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Review

Evaluating the Facilitators, Barriers, and Medical Outcomes Commensurate with the Use of Assistive Technology to Support People with Dementia: A Systematic Review Literature

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Abstract: *Background*: Assistive technologies (AT) have been used to improve the daily living conditions of people living with dementia (PWD). Research supports the positive impact of the use of AT such as decreased burden on caregivers and behavioral support for people with dementia. Four reviews in the last six years have analyzed AT and PWD, but none have incorporated the dimension of medical outcomes. *Objectives:* The purpose of this review is to identify the facilitators, barriers, and medical outcomes commensurate with the use of AT with PWD. *Method:* This review queried The Cumulative Index of Nursing and Allied Health Literature (CINAHL), Web of Science, Science Direct, and PubMed databases for peer-reviewed publications in the last five years for facilitators, barriers, and medical outcomes commensurate with the use of AT with PWD. The study is reported and conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) and the Kruse Protocol for conducting a systematic review. *Results:* 48 studies were analyzed. Fourteen types of AT, 17 facilitators, 17 barriers, and 16 medical outcomes were identified in the literature. The two most frequently mentioned ATs were cognitive stimulators (9/48, 19%) and social robots (5/48, 10%). The two most frequently mentioned facilitators were caregivers want AT (8/68, 12%) and enables increased independence (7/68, 10%). The top two barriers were cost (8/75, 11%) and PWD reject AT (8/75, 11%). The top medical outcomes were improved cognitive abilities (6/69, 9%), increased activities of daily living (ADLs), and increased autonomy (each at 5/69, 7%): Zero negative outcomes were reported. *Conclusion:* The systematic review revealed the positive relations that occur when PWD and their caregivers use AT. Although many reservations surrounding the use of AT exist, a majority of the literature shows a positive effect of its use. Research supports a strong support for AT by caregivers due to many positive medical outcomes, but also a reticence to adopt by PWD. If ATs for PWD are a way to reduce stress on caregivers, barriers of cost and complexity need to be addressed through health policy or grants.

Keywords: dementia; assistive technology; caregiver; cognitive disorder; stress

1. Introduction

1.1. Rationale

Dementia describes a group of symptoms affecting a person's cognitive abilities severely enough to interfere with their daily life [1,2]. Currently, over 46 million people live with dementia, and the numbers are expected to increase with the aging of society to 131.5 million by 2025. Dementia is a

condition affecting older people and has an impact on families, care givers and society. Commonly, family members are seen to be the care givers to support people with dementia and are usually untrained for this demanding role. The situation, of increasing numbers of those who suffer from dementia combined with an untrained social network to care for them, is rife for a technological intervention.

The etiology and disease stage of dementia patients can be characterized based on their cognitive, behavioral, motor, and functional symptoms [3]. Research supports the incorporation of technology with dementia patients because it plays a role in preventing their cognitive and physical decline. Technological intervention could further propose solutions to the challenges and barriers that limit care in dementia patients [4].

Various technological interventions have been introduced for functions such as of memory support, safety and security for the patient, training for both the caregiver and patient, care delivery, overall treatment, and social interaction [5]. However, barriers to technological treatment, such as privacy concerns, adaptation, and design choice, could result in a decline of the technology's effectiveness [6]. Assistive technologies for dementia patients vary in their design: for the occasional use of the patient, by the patient, or on the patient (e.g., caregivers) [7]. Technological interventions for dementia patients could provide quality care measures to accommodate daily needs.

Four reviews in the last six years were published. They recognize the rapidly developing world of intelligent assistive technologies (ATs), and attempted to compile comprehensive lists of such devices and their benefit [8–11]. Date ranges spanned 5–16 years, and the reviewers included studies of both dementia patients and their carers. However, none of these reviews identified the medical outcomes commensurate with the use of AT, which is a basic requirement for a systematic review [12].

1.2. Objectives

The purpose of this review is to compile a current and comprehensive list of facilitators and barriers to the adoption of, and medical outcomes commensurate with, the use of AT by PWD and their carers to perform activities of daily living independently. The results of this review should enable future studies to explore the modifications required for AT to support people with dementia while providing ease of use for the care givers.

2. Methods

2.1. Protocol and Registration

This review followed the Kruse protocol for conducting a systematic review published in 2019 [13], reported in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [14]. This review was registered with PROSPERO on 7 May 2020: PROSPERO ID CRD42020182167. In accordance PROSPERO rules, the registration was completed before analysis began.

2.2. Eligibility Criteria

Studies were eligible for this review if participants were diagnosed with dementia or they were care givers (carers) of those with dementia (regardless of stage, gender, race, ethnicity, or age), if the intervention was AT, if they were published in a quality, peer-reviewed journal in the English language in the last five years, and it they report either facilitators to adoption, barriers to adoption, or medical outcomes associated with the use of AT. Five years was chosen due to the rapidly advancing field of AT development. A quality assessment will be performed on each article using the Johns Hopkins Nursing Evidence-Based Practice Rating Scale (JHNEBP) [15]. Any study below IV C will be discarded.

2.3. Information Sources

Reviewers queried four databases: The Cumulative Index of Nursing and Allied Health Literature (CINAHL), PubMed (MEDLINE), Web of Science, and Embase (Science Direct). Databases were filtered

for the last five years. Database searches occurred between 1–15 February 2020. We expected to find advances in AT and greater level of adoption of AT due to both availability of these devices and the growing number of PWD. We hoped to find fewer barriers to the adoption of AT for PWD.

2.4. Search

Reviewers initially conducted a search on Google Scholar using general terms. When 10 articles were found on the subject, reviewers collected the key terms from these studies to help form a Boolean search string. Using the PubMed Medical Subject Headings (MeSH), reviewers used the terms gathered from the 10 articles to examine how they were indexed and categorized. Once a Boolean search string was assembled, it was tested out several times in PubMed and customized for maximum, most effective yield. The final search string was ("self-help devices" OR "selfhelp devices" OR "self help devices" OR "assistive technology" OR "telemonitoring" OR "tele-monitoring" telemedicine) AND (dementia OR "cognitive impairment"). We used this same search string for all databases. Reviewers filtered out other reviews and helped the database focus on academic or peer-reviewed journals over the last five years.

2.5. Study Selection

Following the Kruse protocol, reviewers conducted three consensus meetings [13]. The first was to select the group of studies to analyze. Once the search identified a large group to screen, the literature matrix manager downloaded the article details from each research database into an Excel literature matrix which served as the applied form from which to extract data. The group leader assigned workload to the group to ensure all abstracts would be screened by at least two reviewers. Reviewers read their assigned abstracts and screened them against the objective statement making a keep or discard recommendation on the shared spreadsheet. Once all abstracts were screened, the group met to discuss disagreements in recommendations. A final determination was made by the end of the meeting by the group leader, by asking another member of the group to read the abstract. A kappa statistic was calculated based on this process [16].

2.6. Data Collection Process

Once the final group of articles for analysis was identified, the group leader assigned workload to ensure all articles were analyzed by at least two reviewers. Reviewers used the applied form as the data extraction tool to collect Participants, Intervention, Comparison, Outcome, Study design (PICOS) and make general observations. Data items on this spreadsheet were published in the protocol [13]. Reviewers independently analyzed articles, extracting all standardized data items as well as general observations commensurate with the objective statement [13]. At consensus meeting 2, these observations were shared, and a narrative analysis was conducted [17]. The narrative analysis attempts to make sense of the observations. From the observations, common threads were identified. Being mindful of the common threads, or themes, reviewers carefully read their articles another time to flush out additional occurrences. Using the themes, reviewers examined interactions between facilitators, barriers, and medical outcomes to determine if some interventions were more consistently successful or problematic than others.

2.7. Data Items

The applied form collected the following data items: participants, AT intervention, study design, results compared to a control group (where applicable), facilitators and barriers to the use of AT, medical outcomes, sample size, bias within studies, effect size, country of origin, statistics used, a quality assessment from the JHNEBP, and general observations about the article that would help interpret the results [15].

