Review Article

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Cognitive impairment and assistive devices: Outcomes and adverse effects

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Abstract

Purpose: The goal of this review was to investigate the relationship between cognitive impairment and assistive device use in elderly persons.

Methods: English-language articles for people aged 65 and over were identified by searching MEDLINE and Embase (1985–June 2015) with the keywords "self-help devices" and "cognition disorders" and relevant synonyms. Bibliographies of retrieved articles were also examined; 510 articles were selected for further evaluation. Abstracts of the remaining articles were evaluated and all of the studies that concerned one or more of the following criteria were included: geriatric, long-term care residents or cognitively impaired patients using assistive devices that addressed benefits, risks, adverse effects, or other problems. Ultimately, 15 articles were analyzed and included in the review.

Results: Very few good-quality studies that specifically addressed the research question were found. We found that cognitively impaired elderly patients were more likely to use assistive devices ineffectively than cognitively intact elders. In addition, the literature describes promising approaches to assistive device training and technologies to accommodate cognitive impairment in this population.

Conclusion: The evidence basis for recommendations and training for assistive devices for cognitively impaired elders is weak. More research is needed on safety and effectiveness of devices for this population.

Keywords

Assistive device, self-help devices, cognitive disorders, cognitive impairment, geriatrics, safety

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Introduction

In recent years there has been much research on assistive devices (ADs) and their effectiveness, but not many studies have focused on how cognitive impairment may affect device use. This is troubling considering that the percentage of the world population represented by people over the age of 65 with some form of cognitive impairment is steadily increasing. Worldwide the WHO estimates that 5–8% of those above the age of 60 have dementia;[1] in Canada this rate is at 14.9% for those aged 65 and over.[2] Cognitive impairment has been shown to be associated with nonuse of ADs[3] and it is expected that misuse of ADs among elders with cognitive impairment would be higher than for those elders without cognitive impairment.

It is common sense that health care professionals make better decisions when they have access to more complete information about their patients. In providing care to elderly patients, making more information available to the clinician is vital as patients' problems may be complex. Assistive technology devices include call alert buttons, orthoses and prostheses, pessaries, pill dispensers and reminders, bathroom grab bars, gopher reachers, hearing aids, long-handled shoe horns, low-vision aids, powered wheelchairs, and raised toilet seats.[4] ADs are very commonly used by elderly persons and may help to slow functional decline in this population and help prevent them from becoming more seriously ill. ADs can significantly compensate for physical and sensory deficits, but they may pose risks to health and safety if not used properly. The presence of memory and cognitive impairment

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increases the risks for complications related to the use of an AD.

The purpose of this review was to examine the risks and outcomes of assistive device use among cognitively impaired geriatric patients. Mann et al.[5] noted that persons with cognitive impairment are more likely to use ADs to aid with their physical rather than cognitive impairments, mainly because of worries relating to safety. In this review the use of ADs for both physical and cognitive disability was examined among geriatric patients, with particular focus on those with cognitive impairment.

Methods

MEDLINE and Embase (1985–June 2015) were searched for the keywords "self-help devices" (or relevant synonyms: "artificial intelligence", "artificial neural network", "assistive technology", "assistive technology device", "neural networks", "robotics", "walking aid") and "cognition disorders" (or its relevant synonyms: "Alzheimer disease", "cognitive defect", "delirium, dementia, amnestic, cognitive disorders", "dementia", "memory disorders", "mild cognitive impairment"). These keywords for assistive devices were used as it was felt they addressed a fair range of different devices for cognitively impaired individuals. The purpose of the search was to be inclusive to all types of assistive devices rather than be exclusive. Specifically, the inclusion of "artificial intelligence" and "artificial neural networks" was to identify whether any novel approach exists to aid patients with cognitive impairments in living independently – possibly replicating a memory device. The search was restricted to English-language articles and human age groups aged 65 and over (see Appendix 1). Bibliographies of relevant articles were reviewed to identify additional references. The search yielded 510 articles that were then scanned for the criteria described below. Figure 1 presents an overview of the search and selection process.

