appropriately / safely **Whether AT is designed specifically for people with dementia or not**: not specifically designed for PwD **Description of intervention**: *Overview* • The intervention consisted of strength and balance training exercises and home hazard reduction. • Occupational therapy (OT), physiotherapy (PT) home visits and three telephone calls were provided over 12 weeks. • The intervention used Allen's Cognitive Disabilities Model to tailor the adaptation and delivery of the exercises and home safety fall prevention interventions (associated with a tool that identifies different levels of cognitive functioning and participants' capacity to perform daily tasks).

	AT elements: • The occupational therapist (OT) completed home safety assessments, prescribed home safety recommendations and helped caregivers implement home safety recommendations. • Caregiver participation was essential for assisting with the recall of falls and they were also important partners in care. • Caregivers were generally responsible for implementation of home safety recommendations. • The home safety intervention involves providing a booklet with home safety recommendations, which were tailored to the specific hazards identified in the home. E.g. recommendations include fluorescent step edges. The booklet was also modified according to Allen's theory. • The booklet was adapted according to cognitive ability. **Additional intervention components (if any)**: • The physiotherapist prescribed and progressed exercises, and monitored adherence. • In summary, each participant was prescribed up to six individually tailored strength and balance exercises which were selected from the Weight-Bearing Exercise for Better Balance (WEBB) program and based on the results of the physical performance assessment. • The booklet accompanying exercises was also designed to be accessible, clear and easy to understand (e.g. in font and colour). • Caregivers supervised exercise sessions. • 'The OT also discussed behaviour and/ or management issues with carers and strategies were provided such as task simplification, modifying the environment, and education about participants' cognitive abilities.' (p.3) • AT received may have included medication dispensers. *Control:* 'Participants in the control group received 'usual care.' They were encouraged to report any falls to their general practitioner and did not receive any further contact from the investigators except for collection of falls data and follow up assessment. Both intervention and control groups received health promotion brochures on fall prevention and home safety' (p.4)
Outcomes	Summary of outcomes PwD

	• Serious adverse events related to the intervention • Number of falls that occurred in total • Number of people who fell at least once / number of people falling vs number of people who didn't fall • The Physiological Profile Assessment (PPA) – (measure of physiological performance) • Near tandem eyes closed (measure of physical performance) • Hill step test (measure of physical performance) • Incidental and Planned Exercise Questionnaire – weekly (IPEQ-W) for older people (Measure of physical activity levels) • The Falls Efficacy Scale - International (Short Form) (Measure of fear of falling) • Iconographical Falls Efficacy Scale – International (ICONFES) (Measure of fear of falling) • Daily functioning using the Interview for Deterioration of Daily Activities in Dementia (IDDD) (Measure of daily functioning) • Cornell Scale for Depression in Dementia (Measure of mood) • Agitated Behaviours in Dementia Scale (Measure of behaviour) Caregiver • Zarit Burden Interview (short form) (measure of carer burden) • Task Management Strategy Index (measure of carers' ability to simplify everyday self care tasks for people with dementia) **Timing of outcomes:** baseline and 12 weeks.
Notes	**Summary of statistical analysis:** As well as descriptive statistics, 'differences between groups for rate of falls were compared with Incident Rate Ratios using the negative binomial regression model and for number of fallers using a relative risk (RR). For other measures, change scores were generated. Due to the small sample size and because the data were skewed, outcome trends were analysed using the Mann–Whitney U-test.' (p.5) **Funding of study:** This project was supported by a new investigator grant from Alzheimer's Association, USA and an Alzheimer's Australia Research (AAR) Dementia Research Grant for new researchers.

Risk of bias tool for studies with a separate control group: Randomised controlled trials;

Non-randomised contolled trials; Controlled before-after (EPOC 2015)

Criteria	Score	Evidence for author's judgement
Was the allocation sequence adequately generated?	Low risk	'Randomisation was conducted by an investigator not involved in assessment or intervention, using a random numbers table and permuted blocks of four and six' (p.2)
Was the allocation adequately concealed?	Low risk	'Group allocation was concealed using opaque, sealed envelopes with study identification number in sequential order' (p.3)
Were baseline outcome measurements similar?[1,2]	Low risk	There were no significant differences at baseline between the intervention and control groups in terms of assessment measures (p.5).
Were baseline characteristics similar?	Low risk	There were no significant differences at baseline between the intervention and control groups in terms of demographic characteristics (p.5).
Were incomplete outcome data adequately addressed?[1]	Low risk	There was differential loss of data at follow up with more loss occurring in the intervention group. Five people (23%) did not complete the measure of daily functioning scale (IDDD) or measure of fear of falling (ICONFES) at follow up and 7 (32%) did not complete one measure of physical performance (the Hill Step Test.) (p.7) Comment: although this may introduce bias, the sample size is small and differential attrition was not based on significance tests. Further, the intervention group only provided less data for certain outcomes.
Was knowledge of the allocated interventions adequately prevented during the study?[1]	Low risk	'Assessors blinded to group allocation were used to complete follow up assessment at four months' (p.2)
Was the study adequately protected against contamination?	Low risk	Randomisation was at the level of the patient-carer dyad. Comment: It is unlikely that the control group received the intervention in this study, which consisted of exercises and home hazard reduction delivered through occupational therapy and physiotherapy home visits.