2.8. Risk of Bias within and across Studies

General observations of bias are collected throughout the analysis phase. Bias is discussed in the second consensus meeting along with other observations. Key observations of bias, such as selection bias, are discussed because these could limit the external validity of the results. The JHNEBP was used to assess the risk and quality of each study analyzed. The cumulative evidence from the analysis (selective reporting, etc.) is discussed at the second consensus meeting. The JHNEBP is comprised of five levels for strength of evidence and three levels for quality of evidence. The strength of evidence for level 1 is an experimental study or RCT. Level 2 is strictly for quasi-experimental studies. Level 3 is for non-experimental, qualitative, or meta-synthesis studies. Level 4 is for opinion of nationally recognized experts based on research evidence or consensus panels. Level 5 is for opinions of experts that is not based on research evidence. The quality of evidence is listed as A (high), B (good), or C (low quality or major flaws). Each of these levels contain specifics for research, summative reviews, organizational, and expert opinion. For instance, research in level A must have consistent results with sufficient sample size, adequate control, and definitive conclusions. Research in level B must have reasonably consistent results, sufficient sample size, some control, and definitive conclusions. Research at level C has little evidence with inconsistent results, insufficient sample size, and conclusions that cannot be drawn from the data. Articles with a strength of evidence rating below Level 4 will be screened out. Quality of evidence below level B are highly suspect and must have full consensus of the group to be kept for analysis.

2.9. Summary Measures

The review analyzed studies with qualitative, quantitative, and mixed methods, so the summary measures sought were not consistent. The preferred summary statistic would be the risk ratio, but descriptive statistics and means' comparisons (student-*t*) are also sufficient. Summary statistics were discussed at the second consensus meeting.

2.10. Synthesis of Results

This subsection addresses a meta-analysis. This is a systematic review. This section is provided to assure reviewers that PRISMA had been followed. It will be deleted prior to publication, if accepted.

2.11. Additional Analysis

At the second consensus meeting, a narrative analysis will be performed to group observations into themes. These themes will be measured across all articles analyzed and reported in summary statistics in a series of affinity matrices. The narrative analysis summarized themes for facilitators, barriers, and medical outcomes. These will be reported in affinity matrices.

3. Results

3.1. Study Selection

The study selection process performed is illustrated in Figure 1. A kappa statistic was calculated after the first consensus meeting (k = 0.85), which indicates strong agreement [16,18]. After screening, removing duplicates, and assessing for eligibility, the 48 articles chosen for analysis came from CINAHL (16, 33%), Web of Science (16, 33%), PubMed (15, 31%), and Science Direct (1, 2%).

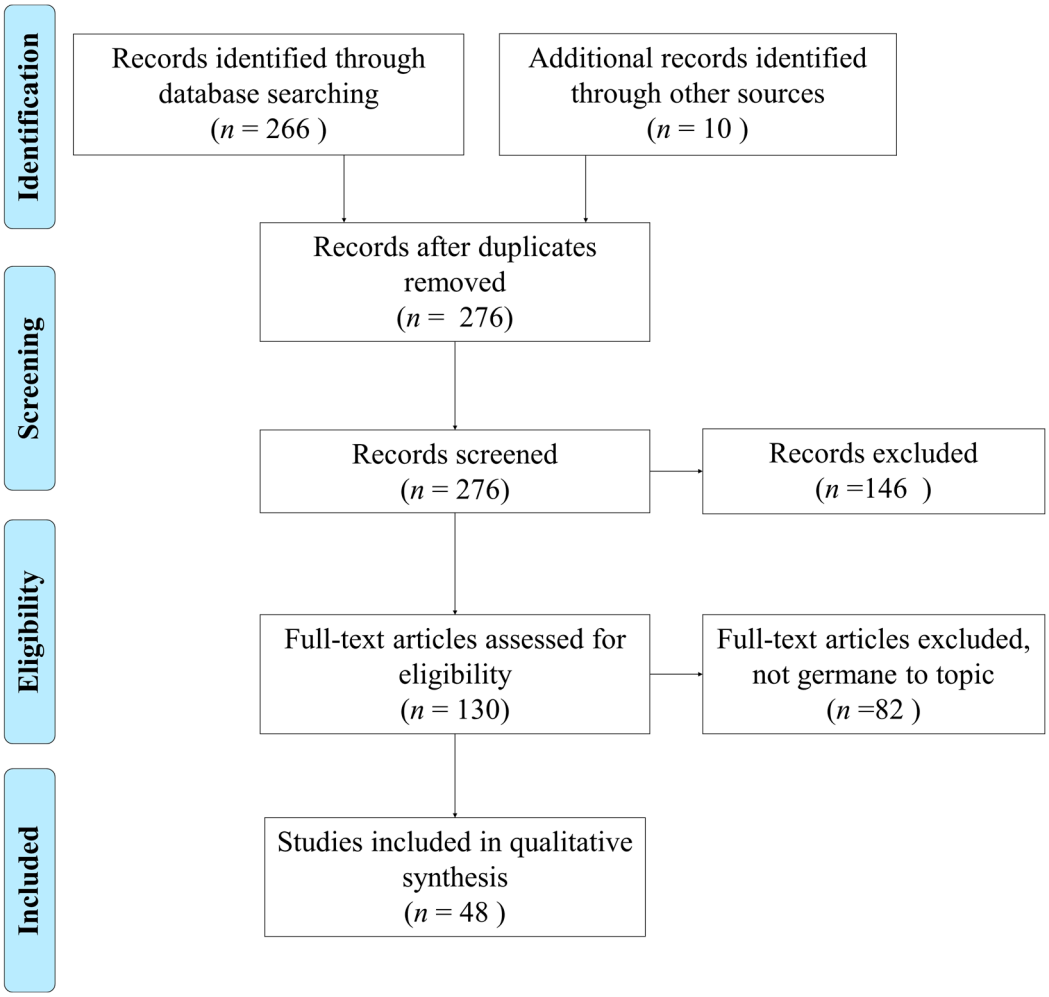

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram of the literature search and selection process.

3.2. Study Characteristics

Using the applied form, reviewers collected several standard items used for summary, such as PICOS. A PICOS table is provided in Table 1. Additional items were collected for analysis, such as forms of AT interventions, facilitators, and barriers to the use of assistive technologies, and the medical outcomes observed from those older adults using AT solutions [13]. These are presented in Table 2. Tables 1 and 2 lists articles in reverse chronological order: 2019 (4) [3,19–21], 2018 (12) [22–33], 2017 (14) [34–47], 2016 (11) [48–58], 2015 (7) [59–65].

Table 1. PICOS table.

Authors	Participants	Intervention	Results (Compared to Control Group)	Medical Outcomes Reported	Study Design
Cruz-Sandoval D. and Favela J. [19]	Older adults with dementia, ≥70, good diction and hearing	Socially assistive robots	No control group. The number of utterances increased when conversational strategies were used and PWD engaged in more sustained conversations. Participants enjoyed conversing with robots.	Increased number of utterances and sustained conversations	Single-subject research design (simple observational, without control group)
Thomas N.W.D., et al. [21]	One older adult with AD and his caregiver, ≥70	Telehealth home-based monitoring Ecological Valid, Ambient, Longitudinal and Unbiased Assessment of Treatment Efficacy in Alzheimer's Disease (EVALUATE-AD)	No control group. Very little effect on depression, but the intervention may have stabilized the burden of care.	Zero effect on depression	Observational case study
Kenigsberg P.A., et al. [3]	Experts, age, race, and gender not reported	Several ATs were explored: smart calendar clocks, social robots, auto lighting, computer, smartphone	No control group. Many ATs show positive health outcomes and increase safety and wellbeing of users and caregivers, but cost is a barrier to adoption	Reduced sensory loss, Reduced isolation, Improved cognitive abilities (memory, judgment, decision making),	Delphi study and survey
Czarnuch S., et al. [20]	Caregivers, 79% female, race not reported	Predictive model to predict survey results. Survey instrument addressed ATs and activities of daily living (ADLs).	No control group. The predictive model predicted 84% of responses (20 daily tasks × 5 response levels per task).	Not reported	Mixed methods
Billis A., et al. [23]	Older adults, 80% female	Interviews about ATs	No control group. Elderly participants exploit technology for several daily tasks such as checking bus schedules, watching online videos, and communicating with friends	Increase in autonomy	Qualitative
Lancioni G.E., et al. [27]	Study 1: 8 participants with mild to moderate stages of disease. Study 2: 9 participants with lower half of the moderate or severe level of Alzheimer's disease	Study 1—wireless Bluetooth earpiece linked to the tablet or smartphone. Study 2—walker with technology that provided stimulations and prompts	Patients started carrying out activities independently and accurately. They increased their ambulation levels and showed signs of positive involvement	Increase in ADLs	Quasi-experimental
Lancioni G.E., et al. [28]	Older adults with Alzheimer's Disease	Use of walker with AT	No control group. Participants showed an increase in indices of positive involvement during intervention sessions	Increase in step frequency	Qualitative Pilot Study
Olsson A., et al. [30]	Older adults with Alzheimer's Disease	Sensor technology with individually prerecorded voice reminders as memory support	No control group. Sensors increased a sense of security, independence, and self confidence	Increase in autonomy, Increased self confidence	Qualitative