Each stage of the review included two reviewers. Abstracts of articles were examined and articles were selected if they focused on cognitively impaired geriatric patients and/or long-term care residents using ADs that addressed benefits, risks, adverse effects, or other problems. Forty-two studies were then selected for a full-text review. Fifteen articles were included in this review as the other articles either did not meet population criteria or had outcomes not relevant to this review. Data from each study was extracted and tabulated in Table 1 according to the type of article, the design (as measured by Sackett's Levels of Evidence),[6] study population, type of assistive device used and the findings/outcomes of each study. Two studies used cognitively intact adults and elders for studying the efficacy

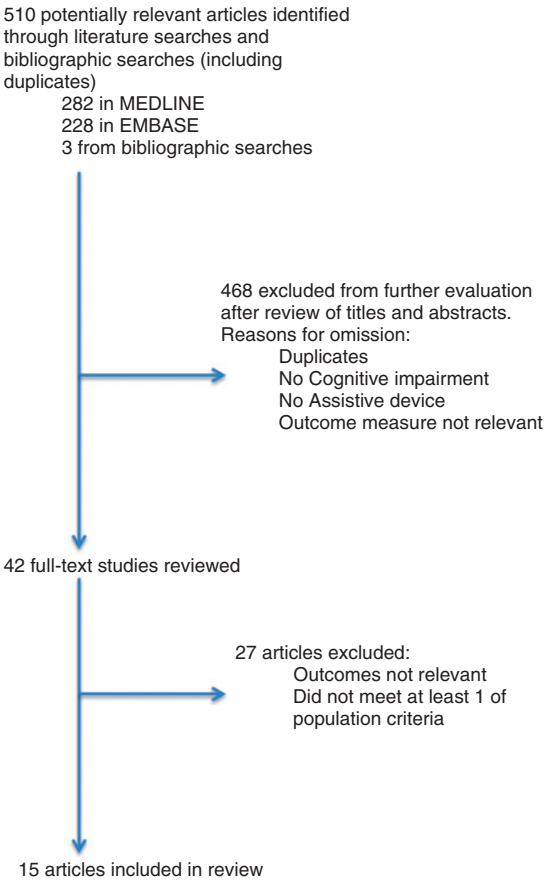

Figure 1. Flowchart of the methods used in searching the literature and extracting relevant data.

of cognitive aids on everyday living for users with cognitive impairment. The number of subjects varied greatly from study to study; some studies used a large group of participants, indicating the results may be extrapolated to the entire population, while the outcomes from a few studies may have limited generalizability as they were case series, involving as few as one participant.

Results

We found no studies of the risks and outcomes of assistive device use among cognitively impaired geriatric patients or community-dwelling elders that included statistically representative and reliable estimates. We did find studies examining assistive device training or outcomes for selected types of technologies used by elders who were either cognitively intact or impaired.

O'Neill et al.[7] studied errors and omissions in knowledge about ADs of cognitively impaired patients ($n = 8$) when donning prosthetic limbs both at a baseline (with no intervention) and also with the use of a voice-mediated assistive technology, known

Table 1. Included studies.

			Population			Assistive device					Findings/outcomes			
							Sensory							
Author	Type[a]	Design[b]	Elderly	Physical disability	Cognitive issues	Mobility	Vision	Aural	Self-care	Other	Domain[c]	Measures	Results	Demonstrates AD[d] misuse
Bailey and DeFelice (1991)[12]	2	4	No	Yes	Yes	Yes	No	No	No	No	(1) e1201	(1) Occupational and physical therapist measured her muscle control.	(1) 33-year-old woman with severe physical disability and cognitive impairment. Following training Miranda was taught how to properly maneuver in a powered wheel chair.	Yes
Bateni and Maki (2005)[10]	1	1A	Yes	Yes	No	Yes	No	No	No	No	(1) e1201		(1) Mobility aids positively affect physical and psychological health of user. Improper use of mobility aid can lead to disability or disease, such as osteoarthritis, tendonitis, and carpal tunnel syndrome. Benefits of mobility aids: biomechanic stabilization, propulsion and braking during gait, augmentation of somatosensory cues. Adverse effects: attentional and neuromotor demands, destabilizing biomechanic effects, interference with limb movement during balance recovery, upper-limb loading and strength demand, metabolic and physiologic demands.	Yes
Bayen et al. (2013)[14]	2	1B	Yes	No	No	No	No	No	Yes	No	(1) e1151	(1) 60 participants randomly assigned to: (a) no support; (b) list support; (c) InBad support. Measured total activities executed before support, and total after support.	(1) All results significant to $\alpha = 0.05$. Activities executed before given any support: (a) 14.0 (SD = 4.3); (b) 15.6 (SD = 3.7); (c) 14.8 (SD = 3.3), showing there is no difference among activities performed before intervention. After intervention activities executed: (a) 15.5 (SD = 3.2); (b) 20.0 (SD = 2.0); (c) 22.0 (SD = 0.0). Results show that any support resulted in higher completion, while InBad support resulted in significantly better performance than list help.	No