		However, in terms of AT generally, the control group was provided with 'usual care' and it is unclear whether or not this included AT. Further information was requested from the author regarding this but has not been provided.
Was the study free from selective outcome reporting?	Low risk	All relevant outcomes in the methods section are reported in the results section.
Was the study free from other risks of bias?	Low risk	

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Title

Effectiveness of assistive technology in increasing the safety of people with dementia: A systematic review

The question this thesis answers

For people in the domestic setting with a diagnosis of dementia, is assistive technology effective in increasing safety, compared to treatment as usual?

Types of participants

Participants must have a diagnosis of dementia, as stated by the author in primary studies. Participants will not be excluded according to age, type or severity of the dementia. This is because individuals' support needs and potential benefit from assistive technology (AT) are not determined by such categories. The domestic setting is defined as an individual's home and excludes people in institutions receiving 24-hour care. People living in warden assisted accommodation or similar, without formal 24-hour care, will be included. Individuals living with family or other informal carers will be included, as informal carers may not be permanently available, due to work or other commitments. Participants will not be excluded according to geographical location.

Types of intervention

AT designed to increase safety, by reducing risk of harm or alerting support when harm has occurred. Such devices include 'telecare' as categorised by Gibson et al. (2014) (see below) and non electronic AT such as a grab rail designed to reduce falls.

Due to the lack of a national and international consensus of the meaning of AT and related terms (Martin et al. 2009), definitions are outlined here. Fleming & Sum (2014) build on the definition provided by the Australian Dementia Resources Guide (Department of health Australia 2008) in order to provide a comprehensive definition of AT:

> *'[…] a product, equipment or device, usually electronic or mechanical in nature, which helps people with disabilities to maintain their independence or improve their quality of life. AT may support the person with dementia or their families or carers by supporting independence in daily living tasks, enhancing communication, increasing sense of wellbeing, reducing risk of harm, and reducing family and carer stress'* (Fleming & Sum 2014: 15).

Gibson et al. (2014) note that AT does not only refer to electronic devices, but includes devices such as plug covers and keysafes, which are designed to reduce risk. Equipment and aids designed to reduce risk in daily living activities, such as grab rails and bath seats, would also meet the inclusion criteria. Gibson et al. (2014) differentiate between telecare and telehealth, which are both subtypes of AT. Telecare refers to devices designed to increase safety or independence and usually involves the remote monitoring of and communication with people in their own homes. Telecare includes sensors which are activated when activity level or movement deviates from predetermined norms. It would alert remote carers or a call centre when an individual falls over or walks outside a specified geographical area, for example (Gibson et al. 2014). On the other hand, Gibson et al. (2014) summarise telehealth as technology supporting the completion of medical or nursing tasks undertaken in a remote site, as well as enabling monitoring and communication with patients.

Telehealth will be excluded because it does not have the primary aim of increasing safety and is rather focused on support for medical tasks or medication reminders. However, it is acknowledged that the distinction is not clear and that telehealth is also designed to reduce harm, such as preventing hospital admission.

It is also acknowledged that some AT cannot be clearly categorised according to purpose and may have a secondary or distal outcome of increasing safety (e.g. reminders to wash hands). Therefore, judgement and discussion will be required when screening studies.

Comparison

Treatment as usual, including psychosocial support without AT. An example of psychosocial support would be between 1 and 4 short (approximately 30 minute) care calls per day from a formal carer, who would assist with activities of daily living such as washing and dressing, as well as monitoring safety and wellbeing. Informal support from a friend or family member may be provided instead of or in addition to formal care. Usual care may also involve

support from professionals such as a GP or mental health professional (Reilly et al. 2015). Case management may also be a component of usual care. Case management refers to an intervention delivered in the community (not in hospital or a residential care setting) in which a professional such as a social worker or nurse plans and coordinates the care required to meet the person with dementia's (PWD's) identified needs (Reilly et al. 2015).