Table 1. *Cont.*

Authors	Participants	Intervention	Results (Compared to Control Group)	Medical Outcomes Reported	Study Design
Nauha L., et al. [29]	Eight nurses from assisted living facility taking care of five test subjects, three female family caregivers in a real home environment in care of their husbands, one female test subject living alone, and several nurses took part in her care during day.	Supportive devices and alarm systems	Large variations in usefulness and usability of different AT. For example, a safety bracelet was very useful and easy to use compared to medical dispenser or a smart flower stand	Not reported	Experiment
Holthe T., et al. [25]	Adults with young-onset dementia (YOD) and their care givers	Interview to discuss experiences with AT	No control group. AT can be both a relief and a burden.	Increase in autonomy, Decreased stress	Qualitative
Wilz G., et al. [33]	Caregivers (80.6% female), and those with moderate and severe dementia (51.3% female), race not reported	Telephone therapy for caregivers	Improvement was observed across several domains	Improved emotional wellbeing, Fewer symptoms of depression, Fewer physical health symptoms, Improved coping, Improved behavior	RCT
Valdivieso B., et al. [32]	Elderly high-risk patients with multiple chronic conditions	Telephone-based telehealth which adds technology for remote self-management	Quality of life was significantly higher for the intervention group	Improved quality of life indicators	Quasi-experimental
Collins, M. [24]	Occupational therapy practitioners that use ATs on clients with Alzheimer's disease and related dementia	Interview	No control group. When using AT, occupational therapy practitioners must consider the stage of dementia their client is in, as well as the client's performance skills. Assistive technology is primarily used with the Alzheimer's disease and related dementia (ADRD) population to address safety concerns such as elopement, fall prevention, kitchen safety, and medical management.	Fewer medication errors, Fewer falls, elopement, and fewer kitchen safety incidents	Qualitative phenomenological approach
Asghar I., et al. [22]	People with dementia between the ages of 63 and 72 (mean = 68)	Interview	No control group. The AT producers should make user interface simpler and tailor future ATs to the specific requirements of the PWD	The use of technology in combination with balanced human care can yield better results for the wellbeing of the PWD; some participants used ATs for health monitoring purposes. These devices helped them to monitor their physical conditions like blood pressure, heartbeat rate, diabetes level, etc., on regular basis. This continuous health monitoring helped them to adapt a healthier lifestyle	Qualitative

Table 1. *Cont.*

Authors	Participants	Intervention	Results (Compared to Control Group)	Medical Outcomes Reported	Study Design
Jouvelot P., et al. [26]	Older adults, 79% female	Lovely User Interface for Servicing Elders	No control group. 13/14 were able to interact with the intervention	Increased autonomy	Non-experimental
Thoma-Lürken T., et al. [31]	Formal and informal caregivers and experts in the field of AT	Interview to gain insight into the most important practical problems preventing people with dementia from living at home	No control group. Problems within three domains were identified: informal caregiver/ social network-related problems, high load of care, safety-related problems, decreased self-reliance	Not reported	Qualitative study using six focus group interviews
Kouroupetroglou C., et al. [42]	People with dementia	MARIO robot	No control group. PWD who engaged in the above testing phase were accepting of MARIO and liked his appearance but the multimodal interaction combining verbal and visual cues was, in some cases, challenging	Not reported	Questionnaire (qualitative and quantitative)
Jiancaro T., et al. [40]	Developers (including technical, clinical, and other specialists) working in the design and/or evaluation of technologies for people with AD or related dementias	Exploratory survey with developers	No control group. To summarize, developers are encouraged to consider the following design recommendations for their own projects: Acknowledge the considerable degree of diversity amongst users with dementia, potentially adopting user centered design (USD) techniques, such as designing for "extraordinary users"; Recognize the important theoretical role that clinical specialists can fulfil concerning the use of design schemas; Stipulate precise usability criteria; Consider "learnability" and "self-confidence" as technology adoption criteria; Consider possible cost/adaptability tradeoffs during the design process; Encourage interdisciplinary communication via education and team engagement.	Not reported	Case-based survey (qualitative)
Jarvis F., et al. [39]	Occupational therapists	Survey on occupational therapists use and awareness of AT for PWD.	No control group. There is a limited understanding from occupational therapists about available interventions for PWD.	Not reported	Survey
Dethlefs N., et al. [36]	Elderly adults, 74% male, 10 with dementia	Natural language presentation (Wizard of Oz interface) of cognitive stimulation	No control group. Of the sorting activity, name-recall activity, quiz activity, and proverb activity, 83% reported enjoyment.	Not reported	Pilot study
Wang R.H., et al. [47]	Older adults and caregivers as dyads	Robots to assist in daily activities	Robots were well received by carers but resisted by PWDs.	Not reported	Qualitative analysis,

Table 1. *Cont.*

Authors	Participants	Intervention	Results (Compared to Control Group)	Medical Outcomes Reported	Study Design
Toots A., et al. [46]	People with dementia	Participants were randomized to the high-intensity functional exercise program or a seated attention control activity	In people with dementia living in nursing homes, exercise had positive effects on gait when tested unsupported compared with when walking aids or minimum support was used.	Improved gait	Cluster-randomized controlled trial
Bahar-Fuchs A., et al. [34]	45 older adults, >65, with mild cognitive impairment (n = 9), mood-related neuropsychiatric symptoms (n = 11) or both (n = 25)	eHealth Tailored and adaptive computer cognitive training in older adults at risk for dementia	Participants in both conditions reported greater satisfaction with their everyday memory following intervention and at follow-up. However, participants in the computerized cognitive training (CCT) condition showed greater improvement on composite measures of memory, learning, and global cognition at follow-up. Participants with Mood-related Neuropsychiatric Symptoms (MrNPS) in the CCT condition were also found to have improved mood at three-month follow-up and reported using fewer memory strategies at the post-intervention and follow-up assessments. There was no evidence that participants with MCI+ were disadvantaged relative to the other diagnostic conditions. Finally, informant-rated caregiver burden declined at follow-up assessment in the CCT condition relative to the AC condition.	Increase in memory, Increase in global cognition, Increase in learning, Increase in mood	RCT
Kiosses D.N., et al. [41]	Older adults with major depression, cognitive impairment (up to the level of moderate dementia)	Two home-delivered psycho-social treatments, Problem Adaptation Therapy (PATH) and Supportive Therapy for Cognitively Impaired Older Adults (ST-CI)	Montgomery Asberg's Depression Rating Scales' (MADRS) Negative Emotions scores were significantly associated with suicidal ideation during treatment	Improved negative emotions, significantly predicted reduction in suicidal ideation at follow-up interview	RCT comparing the efficacy of PATH versus ST-CI
Soilemezi D., et al. [44]	Carers of people with dementia	Interview with carers in their home	No control group. Aspects of the architectural and interior environment (e.g., size, condition, layout and accessibility, familiarity) are perceived as important as well as a plethora of environmental strategies that encourage independence and comfort at home	All the carers recommended the use of equipment to increased quality of life for both the carer and the person with dementia	Cross-sectional qualitative study analyzing experience of caregivers
Me R., et al. [43]	Adult caregivers for dementia pts, 55% female	Survey on caregivers to assess acceptability, wearability, setting suitability, usability, and general concept about wearables for navigation for those with dementia.	No control group. Survey responses showed high usability and acceptability of device, but positioning is problematic, and it is unlikely it would be worn for very long.	Not reported	Qualitative survey concerning wearables for navigation