(continued)

Table 1. Continued

			Population			Assistive device					Findings/outcomes			
							Sensory							
Author	Type[a]	Design[b]	Elderly	Physical disability	Cognitive issues	Mobility	Vision	Aural	Self-care	Other	Domain[c]	Measures	Results	Demonstrates AD[d] misuse
Bradley and Hernandez (2011)[11]	1	5	Yes	Yes	No	Yes	No	No	No	No	(1) e1201		(1) Cane issues: improper height, poor maintenance, poor posture, wrong side. Crutches: require lots of energy, axillary can cause nerve compression. Walkers: can lead to bad posture, legs should be between posterior legs/wheels, wheeled walker not good for patient with cognitive impairment.	Yes
Clarke et al. (2009)[16]	2	2C	Yes	Yes	Yes	Yes	No	No	No	No	(1) e1201	(1) Data from Canadian Study of Health and Aging (CSHA) Phase 2 of the participants that transferred to long-term care institutions ($n = 308$).	(1) Cognitive impairment measured using modified MMSE. 294/308 (95.45%) provided information on mobility aid use, data restricted to the 294 participants. 70% use mobility aid, 53.7% use wheelchair, 17% use walker/cane. For wheelchair and cane/walker cognitive impairment negatively associated with use, but not significant when $\alpha = .05$.	Yes
Cook et al. (1991)[13]	2	4	Yes	No	Yes	No	No	No	No	No	(1) e1151, d5400	(1) Cognitive and perceptual impaired woman monitored putting clothes on.	(1) Developed audiotape that gave woman cues on dressing. After a few weeks she was fully independent in dressing herself, as long as clothes were arranged. Also added stop cue at end and encouraging cues (pay attention).	Yes
Eek and Wressle (2011)[18]	2	4	Yes	Yes	Yes	No	No	No	No	Yes	(1) e1150, e1200, e1250, b117	(1) Everyday technology questionnaire, MMSE.	(1) Most problems associated with vision and hearing. Mean value for MMSE 27.17 (SD = 3.896). When organized by MMSE (4–26 vs. 27–30), lower MMSE score found lower frequency of technology use different and more problems.	Yes

(continued)

Table 1. Continued

Author	Type[a]	Design[b]	Population			Assistive device					Findings/outcomes			Demonstrates AD[d] misuse
			Elderly	Physical disability	Cognitive issues	Mobility	Sensory: Vision	Sensory: Aural	Self-care	Other	Domain[c]	Measures	Results	
Kaye et al. (2008)[17]	2	2C	No	Yes	Yes	No	No	No	Yes	No	(1) e1151	(1) 2005 survey, 1919 adult consumers of California Independent Living Centers.	(1) Cognitively impaired less likely to use AD ($p < 0.01$)	Yes
Mann et al. (1992)[5]	2	2B	Yes	Yes	Yes	Yes	No	No	Yes	Yes	(1) e1151	(1) Face-to-face interview with 31 participants to examine AD for older persons with cognitive deficiency.	(1) Participants use assistive devices but mostly for physical disability, not cognitive. Device need was related to safety. People with cognitive impairment less likely to use mobility devices due to difficulties using devices.	Yes
Mihailidis et al. (2008)[8]	2	2C	Yes	No	Yes	No	No	No	Yes	No	(1) b117, e1151	(1) Six participants with moderate-to-severe dementia. Baseline phase then intervention phase (with COACH system).	(1) Overall 11% more steps completed, and 60% fewer interactions with caregiver. For moderate dementia (5/6 patients): Caregiver interactions decreased by average of 66% after device introduction. COACH not responding to 10.9% of errors and COACH made error 26% of time where participant was completing step correctly. 4/5 participants were able to independently complete hand washing after intervention.	No
Nilsson et al. (2011)[9]	2	2B	No	Yes	Yes	Yes	No	No	No	No	(1) e1201, b117	(1) Free driving in powered wheelchair by each participant. Interviews with facilitators concerning participant performance.	(1) Increased awareness by facilitators led to growing consciousness of joystick by user. Participants in reference group followed same trajectory of learning, but less slowly. 8 of the 45 participants with cognitive disorder reached Phase 6 (Goal directed, but unskilled) or higher.	Yes

(continued)