Types of outcomes

These outcomes draw on those selected by the relevant papers by Van Der Roest et al. (2012), Reilly et al. (2015) and (Leroi et al. (2013). Sources of outcomes may include individuals with dementia, carers, professionals and official records (such as hospital records). Where appropriate, outcomes will be measured on established scales, such as those listed in the Cochrane Dementia and Cognitive Improvement Group (McShane & Marcus 2010). The thesis will distinguish between objective and subjective outcomes.

Primary outcomes

- Institutionalisation (number of people admitted to residential or nursing homes, collectively referred to as 'care homes')
- Time to institutionalisation, defined as the permanent transition of PwD to a care home or to admission to an acute care facility that results in permanent placement in a care home.
- Increased safety of PwD in the home, defined reduction in or absence of harm. Harm is measured by number of serious adverse events (requiring hospital care or medical care in the community). If hospital admission occurs, mean number of nights or number of admissions will be measured.
- Falls – number of participants who fall or number of falls or time to first fall, depending on outcomes reported in the primary studies.
- Number of deaths that occur as a consequence of an identified risk that the AT might have affected.

Secondary outcomes

- Adoption of AT
- Wellbeing / quality of life
- Change in level of care needs
- Experienced usefulness and user-friendliness of AT

- Carer burden; carer mood; carer perception of ability to cope
- Attrition
- Adverse effects (user wellbeing; clinical; care; informal carer)

Time

The aim is to gain short, medium and long terms outcomes where available in primary studies. AT is designed to increase safety immediately. However, it is informative to ascertain whether AT prevents or delays long term outcomes, such as institutionalisation. As per the review by Reilly et al. (2015), short-terms outcomes are defined as less than 12 months, medium-term as equal to or greater than 12 months but less than 18 months, and longer-term as greater than or equal to 18 months.

Background

The number of people living with dementia worldwide in 2015 was estimated to be over 47 million (World Health Organization (WHO) 2015). The WHO estimates that it will increase to over 75 million by 2030 and that the number will triple by 2050 (WHO 2015). Through meta-analysis of the available evidence, ADI (2015) estimate over 9.9 million new cases of dementia each year worldwide.

Dementia is associated with particularly intense care needs, relative to other health conditions (Alzheimer's Disease International 2015). The implications for social care provision is therefore significant. In the UK, the costs associated with dementia are expected to reach over 50 billion in the next 30 years (Department of Health 2015).

Most people with dementia globally live in the community (Reilly et al. 2015). The majority of older adults prefer to age at home and quality of life has been found to decrease with institutionalization (Khosravi & Ghapanchi 2016; Scocco et al. 2006). In addition, institutionalization is expensive (Hermans et al. 2009). Enabling people with dementia (PWD) to remain at home for as long as possible is consistent with UK government aims for 2020 (Department of Health 2015). Concerns regarding safety, such as PWD walking unsafely outside, are a key reason for institutionalization (Altus et al. 2000). In addition, Topo (2009) refers to research finding that safety in the home is a key concern for family of PWD.

AT has been proposed as a way of increasing the independence and safety of PWD (Cahilla et al. 2007). The area of AT is rapidly growing and health and social care departments increasingly provide it as an intervention (Martin et al. 2009; Van Der Roest et al. 2012). The UK government (DoH 2015) has also highlighted the importance of AT and information and communication technology to support PWD. Research into the effectiveness of AT will provide valuable information to PWD, their carers, and AT developers regarding the usefulness of existing technologies and outstanding problems (Van Der Roest et al. 2012). It will also inform practitioners, statutory and voluntary organisations which commission AT. It is hypothesised that AT will contribute towards prevention or delay in institutionalisation. However, as noted below, little empirical support exists for this theory to date.

State of the Evidence What is already known in this area (major reviews, primary studies, etc.)? What will this thesis add?

Early research on electronic AT commenced in the 1990s (Khosravi & Ghapanchi 2016). Although significant research exists today regarding the acceptability of AT, research into effectiveness is scant (Khosravi & Ghapanchi 2016; Van Der Roest et al. 2012). The evidence base for AT is largely limited to trials with a small sample size, focusing on individual devices or specific health conditions (Gibson et al. 2014). Trials relating to AT in the care of PWD specifically were rated as not strong overall in a recent systematic review (Fleming & Sum 2014). Most studies have taken place in North America (Khosravi & Ghapanchi 2016).

Two systematic reviews and a protocol have been identified as particularly relevant. Fleming & Sum (2014) completed a systematic review of empirical support for AT in the care of PWD, focusing on its effectiveness in increasing independence, safety, communication, wellbeing and carer support. Their key findings are that included studies were not methodologically strong and that the transfer of technology from the laboratory setting to the real world is problematic. Although this review is similar to the thesis question, it is broader and shallower. In addition, no methodologically strong studies relating to safety and security were identified. As there has been significant growth in effectiveness studies in the last few years (Khosravi & Ghapanchi 2016), further studies may have emerged.