Table 1. *Cont.*

Authors	Participants	Intervention	Results (Compared to Control Group)	Medical Outcomes Reported	Study Design
Lazarou I., et al. [56]	Adults with dementia	Home monitoring	No control group. Interventions included wearable, sleep, object motion, presence, and utility usage sensors. Positive effects on movement intensity, cognitive function, activities of daily living (ADLs), and behavior are attributed to early detection of problems, objective measurements, and direct guidelines from provider to patient.	Improvement in movement intensity, Improved cognitive function, Improved ADLs, Improved behavior	Case study
Purves B.A., et al. [64]	Dementia patients	Computer Interactive Reminiscence Conversation Aid (CIRCA)	No control group. The computer serves as an additional participant in the conversation.	Computer-mediated interactions enable greater engagement and more enjoyment than a traditional method of story capture.	Focus groups and pilot Study
Newton L., et al. [57]	General practitioners, Patients with dementia, carers	Survey instrument inquired about AT from providers, caregivers, and those with dementia	No control group. This study raised awareness of AT just by asking about it, and it helped care givers find information on AT	Not reported	Qualitative methods with semi-structured interview and thematic analysis
Egan K.J. and Pot A.M. [52]	People with dementia and care givers	Focus group to discuss AT	No control group. Assistive health technology is early in development; however, its promise to improve the lives of those with dementia and their caregivers is great.	Not reported	Qualitative, exploratory, focus groups
Wolters M.K., et al. [58]	Adults with dementia, family caregivers, older people without diagnosis of dementia	Intelligent cognitive assistant	No control group. Participants varied in the technology they owned, the technology they used, their sense of proficiency, and their attitudes towards technology. The speaking calendar was helpful.	Improvement to cognitive decline	Questionnaire in focus group
Gibson G., et al. [61]	People with dementia, carers	Semi-structured interviews on everyday use of AT	No control group. Three categories of AT were identified as most common: those accessed through social care services, those purchased "off-the-shelf", and "do-it-yourself"	Not reported	Semi-structured interview
Hattink B.J., et al. [53]	Dementia Care	Questionnaire on the intervention Rosetta, which was installed in the homes of patients.	All participants concluded that Rosetta is a very useful development in aiding dementia patients	Not reported	Controlled trials with pre- and post-test measures
Adolfsson P., et al. [48]	Twelve adults with cognitive disabilities and experience of using electronic planning devices (EPDs)	Electronic planning devices	No control group. Two themes emerged from the five categories: An increasing desire to participate and a need for necessary individual adaptation of the electronic daily planner (EPDs). The themes describe how the environment influences the use of EPDs.	Device enhanced their ability to concentrate and focus, resulting in less stress and forgetfulness	Interview and qualitative analysis

Table 1. *Cont.*

Authors	Participants	Intervention	Results (Compared to Control Group)	Medical Outcomes Reported	Study Design
Czarnuch S., and Mihailidis A. [51]	Older adults with dementia	Intelligent AT, random-decision forest (computer learning)	No control group. Precision and recall were 0.994 and 0.938 for the depth tracker compared to 0.981 and 0.822 for the color tracker with the current data, and 0.989 and 0.466 in the previous study.	Not reported	Non-experimental
Jupiter T. [55]	Older adults with dementia	Hearing AT	No control group. No differences were found on the Mini Mental Status Evaluation (MMSE) pre- to post-fitting. Self and Staff Nursing Home Hearing Handicap Index (NHHI) scores were similar.	Improve hearing	Pilot study, longitudinal time-series
Boger J., et al. [50]	Two engineers, two computer scientists, a human factors expert, a rehabilitation scientist, a statistician, two clinical research assistants and 27 older adult participants ranging from cognitively intact to advanced stages of dementia	Self-reporting by asking participants to rate how difficult they found using the tap to be through a verbally administered, single four-point Likert scale question	No control group.	Not reported	Two sub-studies: (1) determining usability factors and evaluating tap usability and (2) automating the analysis of tap use
Jawaid S., and McCrindle R. [54]	Elderly adults	Computerized Help Information and Interaction Project (CHIIPS) program	No control group. Participants found CHIIPS to be useful, especially for people with age related memory loss or mild dementia	Not reported	Qualitative (questionnaire) collected opinions on the usefulness of the application
Fardoun H.M., et al. [37]	People with dementia	Analyzing pictures taken by a smart watch, which the patient carries; the person in front is recognized and information about him is sent to the watch.	No control group. Prototype showed correct results as a personal information system based on face recognition. However, usability flaws were identified in the interaction with the smart watch	Not reported	Qualitative, exploratory
Kerssens C., et al. [62]	Older adults and caregivers as dyads	The Companion (touch screen technology) that delivers non-drug, psychosocial intervention	No control group. Technology was easy to use, significantly facilitated meaningful and positive engagement, and simplified caregivers' daily lives	Made their daily lives easier and made helping their spouse easier	Interview, implementation study
Arntzen C., et al. [49]	Young People (under 65) Living with Dementia	Incorporation of AT into everyday life for young people with dementia	No control group. AT are being negotiated and transformed by active embodied and situated social subjects in their everyday life	Not reported	Qualitative longitudinal study
Woodberry E., et al. [65]	Alzheimer's patients	Wearable camera to improve memory	No control group. SenseCam outperformed the diary method for 5/6 people in the study	Help patients recall past events	Longitudinal design

Table 1. *Cont.*

Authors	Participants	Intervention	Results (Compared to Control Group)	Medical Outcomes Reported	Study Design
Corbett A., et al. [60]	Eligible participants were older than the age of 50, and had access to a computer and the Internet	Compared evidence-based reasoning and problem-solving cognitive training (ReaCT), general cognitive training (GCT), and a control treatment	Online cognitive training (CT) confers significant benefit to cognition and function in older adults, with benefit favoring the Reasoning package. Scale of benefit is comparable with in-person training, indicating its potential as a public health intervention	Significant benefit to activities of daily living in a group of adults older than 60 receiving both the online GCT and ReaCT interventions compared with control, over a period of six months	Double-blind six-month online randomized controlled trial
Adolfsson P., et al. [59]	People with psychiatric or neuropsychiatric disorders (the respondents had to be ≥18 years old, had to have at least two months experience in using an EPD and have regular contact with a prescriber)	Interviewed with support from a study specific guide to explore the subjective experiences of people with cognitive disabilities in relation to the use of EPDs	No control group. EPDs can help people with cognitive disabilities not only in planning but also in organization and managing time	Use of EPDs seems to reduce the gap between the challenges the respondents encounter in everyday life and their cognitive disability; increased autonomy	Qualitative content analysis
Mao H., et al. [63]	The study consisted of caregivers perceptions of the usefulness of AT devices and Expert agreement on the common indicators of AT devices	Questionnaires to determine high perceived usefulness vs low perceived usefulness	No control group. The results suggested that caregivers preferred technologies that prevented accidents over technologies that informed them of the occurrence of an accident or that only managed the consequences.	There were no medical outcomes, the study was done to view the caregivers' perception on the usefulness of AT devices	Qualitative (questionnaire)

Table 2. Summary of evidence.