Table 1. Continued

			Population			Assistive device					Findings/outcomes			
							Sensory							
Author	Type[a]	Design[b]	Elderly	Physical disability	Cognitive issues	Mobility	Vision	Aural	Self-care	Other	Domain[c]	Measures	Results	Demonstrates AD[d] misuse
Nygard et al. (2008)[15]	2	3B	Yes	Yes	Yes	No	No	No	No	Yes	(1) e1151	(1) Public files at Agency of Home Modifications.	(1) 939 cases were given a stove timer: 788 had memory loss or dementia (Group A) and 151 did not (Group B). Group A: 10.5% had or suspected to have dementia, 89.5% had memory defects. Dementia significantly lower among those who lived alone, rate of memory deficits and physical disabilities was higher ($p < 0.001$). Age of dementia cases was younger ($p = 0.001$). Help when applying for timer: Group A: 93.8%, Group B: 88.7%. Not wanting to use auditory alarm: Group A: 49%, Group B: 35.8%. Timer setting recommendations for Group A: With dementia: 70.4%, no dementia: 82% ($p = 0.046$).	Yes
O'Neill et al. (2010)[7]	2	2C	Yes	Yes	Yes	No	No	Yes	No	Yes	(1) b117; (2) e1151	(1) Repeatable Battery for the Assessment of Neuropsychological status (RBANS), Addenbrookes Cognitive Examination – Revised (ACE-R); (2) Video data of patients putting on prosthetic limbs was analyzed.	(1) RBANS: 61.9, ACE-R: 72.9, (2) 6/8 participants had statistically significant reductions of omissions and errors after intervention. As a whole after intervention compared to baseline: mean errors ($t = 4.80$, $p = 0.002$) and mean omissions ($t = 3.95$, $p = 0.006$) significantly reduced; deviations ($t = 1.04$, $p = .12$) and repetitions ($t = 0.22$, $p = .83$) not significantly different. Mean time per trial increased significantly in the intervention condition ($t = -3.78$, $p = .007$).	Yes

(continued)

Table 1. Continued

Author	Type[a]	Design[b]	Population			Assistive device					Findings/outcomes			Demonstrates AD[d] misuse
			Elderly	Physical disability	Cognitive issues	Mobility	Sensory: Vision	Sensory: Aural	Self-care	Other	Domain[c]	Measures	Results	
Yang et al. (1997)[19]	2	4	Yes	Yes	Yes	No	No	No	No	No	(1) e1151	(1) Interviews with each participant to explore major purposes for which cognitively impaired persons use AD. Was follow up to OT.	(1) Mean owned devices following OT intervention: 10, dropped to 8.6 at follow-up. Mean used devices following intervention: 8.5, dropped to 6.3 at follow up. Participants living alone at home ($n = 5$) gave 12 AD in total; 9 for physical impairment, 3 for cognitive impairment. At nursing home ($n = 2$) participants no longer used any AD they used at home, this is because they were replaced by aides at nursing home.	Yes
Zhang et al. (2014)[20]	2	2B	No	No	Yes	No	No	No	No	Yes	(1) d2102	(1) Interviews conducted to examine which features affect mobile-streaming use in dementia patients.	(1) MMSE scores, age, living arrangement, caregiver involvement, gender, broadband, and mobile reception were all found to be statistically significant concerning adoption rates in participants.	No

[a]Type 1 refers to a Review, while type 2 refers to an original research article.
[b]Design was measured using Sackett's levels of evidence.[6]
[c]Domain is labeled using the ICF framework as defined by the WHO.
[d]AD, assistive device.

as Guide intervention. Their study noted that the mean numbers of errors and omissions at baseline were 2.22 (SD = 1.71) and 1.97 (SD = 1.69) respectively. When using the Guide intervention errors and omissions were significantly reduced for six of eight patients with mean scores of 0.94 (SD = 1.48) and 0.76 (SD = 1.46). The study showed that AD misuse by patients with cognitive impairment could be significantly reduced with the use of cognitive aids. The authors did not report outcomes or adverse events from incorrectly donning the prosthetic limb.

The success of cognitive aids for geriatric patients with cognitive impairment was also demonstrated by the findings of Mihailidis et al.[8] In their study they tested the efficacy of the Cognitive Orthosis for assisting ACtivities in the Home (COACH) in replacing a caregiver for an activity of daily living (ADL), specifically hand washing. Six participants with moderate-to-severe dementia were included in the study with two phases; Phase A, which was baseline, and Phase B, which was with the COACH intervention. In general, 11% more steps in hand washing were completed successfully with the introduction of the COACH system, while caregiver interactions were reduced by 60%.[8] Ultimately four of the six participants were able to complete hand washing independently after intervention, confirming the success of cognitive aids in ensuring that tasks are completed individually and correctly.