Khosravi & Ghapanchi (2016) completed a systematic review into the effectiveness of AT in assisting older adults. They draw more positive conclusions, stating that AT is effective and

can improve quality of life in older adults, although they also note that methodology in included studies was generally not strong. Khosravi & Ghapanchi (2016) searched only four databases and their search terms did not relate to dementia. Therefore, the thesis will build on this review to provide a deeper investigation in relation to this population.

Van Der Roest et al. (2012) submitted a protocol for a systematic review of the efficacy of AT for memory support in PWD. The thesis is designed to complement this review by focusing on the safety of PWD.

A number of primary studies have been identified but further searching is required. For example, Rasquin et al. (2007) investigated the effectiveness of GPS technology to manage unsafe walking in PWD. Shaw et al. (2003) investigated the effectiveness of a multifactorial intervention, including home modification, in reducing falls risk in patients with dementia and cognitive impairment.

Objectives

- To systematically review the research evidence on: for people in the domestic setting with a diagnosis of dementia, is assistive technology effective in increasing safety, compared to treatment as usual?
- To identify research and policy gaps and recommendations to support the aim of enabling service users to remain in at home for as long as possible, increasing quality of life and reducing carer burden, through cost effective means.

Protocol and practicalities

Inclusion and exclusion criteria are based on the PICO question above. Randomised controlled trials (RCTs), non-randomised controlled trials (NRCTs) and controlled before-after CBA (studies) will be included. This is consistent with the Effective Practice and Organisation of Care (EPOC) Guidelines (EPOC 2013) for health interventions in which sufficient RCTs are not available. It is not considered appropriate to include interrupted time series studies, as identification of a control group is feasible for the intervention in question.

Relevant literature, including relating to dementia, health and social care and ICT will be searched. Relevant databases include: Medline, Cinahl, Pubmed, Embase, PsycInfo, ASSIA and the Cochrane Dementia and Cognitive Improvement Group Specialized Register. A

search for grey and other unidentified literature is also proposed, including via contacting experts, a search of Google Scholar, conference proceedings and unpublished theses.

Key search terms:

AT	"Assistive technology" or telecare or "cognitive prosthetics" or "technology-based reminding support" or "pervasive computing" or "electronic tagging" or "electronic tracking" or ICT or "information communication technolog%" or "pervasive healthcare technologies" or "smart home technologies" or techolog% or "assistive device" or surveillance or tagging or tracking or monitoring or "electronic assistive technology" or "non-pharmacological" or equipment or "occupational therapy equipment" or "adapt% equipment" or "special equipment" or "care equipment" or "daily living equipment" or "mobility aids" or "community equipment" or modif% or "home modification%" or "modification intervention%" or "home safety intervention%" or "environmental modification" or aids or "aids for daily living" or "disability aids" or "disability products"
Dementia	dementia or Alzheimer or "Lewy bod%" or "vascular diseases" or "Delirium" or "Cognitive Disorder" or "Multi- Infarct" or "Wernicke Encephalopathy" or Amnestic or "Huntington Disease" or "Creutzfeldt-Jakob Syndrome" or "Korsakoff Syndrome" or "Cerebral Infarction" or CADASIL or "Cerebrovascular Disorders" or "Kluver-Bucy Syndrome"

It is proposed that, if controlled studies are found which are sufficiently homogenous, quantitative results will be combined in a meta analysis. In addition, and if this is not possible, it is proposed that all studies are synthesized through a narrative synthesis. This may involve organizing studies according to characteristics such as participants, intervention and outcomes, followed by a presentation of results, as a thematic summary (Thomas et al. 2012). In addition, the thesis will discuss main results according to AT categorised by aim (for example to reduce risk of falls or to increase safety while walking outside) as well as separating telecare from other AT, due to the distinction in their method of functioning and the level of research completed in relation to them.

The thesis will discuss whether positive, negative or no evidence exists of the effectiveness of each category of AT, or different types of AT where certain devices are more effective than others within a category. Conclusions will be drawn with consideration to the methodological quality of studies to avoid 'vote counting', which risks biased conclusions (Thomas et al. 2012). Sensitivity analysis will also be completed according to study design, type of dementia, intensity of use if possible or other relevant factors which may affect results. Whether or not the results support the hypothesis and possible explanations for results will be discussed.

It will be possible to access most resources via the Oxford SOLO library system. However, it may not be possible to access certain material, particularly grey literature such as conference proceedings. Resources will be required in order to access or purchase such material.

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