Authors	Intervention Theme	Medical Outcomes Themes	Facilitator Themes	Barrier Themes
Cruz-Sandoval D. and Favela J. [19]	Social robots	Increased talking Increased talking	Not reported	Not reported
Thomas N.W.D., et al. [21]	Telehealth	No effect on depression	AT are invisible to users No personal interface necessary	Not reported
Kenigsberg P.A., et al. [3]	Interview	Reduced sensory loss Improved coping Improved cognitive abilities	Increased safety Increased wellbeing Increased independence	Cost Users forget how to use them Complex interfaces Liability concerns
Czarnuch S., et al. [20]	Predictive model	Not reported	Not reported	Cost
Billis A., et al. [23]	Interview	Increased autonomy	Continuous training	Complex interfaces Users forget how to use them PWD do not want AT Ethical concerns Technical literacy
Lancioni G.E., et al. [27]	Mixed interventions	Increased ADLs	Not reported	Not reported
Lancioni G.E., et al. [28]	Walker with technology	Increased step frequency	Increased involvement	Not reported
Olsson A., et al. [30]	Sensors with voice	Increased autonomy	Increased safety Increased independence	Complex interfaces Poor sound quality
			Increased self-confidence Increased mindfulness	Limitations of device
Nauha L., et al. [29]	Interview	Not reported	Not reported	Development must improve capabilities Complex interfaces Poor sound quality
Holthe T., et al. [25]	Interview	Increased autonomy Decreased stress	Increased safety Simple interfaces Visual reminders Auditory reminders	Degenerative nature of AD complicates timing of AT used Development must improve capabilities Needs more government involvement Complex interfaces

Table 2. *Cont.*

Authors	Intervention Theme	Medical Outcomes Themes	Facilitator Themes	Barrier Themes
Wilz G., et al. [33]	Telephone	Improved mood Improved depression Improved overall health Improved coping Improved behavior	Not reported	Not reported
Valdivieso B., et al. [32]	Telephone	Increased ADLs	Not reported	Not reported
Collins, M. [24]	Interview	Fewer medication errors Fewer falls Improved behavior	Continuous training Remote monitoring Visual reminders	Degenerative nature of AD complicates timing of AT used PWD do not want AT
Asghar I., et al. [22]	Interview	Improved overall health	Increased communication Increased involvement Visual reminders	PWD do not want AT Font size Limitations of device
Jouvelot P., et al. [26]	Cognitive stimulation	Increased autonomy	Visual reminders Remote monitoring	Development must improve capabilities
Thoma-Lürken T., et al. [31]	Interview	Not reported	Not reported	Safety
Kouroupetroglou C., et al. [42]	Social robots	Not reported	Increased communication	Degenerative nature of AD complicates timing of AT used Development must improve capabilities
Jiancaro T., et al. [40]	Mixed interventions	Not reported	Increased independence	Degenerative nature of AD complicates timing of AT used Cost
Jarvis F., et al. [39]	Interview	Not reported	Simple interfaces	Lack of awareness of availability of AT
Dethlefs N., et al. [36]	Cognitive stimulation	Not reported	Caregivers want AT	Degenerative nature of AD complicates timing of AT used
Wang R.H., et al. [47]	Social robots	Not reported	Caregivers want AT	PWD do not want AT Could decrease interaction with caregiver
Toots A., et al. [46]	Walker with technology	Increased step frequency	Increased independence	AT could mask changes in gait over time
Bahar-Fuchs A., et al. [34]	eHealth	Improved memory Improved cognitive abilities Improved mood Improved memory	Not reported	Not reported

Table 2. *Cont.*

Authors	Intervention Theme	Medical Outcomes Themes	Facilitator Themes	Barrier Themes
Kiosses D.N., et al. [41]	Telehealth	Improved mood Improved depression	Increased safety	Not reported
Soilemezi D., et al. [44]	Interview	Increased ADLs	Caregivers want AT	Not reported
Me R., et al. [43]	Interview	Not reported	Caregivers want AT	Development must improve capabilities
Teunissen L., et al. [45]	eHealth	Not reported	Increased communication	Degenerative nature of AD complicates timing of AT used
Darragh M., et al. [35]	Social robots	Improved overall health	Increased safety	Cost
Fardoun H.M., et al. [37]	Cognitive stimulation	Not reported	Increased wellbeing	Font size
Garzon-Maldonado G., et al. [38]	Telephone	Not reported	Cost benefits Caregivers want AT	Not reported
Lazarou I., et al. [56]	Tele-monitoring	Improved cognitive abilities Improved behavior Increased ADLs	Not reported	Not reported
Newton L., et al. [57]	Interview	Not reported	Increased safety	Not reported
Egan K.J. and Pot A.M. [52]	Focus group	Not reported	Not reported	Users forget how to use them Needs more government involvement Cost Cost Degenerative nature of AD complicates timing of AT used
Wolters M.K., et al. [58]	Cognitive stimulation	Improved cognitive abilities	Auditory reminders	Not reported
Gibson G., et al. [61]	Interview	Not reported	Can be provided by government	Could decrease interaction with caregiver Cost
Hattink B.J., et al. [53]	Interview	Not reported	Increased independence	Development must improve capabilities
Adolfsson P., et al. [48]	Electronic planners	Decreased stress Improved memory	Increased self-confidence Increased mindfulness	Development must improve capabilities

Table 2. *Cont.*

Authors	Intervention Theme	Medical Outcomes Themes	Facilitator Themes	Barrier Themes
Czarnuch S., and Mihailidis A. [51]	Cognitive stimulation	Not reported	Increased independence	Complex interfaces
Jupiter T. [55]	Hearing AT	Improved overall health	Increased mindfulness	PWD do not want AT
Boger J., et al. [50]	Interview	Not reported	Simple interfaces	Not reported
Jawaid S., and McCrindle R. [54]	Cognitive stimulation	Not reported	Cost benefits Simple interfaces	Not reported
Arntzen C., et al. [49]	Interview	Not reported	Increased wellbeing	Not reported
Kerssens C., et al. [62]	Social robots	Improved coping	Increased wellbeing	PWD do not want AT
Purves B.A., et al. [64]	eHealth	Improved mood	Increased communication	Not reported
Woodberry E., et al. [65]	Cognitive stimulation	Improved memory	Increased self-confidence	PWD do not want AT
Corbett A., et al. [60]	Cognitive stimulation	Increased ADLs Improved cognitive abilities	Not reported	Not reported
Adolfsson P., et al. [59]	Interview	Improved cognitive abilities Increased autonomy	Increased independence Increased wellbeing	Not reported
Mao H., et al. [63]	Interview	Not reported	Caregivers want AT	PWD do not want AT

3.3. Risk of Bias within Studies

Reviewers recorded observations of bias at the study level. The most common form of bias was selection bias. Examples of selection bias were all: participants had experience with technology [23], same site [25,28,30,34], or a disproportionately large sample that was male [22,30,36]. These examples of bias limit the external validity of the results.

3.4. Results of Individual Studies

Reviewers collected their observations of intervention and medical outcomes during the analysis phase. The narrative analysis of their observations identified themes. A summary of these themes is listed in Table 1. Repetition in the frame of a theme is due to multiple observations from the same article for that theme. For instance, the theme *increased talking* comprised observations of "increased utterances" and "increased sustained conversations" [19]. A translation from observations to themes for interventions, medical outcomes, facilitators, and barriers us listed in Tables A1–A3. Reviewers collected the standard PICOS fields and included them in Table 1. Additional data collected is displayed in Tables A4 and A5: bias, statistics, country of origin, and quality assessments.

3.5. Synthesis of Results

This subsection addresses meta-analyses. This is a systematic review. This section will be deleted after the review process. It is included to reassure reviewers that we followed the PRISMA checklist.

3.6. Risk of Bias across Studies

Table 3 summarizes the quality indicators identified by the JHNEBP tool [15]. The most prevalent assessment in the strength of evidence (panel a) was level III, followed by I, II, and IV. For quality of evidence (panel b), the most frequently assessed level was level B, followed by A. It is certainly preferable for the strength of evidence to be closer to level I, but that has not resulted from the screening and selection process. This limitation will be addressed later.

Table 3. Summary of quality assessments.

Strength of Evidence	Frequency of Occurrence	Quality of Evidence	Frequency of Occurrence
III (Non-experimental, qualitative)	31 (65%)	B (Good quality)	39 (81%)
I (Experimental study or RCT)	7 (15%)	A (High quality)	9 (19%)
II (Quasi-experimental)	5 (10%)	C (Low quality or major flaws)	0 (0%)
IV (Opinion)	5 (10%)		
a		b	

3.7. Additional Analysis

3.7.1. Interventions of AT

Consensus meeting three identified eight themes and six individual observations that corresponded with AT for PWD. These are listed in Table 4. In the interest of brevity, only the first 60% will be listed. The intervention most often noted was an interview [3,22–25,29,31,39,43,44,49,57,59,61,63,65]. Researchers interviewed users of AT (PWD and carers) in 16/48 studies (33%). Three of these studies originated in the United Kingdom, two from Norway, two from the Netherlands, and the rest were from single originations: Greece, United States, Pakistan, Finland, Australia, United Kingdom/Italy/Malaysia, Canada, Sweden, and Taiwan. The theme cognitive stimulation (natural language presentation through a Wizard-of-Oz presentation, intelligent cognitive assistant, computerized help information and interaction project, wearable cameras, and evidence-based reasoning and problem solving training) occurred in 9/48 studies (19%) [26,36,37,51,53,54,58,60,65]. Four of these studies originated from

the United Kingdom, while the rest were from single originations: France, Scotland, Saudi Arabia, Canada, and Netherlands/Germany/Belgium. Socially assistive robots (artificial intelligence system designed to interact with humans and other robots) were identified in 5/48 studies (10%) [19,35,42,47,62]. These studies all came from single originations: Mexico, Italy/Ireland, Canada, New Zealand, and the United States.