Nilsson et al.[9] studied the interactions of cognitively impaired adults with a mobility device, a joystick-operated powered wheelchair. Nilsson et al.[9] explored ways to help people ($n = 45$) with cognitive disabilities practice operating the wheelchair over a 12-year period while comparing them to two reference groups: normally developing infants ($n = 17$) and participants with a lesser degree of cognitive disability ($n = 64$). The findings showed that, with training and practice, the group with cognitive disabilities progressed significantly faster in learning to use a wheelchair compared with the reference groups; however, only 8 of the 45 participants were able to achieve the researchers' goals for independent wheelchair operation.

The elevated rate of ineffective use of ADs among cognitively impaired patients, as demonstrated by O'Neill et al.[7] and Nilsson et al.,[9] is worrying when one considers the risks associated with the misuse of ADs. In their review of the literature concerning mobility aids, Bateni and Maki[10] noted that improper use of canes and walkers can have adverse and unexpected effects, contributing to the pathologies of tendonitis, osteoarthritis, and carpal tunnel syndrome.

Misuse of mobility aids, specifically canes, can be largely attributed to the fact that two-thirds of patients acquire their assistive device independently of advice and education from a health care professional.[11] Among the one-third of patients who do obtain their assistive device through the advice of a professional, only 20% received education on how to use it.[11] Common, yet avoidable problems that arise with cane use are due to improper height, poor posture, poor maintenance, and poor use (e.g. holding the device on the wrong side of the body).[11] Adverse effects could possibly be avoided if proper training and direction are given to persons who have a disability, especially those with cognitive impairment. Training methods can include some that have been successful in the literature with adults who have cognitive impairment, such as switch-use training for powered wheelchair operation[12] and audiotape-assisted training for ADLs.[13]

Adverse effects and risks of improper use of ADs among individuals with cognitive defects may also be avoided through the implementation of cognitive aids. Bayen et al.[14] used randomized control trials to demonstrate the effectiveness of InBad, a cognitive aid for bathroom-related daily care. Though the study was done with cognitively unimpaired elderly individuals ($n = 60$), it demonstrated the effectiveness of cognitive aids. An InBad-supported group was compared with a group supported by a reminder checklist and a group that received only encouragement to remember. The group that received encouragement only completed an average of 15.5 (SD = 3.2) care tasks compared with 14.0 (SD = 4.3) tasks completed at baseline. The group who received checklist support completed an average of 20.0 (SD = 2.0) tasks compared with 15.6 (SD = 3.7) at baseline. The InBad-supported group completed an average of 22.0 (SD = 0.0) tasks compared with 14.8 (SD = 3.3) tasks at baseline. Performance was significantly better following intervention with InBad compared with checklist support and encouragement alone. Further research is needed to investigate the outcomes of InBad in elderly persons who have cognitive impairment.

Customized education and training on assistive device use has been recommended from research on the effectiveness of stove timers for elderly persons who have cognitive impairment. Nygard et al.[15] examined data from 939 cases of elders who had been given stove timers, 788 of whom were elders diagnosed or suspected of dementia or memory deficits and 151 who had other diagnoses. They reported that the devices had been provided to the elders in a very standardized manner, with little or no consideration of the user's diagnosis and needs, information from the user about history and experiences with device use, and input from health care professionals and caregivers. The authors concluded that assistive device provisions should be customized to address the user's needs and preferences, both to promote safety and improve device use in daily living.

The lack of training for assistive device use may also explain the lower rate of device use among geriatric patients with cognitive deficits.[16–18] Clarke et al.[16] used survey data from Phase 2 of the Canadian Study of Health and Aging and found that mobility aid use (walkers/canes and wheelchairs) was negatively associated with cognitive impairment. Kaye et al.[17] conducted a similar survey of 1919 consumers of California Independent Living Centers who were questioned to examine disparities in the usage of ADs. The authors reported that individuals with mental disabilities or most types of cognitive impairment were less likely to use assistive technology when compared to others in the sample without these disabilities. Eek and Wressle[18] found that the lower rate of use extends to everyday technologies as well. They reported that elderly individuals in Sweden ($n = 274$) with a Mini Mental State Examination (MMSE) score of 4–26, indicative of mild to severe dementia, were less likely to use everyday technologies (e.g. stove, coffee machine, cell phone) than those with a MMSE score of 27–30. Those with dementia were also reported to be more likely to encounter problems with these devices. It seems reasonable to conclude from the research that the more complex the technology, the less likely are elders with cognitive impairments to use it effectively, whether or not it is a device designed specifically for persons who have a disability.