Table 4. Affinity matrix of ATs.

Intervention	References	Occurrences *n* = (48)	Frequency
Interview	[3,22–25,29,31,39,43,44,49,57,59,61,63,65]	16	33%
Cognitive stimulation	[26,36,37,51,53,54,58,60,65]	9	19%
Social robots	[19,35,42,47,62]	5	10%
Telephone	[32,33,38]	3 *	6%
eHealth	[34,45,64]	3	6%
Walker with technology	[28,46]	2	4%
Telehealth	[21,41]	2	4%
Mixed interventions	[27,40]	2	4%
Tele-monitoring	[56]	1	2%
Predictive model	[20]	1	2%
Electronic planners	[48]	1	2%
Focus group	[52]	1	2%
Sensors with voice	[30]	1	2%
Hearing AT	[55]	1	2%

* Multiple occurrences in one study.

3.7.2. Facilitators to the Adoption of AT

Fourteen themes and three individual observations were identified as facilitators to the adoption of AT for PWD. These are listed in Table 5. In the interest of brevity, only the top 40% most frequently observed will be reported (other than those not reported). The theme *caregivers want* AT (AT more ethical than physical barriers, users are open-minded to robotic assistance and sensors, usefulness is high, AT enables PWD to live at home more safely) occurred in 8/68 occurrences (12%) [36,38,39,43,44,47,53,63]. These studies all came from single originations: Australia, Scotland, Canada, United Kingdom, United Kingdom/Italy/Malaysia, Spain, Netherlands, Germany/Belgium, and Taiwan. The theme *increased independence* (keeps PWD home longer, helps structure everyday events) occurred in 7/68 occurrences (10%) [3,30,40,46,51,53,59]. Three of these studies originated from Sweden, and two were from Canada, while the rest were from single originations: Netherlands, Netherlands/Germany/Belgium. The theme *increased safety* (increases a sense of security, increases safety) occurred in 6/68 occurrences (9%) [3,25,30,35,41,57]. These studies all came from single originations: Netherlands, Sweden, Norway, United States, New Zealand, and United Kingdom.

Table 5. Affinity matrix of facilitators to the use of ATs.

Facilitators	References	Occurrences *n* = (68)	Frequency
Not reported	[19,20,27,29,31–34,52,56,60]	11	16%
Caregivers want AT	[36,38,39,43,44,47,53,63]	8	12%
Increased independence	[3,30,40,46,51,53,59]	7	10%
Increased safety	[3,25,30,35,41,57]	6	9%
Increased wellbeing	[3,37,49,59,62]	5	7%
Increased communication	[22,42,45,64]	4	6%
Simple interfaces	[25,39,50,54]	4	6%
Visual reminders	[22,24–26]	4	6%
Increased self-confidence	[30,48,65]	3	4%
Increased mindfulness	[30,48,55]	3	4%
Remote monitoring	[24,26]	2	3%
Continuous training	[23,24]	2	3%

Table 5. *Cont.*

Facilitators	References	Occurrences *n* = (68)	Frequency
Cost benefits	[38,54]	2	3%
Increased involvement	[22,28]	2	3%
Auditory reminders	[25,58]	2	3%
AT are invisible to users	[21]	1	1%
No personal interface necessary	[21]	1	1%
Can be provided by government	[61]	1	1%

3.7.3. Barriers to the Adoption of AT

Eleven themes and six individual observations were identified as barriers to the adoption of AT for PWD. These are listed in Table 6. In the interest of brevity, only the first 50% of the most frequently observed occurrences will be reported (other than those not reported). The theme of cost was identified in 8/75 occurrences (11%) [3,20,35,39,40,52,61]. Two of these studies came from Canada while the rest were from single originations: Netherlands, Australia, New Zealand, Switzerland, and the United Kingdom. The theme PWD *do not want AT* (PWD reject AT, users do not want a robot, users immediately returned the device, devices are unfamiliar, and participants feel targeted and embarrassed) occurred in 8/75 occurrences (11%) [22–24,47,55,62]. Three of these studies originated from the United States, while the others were from single originations: Greece, Canada, Pakistan, Taiwan, and the United Kingdom. The theme *complex interfaces* (pushing buttons does not always yield the desired result, system was perceived to be complex, complex setup) occurred in 7/75 occurrences (9%) [3,23,25,29,30,51,53]. These studies all came from single originations: Netherlands, Greece, Sweden, Finland, Norway, Canada, Netherlands/Germany/Belgium. The theme *development must improve capabilities* (false alarms, would only be worn for a few hours due to weight, technical problems, difficult to understand) occurred in 7/75 occurrences (9%) [25,26,29,42,43,48,53]. The theme *degenerative nature of dementia complicates the timing of* AT used (timing is important – before it is too late, dementia's progressive nature makes useless today AT that may have been helpful only a short while ago, client's reduced cognitive and physical abilities greatly reduces the effectiveness of AT more each day) occurred in 7/75 occurrences (9%) [24,25,36,40,42,45,52]. These studies occurred in single originations: Norway, United States, Italy/Ireland, Canada, Scotland, Netherlands, and Switzerland.

Table 6. Affinity matrix of barriers to the use of ATs.

Barriers	References	Occurrences *n* = (75)	Frequency
Not reported	[19,21,27,28,32,34,38,41,44,49,50,54,56–60,64]	19	25%
Cost	[3,20,35,39,40,52,61]	8 *	11%
PWD do not want AT	[22–24,47,55,62]	8 *	11%
Complex interfaces	[3,23,25,29,30,51,53]	7	9%
Development must improve capabilities	[25,26,29,42,43,48,53]	7	9%
Degenerative nature of AD complicates timing of AT used	[24,25,36,40,42,45,52]	7	9%
Users forget how to use them	[3,23,52]	3	4%
Could decrease interaction with caregiver	[47,61]	2	3%
Font size	[22,37]	2	3%
Poor sound quality	[29,30]	2	3%
Limitations of device	[22,30]	2	3%
Needs more government involvement	[25,52]	2	3%
AT could mask changes in gait over time	[46]	1	1%
Liability concerns	[3]	1	1%
Lack of awareness of availability of AT	[39]	1	1%
Safety	[31]	1	1%
Ethical concerns	[23]	1	1%
Technical literacy	[23]	1	1%

* Multiple occurrences in one study.

3.7.4. Medical Outcomes Commensurate with the Adoption of AT

Twelve themes and four individual observations of medical outcomes were recorded commensurate with the adoption of AT. These are listed in Table 7. In the interest of brevity, only the first 40% will be reported. The theme of *improved cognitive abilities* (reduced sensory loss, increased global cognition, decreased cognitive decline) occurred in 6/69 occurrences (9%) [3,34,56,58–60]. Two of these studies originated from the United Kingdom, while the others came from the Netherlands, Australia, Greece, and Sweden. The theme of *increased* ADLs occurred in 5/69 occurrences (7%) [27,32,44,56,60]. Two of these studies originated from the United Kingdom, while the others came from the United States, Spain, and Greece. The theme of *increased autonomy* occurred in 5/69 occurrences (7%) [23,25,26,30,59]. Two of these studies originated from Sweden, while the others came from Greece, Norway, and France. The theme of *improved memory* (helps patients recall past events) occurred in 4/69 occurrences (6%) [34,48,65]. These studies originated from Australia, Sweden, and the United Kingdom. The theme of *improved overall health* (improved emotional health, improved psychological wellbeing, improved hearing, better tracking of health monitoring through AT) occurred in 4/69 occurrences (6%) [22,33,35,55]. These studies originated from Germany, Pakistan, New Zealand, and the United States. The theme of *improved mood* (improved emotional wellbeing, improved negative emotions, enabled greater enjoyment) occurred in 4/69 occurrences (6%) [33,34,41,64]. These studies originated from Germany, Australia, British Columbia, and the United States.