In our review of the literature, we found that abandonment of ADs by elders who have cognitive impairment has been given little attention. One follow-up study, which recruited 10 cognitively impaired participants living at home and completed assessments on only five, found that, at a one-to-two year follow-up after intervention, the amount of devices owned, used, and satisfied with by the users had decreased.[19] Since the study did not include a control group, it is not clear whether or not the findings were specific for cognitive impairment. One recent study attempted to create a predictive model for assistive technology adoption among users with dementia.[20] In this study, interviews were conducted with patients following their use of a mobile phone-based video streaming system, and characteristics of users were compared to adoption rates. Ultimately, seven characteristics were found to be statistically significant predictors of adoption rates of the mobile streaming system in patients with dementia: MMSE scores, age, living arrangement, caregiver involvement, gender, broadband, and mobile reception.[20] Researchers should continue to identify factors that are predictive of AD use and disuse in elders who have cognitive impairment with the goal of designing interventions to increase rates of successful adoption and use.

We were unable to find any statistically representative studies of adverse events and health outcomes associated with assistive device use by elders who have cognitive impairment. Nor were we able to find any studies that specifically examined how cognitive impairment in elders affects the adoption and use of ADs, how this knowledge should be used for assessment for ADs, and how safety, function, and quality of life for elders who have cognitive impairment may be improved through assistive device education and training.

Discussion

The safe and effective use of ADs can require considerable attentional, neuromotor, and musculoskeletal capabilities, and in some instances may directly increase the risk for falls. Mobility aids may interfere with limb movements during balance recovery, and cause repetitive strain injuries because of stress on upper extremity joints. There is some evidence that health care professionals may not be recommending ADs to certain patients because of assumptions about their cognitive abilities.[3] Our review suggests that there is a weak evidence basis for making these decisions as the relationship between cognitive impairment and the safe and effective use of ADs is not completely understood. Consequently, our results may have implications regarding the quality of education about ADs given to elderly users who have cognitive impairment. The studies that were reviewed provided little detail to describe approaches to AD education and training, which require systematic investigation with representative samples of elderly device users. Additionally, the studies that were reviewed rank on the lower end of Sackett's levels of evidence,[6] indicating that information currently available to clinicians on which they base their decisions is of poor quality. To address the lack of reliable information about health outcomes and adverse events associated with AD use, we need to establish surveillance systems such as those that have been proposed for medical devices.[21] Future research studies should focus on yielding higher quality of evidence studies than what is currently available. Though a true randomized control trial (RCT) may not be feasible, in terms of practicality with this population and informing everyday practice, a pragmatic RCT may prove useful. It would be important to limit the bias in such studies by using a larger sample of matched participants with a standardized definition of users and the devices they are using. The findings from these higher quality research studies will better inform health care professionals concerning assistive devices that are safe and effective for elderly patients with cognitive impairments.

Declaration of conflicting interests

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Appendix 1

Search strategy for MEDLINE

(1) exp Self-Help Devices/
(2) artificial intelligence/or exp "neural networks (computer)"/or exp robotics/
(3) 1 or 2
(4) exp Cognition Disorders/
(5) exp Dementia/
(6) exp Alzheimer Disease/
(7) exp Mild Cognitive Impairment/
(8) exp Delirium, Dementia, Amnestic, Cognitive Disorders/
(9) exp Memory Disorders/
(10) 4 or 5 or 6 or 7 or 8 or 9
(11) 3 and 10
(12) limit 11 to ("all aged (65 and over)" and english)

Search strategy for Embase

(1) exp assistive technology device/
(2) exp self help device/
(3) exp artificial intelligence/
(4) exp artificial neural network/
(5) exp cognitive defect/
(6) exp dementia/
(7) exp Alzheimer disease/
(8) exp mild cognitive impairment/
(9) exp memory disorder/
(10) 5 or 6 or 7 or 8 or 9
(11) exp assistive technology/
(12) exp walking aid/
(13) 1 or 2 or 3 or 4 or 11 or 12
(14) 10 and 13
(15) limit 14 to (english and yr = "1985 -Current" and aged < 65 + years>)