Table 7. Affinity matrix of medical outcomes commensurate with the use of ATs.

Medical Outcomes	References	Occurrences *n* = (69)	Frequency
Not reported	[20,29,31,36–40,42,43,45,47,49–54,57,61,63]	23 *	33%
Improved cognitive abilities	[3,34,56,58–60]	6	9%
Increased ADLs	[27,32,44,56,60]	5	7%
Increased autonomy	[23,25,26,30,59]	5	7%
Improved memory	[34,48,65]	4 *	6%
Improved overall health	[22,33,35,55]	4	6%
Improved mood	[33,34,41,64]	4	6%
Improved behavior	[24,33,56]	3	4%
Improved coping	[3,33,62]	3	4%
Improved depression	[33,41]	2	3%
Increased step frequency	[28,46]	2	3%
Decreased stress	[25,48]	2	3%
Increased talking	[19]	2 *	3%
No effect on depression	[21]	1	1%
Reduced sensory loss	[3]	1	1%
Fewer medication errors	[24]	1	1%
Fewer falls	[24]	1	1%

* Multiple occurrences in one study.

3.8. Interactions between Observations

The intervention of eHealth resulted in two instances of increased communication [45,64]. The intervention of cognitive stimulation resulted in two instances of increased independence [51,53]. When researchers interviewed users of AT, there were two instances of PWD do not want AT [22,63] and two instances of increased autonomy [23,25]. The intervention of social robots resulted in two instances of PWD do not want AT [47,62].

4. Discussion

4.1. Summary of Evidence

Fourteen interventions of AT in 48 studies revealed 17 facilitators, 17 barriers, and 16 positive or neutral medical outcomes. The two most frequently mentioned AT were cognitive stimulators (9/48, 19%) and social robots (5/48, 10%). The two most frequently mentioned facilitators were caregivers want AT (8/68, 12%) and enables increased independence (7/68, 10%). The top two barriers were *cost* (8/75, 11%) and PWD do not want AT (8/75, 11%). The top medical outcomes were improved cognitive abilities (6/69, 9%), increased ADLs, and increased autonomy (each at 5/69, 7%): Zero negative outcomes were reported. Interactions of note occurred with interventions of eHealth and cognitive stimulation, which resulted in multiple observations of increased communication and increased independence, respectively.

Two interesting dichotomies were observed. One study noted no effect in depression, while others noted improved depression [33,41], behavior [24,33,56], mood [33,34,41,64], coping [3,33,62], and decreased stress [25,48]. Also, caregivers want AT [36,38,39,43,44,47,53,63], while PWD do not want AT [22–24,47,55,62]. Caregivers feel a sense of relief knowing sensors are in place, and they feel these sensors are more ethical than using physical barriers to prevent elopement, but the complex and foreign nature of the sensors coupled with false alarms cause PWD to reject the same devices that increase their sense of autonomy [23,25,26,30,59].

The observations that AT needs additional development to improve interfaces, reduce false alarms, and improve functionality of devices was no surprise. The challenging aspect to development is seen in the observation that the degenerative nature of AD complicates the timing of AT used. Even the ideal interface, that has been proven effective for a PWD for months, may be obsolete one specific morning due to the degenerative nature of AD, because the PWD may forget how to use it [3,23,52]. Developers might consider AT with phases of simplicity of operation (which might result in reduced capabilities) so that the AT can advance along with the PWD.

Health policy makers should consider augmenting AT development through grants or subsidies. As the aging of society progresses, so will the prevalence of PWD [2]. Development of AT for PWD should be a priority. This corresponds with the theme needs more government involvement.

Social services workers should keep a list of ATs available to PWD at different stages of AD. Caregivers, often spouses or close family, are already experiencing high levels of stress and concern. A general lack of awareness was observed in one study [39]. The combination of more government involvement and funded development should enable such lists to be readily available and regularly updated.

Caregivers should know that AT exists for PWD, and that they are not alone in the struggle to care for their loved ones while also maintaining their own life. AT currently exists, and it improves the quality of life for both PWD and the caregivers [27,32,44,56,60]. The research strongly supports a desire by caregivers for AT. Although a barrier was observed of complex interfaces, several other studies noted the existence AT with simple interfaces with visual and auditory reminders and constant training to control for forgetfulness. Some AT can be provided by the government as part of national health plans.

The findings of this review are commensurate with the other four reviews from the previous six years [8–11]. The AT reviewed is similar to each of these articles [8]. The decline in memory and cognition is common [9]. One semantic difference is that one review called AT intelligent ATs, and this same review provides an extensive index of AT for clinicians and other stakeholders involved in the management of PWD [10].

The findings in this review are also commensurate with four others from the last year, and the AT reviewed are similar [66–70]. AT interventions can be beneficial to quality of life, social interaction, reducing neuropsychiatric symptoms such as depression, anxiety, and agitation, but continued use of AT becomes problematic due to the progressive nature of dementia [69,70]. Both carers and PWD

shared observations on aspects of AT such as ease of use, stability and flexibility of technology, and the importance of privacy and confidentiality [67,68]. One finding that was not in this review was an improvement in pain management, as was found in a review from 2019 [69].

Future research in this area should examine the ethical concerns surrounding AT. If AT yields so many positive medical outcomes, and it is strongly desired by caregivers, why is it also rejected by PWD? Is AT perceived as an annoyance or a bother? Do some view AT as a constraint on liberty? The literature supports the use of AT. It is important for the subject of AT to perceive its value and willingly accept it.

4.2. Limitations

The researchers reviewed papers published between 2015 with 2020 and did not include studies outside this period. One limitation is publication bias for five years. Including some grey literature could have controlled for this limitation. We limited our review to four databases, CINAHL, PubMed, Web of Science, and Science Direct. The intent of including four databases was to mitigate the risk of selection bias. The limitation is that we did not include other databases that might have yielded other articles for consideration.

A team of reviewers determined the articles to be included in the study. This was also done to mitigate the risk of selection bias. The risk of this practice, however, is that the team may have differed in their selection processes. To mitigate this risk, researchers held consensus meetings, identified the research objective, and received multiple reviews for each article. The limitation is that there may not have been enough consensus meetings. The kappa statistic shows the consensus meetings were effective, but a stronger level of agreement is possible.

The assessment of both strength of evidence and quality of evidence was not as high as preferred. The most common strength of evidence was III, while the preference would have been for more level I. To control for this limitation in the future, additional years could have been considered so that more experimental studies or RCTs could have been included in the analysis.

5. Conclusions

The research supports the use of AT with PWD, and many positive or neutral medical outcomes are associated with this practice. This review presents facilitators and barriers associated with the use of AT by PWD, and it presents medical outcomes commensurate with this intervention. It is consistent with other reviews on the same or similar topics. Policy makers and carers should focus on the enablers listed in this review and work to eliminate the barriers to the adoption of AT. Such practice would help policy makers enable additional PWDs and carers to experience the positive aspects of this intervention, for as long as the progressive nature of dementia will allow. Particular focus should be given to helping PWD accept AT based on the positive aspects of their use.

Author Contributions: G.U. was the visualization coordinator and project administrator, who facilitated the project schedule, consensus meetings, milestones, and Figure 1. G.U. analyzed 1/3 of the articles. S.P. was in charge of the literature matrix and tables, and she analyzed 1/3 of articles. K.P. was the editor, to ensure a consistent voice throughout the review, and she analyzed 1/3 of articles. J.F. helped conceptualize the project and analyzed 1/2 of the articles. C.S.K. designed the review, analyzed all articles, and served as senior editor for the project. All authors have read and agreed to the published version of the manuscript.

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Abbreviations

ADL	activity of daily living
ADRD	Alzheimer's disease and related dementia
AMSTAR	assessment of multiple systematic reviews
AT	Assistive Technology
CCT	Computerized Cognitive Training
CT	Cognitive Training
CDN	COGKNOW Day Navigator
CINAHL	Cumulative Index of Nursing and Allied Health Literature
CRDL	(not English) Interactive instrument, developed to stimulate communication between users through sound and touch
EPD	Electronic Planning Device
GCT	General Cognitive Training
ICA	Intelligent cognitive assistants
JHNEBP	Johns Hopkins Nursing Evidence-Based Practice rating scale
MADRS	Montgomery Asberg's Depression Rating Scales'
MARIO	Not an abbreviation—just the name of a social robot
MCI	Mild Cognitive Impairment
MeSH	Medical Subject Heading
MMSE	Mini Mental Status Evaluation
MrNPS	Mood-related Neuropsychiatric Symptoms
NHHI	Nursing Home Hearing Handicap Index
PICOS	Participants, Intervention, Comparison (results), Outcomes, Study design
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PWD	People with dementia
ReaCT	Reasoning and Problem-Solving Cognitive Training
ST-CI	Supportive Therapy for Cognitively Impaired Older Adults
UCD	User Centered Design

Key Terms

Dementia	A progressive, irreversible decline in mental function
AT Device	AT device is defined as any item, piece of equipment, or product system whether acquired off the shelf, modified or customized that is used to increase, maintain, or improve functional capabilities of individuals with disabilities.
Caregivers or Carers	A caregiver is someone, typically over age 18, who provides care for another. It may be a person who is responsible for the direct care, protection, and supervision of children in a childcare home, or someone who tends to the needs of the elderly or disabled. It is generally one who assists another person who is no longer able to perform the critical tasks of personal or household care necessary for everyday survival.

Appendix A

Table A1. Map of Observations for Facilitators to Facilitator Themes.

Authors	Facilitators	Facilitator Themes
Cruz-Sandoval D. and Favela J.	Not reported	Not reported
Thomas N.W.D., et al.	Invisible to participant, No interaction with monitoring device necessary	AT are invisible to users No personal interface necessary
Kenigsberg P.A., et al.	Increases safety, Increased wellbeing, Increased independence	Increased safety Increased wellbeing Increased independence
Czarnuch S., et al.	Not reported	Not reported
Billis A., et al.	continuous training on an individual learning pace	Continuous training
Lancioni G.E., et al.	Not reported	Not reported
Lancioni G.E., et al.	Increased involvement	Increased involvement
Olsson A., et al.	Increases sense of security, Increased independence, Increased self-confidence; Increased mindfulness of medication	Increased safety Increased independence Increased self-confidence Increased mindfulness
Nauha L., et al.	Not reported	Not reported
Holthe T., et al.	Safety & security, Simple interfaces, Visual reminders, Auditive reminders	Increased safety Simple interfaces Visual reminders Auditory reminders
Wilz G., et al.	Not reported	Not reported
Valdivieso B., et al.	Not reported	Not reported
Collins, M.	1. Caregiver education: educating the client's family often allowed for more success than educating the client alone due to cognitive or physical impairments (e.g., the client may not remember the education being provided). 2. Providing repeated demonstration and opportunities to practice with the AT for carryover. 3. Having caregivers and family members practice with the equipment was also seen as beneficial to ensure proper and correct usage. 4. Door locks and alarms to protect patients from elopement. 5. Chair alarms, pull cord alarms, and floor alarms can be used to alert caregivers when a client is trying to get up. 6. Medication dispenser to aid in taking correct type and amt of medication.	Continuous training Remote monitoring Visual reminders

Table A1. *Cont.*

Authors	Facilitators	Facilitator Themes
Asghar I., et al.	The happy users termed facilitated communication, travel and timely medication and activities support as major contributions of AT support in their lives; the ATs such as software applications and communication websites helped them to stay connected to their loved ones. At the same time, these ATs also support leisure activities like cognitive games and paintings, pictures as memories etc.; the reminders ATs helped the PWD family members and caregivers to set reminders for the specified times to perform important tasks.	Increased communication Increased involvement Visual reminders
Jouvelot P., et al.	Enables pill dispensing, blood pressure measurement, water self-serving.	Visual reminders Remote monitoring
Thoma-Lürken T., et al.	Not reported	Not reported
Kouroupetroglou C., et al.	Speech can still be used from the robot to trigger responses from PWD by using longer pauses and shorter sentences	Increased communication
Jiancaro T., et al.	On Design Approaches, user/human-centered design (UCD/HCD) was "always" recommended, followed closely by participatory design; more than 95% of respondents rated usability as important or higher; cost was also rated as "very important" overall; self-confidence (during use) is another key finding with more than 80% of all respondents rating this as "important" or higher	Increased independence
Jarvis F., et al.	The most frequently prescribed items were devices that have been commonly available for many years and are usually low cost such as locks and personal identification bracelets	Simple interfaces
	More ethical than physical barriers	Caregivers want AT
Dethlefs N., et al.	Enjoyment of activities implies willingness to use the interface.	Caregivers want AT
Wang R.H., et al.	Users are open-minded to robotic assistance Care givers want robots	Caregivers want AT
Toots A., et al.	Four-month high-intensity functional exercise program had positive effects on gait in participants who tested unsupported compared with when walking aids or living support was used	Increased independence
Bahar-Fuchs A., et al.	Not reported	Not reported
Kiosses D.N., et al.	PATH participants had significantly greater improvement in MADRS emotions than ST-CI participants; improved negative emotions, between lagged and follow-up interview, significantly predicted reduction in suicidal ideation at follow-up interview	Increased safety
Soilemezi D., et al.	Five carers reported using assistive devices, such as baby monitors, sensors (chair, motion), and alarms (telecare, door alarm); a large property was considered helpful as it can offer choices and space to accommodate equipment (or even conversions), and implement various environmental strategies; blocking and locking (doors, cupboards, and cabinets) as a strategy to control behaviors and access to rooms or objects	Caregivers want AT
Me R., et al.	Acceptability is high, Usefulness is high	Caregivers want AT
Teunissen L., et al.	Increases communication between provider, therapist, family member, and patient	Increased communication

Table A1. *Cont.*

Authors	Facilitators	Facilitator Themes
Darragh M., et al.	Safety & security	Increased safety
Garzon-Maldonado G., et al.	Cost savings of 80 euros per user Caregivers prefer it over in-person High satisfaction	Cost benefits Caregivers want AT
Fardoun H.M., et al.	Technology enables patients to have all the information on any close person, as a remainder, easing their daily lives, improving their self-esteem and stimulating the patient with novel technology	Increased wellbeing
Newton L., et al.	Safety & security	Increased safety
Lazarou I., et al.	Not reported	Not reported
Egan K.J. and Pot A.M.	Not reported	Not reported
Wolters M.K., et al.	Some AT can speak to the person with dementia, which is helpful.	Auditory reminders
Hattink B.J., et al.	Rosetta system keeps the person with dementia home longer Gives care givers more security and confidence	Increased independence Caregivers want AT
Adolfsson P., et al.	How important it was to have self-confidence in mastering and controlling the alterations of the product; user-friendly design; support from colleagues and family members; device enhanced their ability to concentrate and focus, resulting in less stress and forgetfulness; facilitated communication and aided the participants in gaining a better understanding of their disability; providing assistance in the development of the participants' general abilities, such as changing habitual patterns of behavior.	Increased self-confidence Increased mindfulness
Czarnuch S., and Mihailidis A.	Enables those with dementia to stay home longer	Increased independence
Jupiter T.	Two participants immediately wanted new hearing aids because the study helped them realize their hearing was deficient	Increased mindfulness
Boger J., et al.	Interdisciplinary collaboration can result in a more holistic understanding of AT research challenges and enable innovative solutions; computer-based automated tool can significantly reduce the time and effort required to perform product usability analysis; products that are implicitly familiar and usable by older adults could foster independent activity completion, potentially reducing reliance on a caregiver; familiarity plays an important (and perhaps crucial) role in a product's usability	Simple interfaces
Jawaid S., and McCrindle R.	Affordable, especially if a person already owns a smartphone; app can be downloaded and installed within seconds and can be set up for use within minutes by anyone with a small knowledge of how to use a smart phone; only requires the older user to remember the single action of holding the phone close to a tag in order to be reminded of something or to perform an action; same tag can be associated with a number of tasks	Cost benefits Simple interfaces
Arntzen C., et al.	AT had to: 1. be valuable by addressing practical, emotional, and relational challenges 2. fit well into, or be a better solution for, habitual practice and established strategies 3. generate positive emotions and become a reliable and trustworthy tool 4. interest and engage the family carer.	Increased wellbeing
Gibson G., et al.	Some can be provided by social services	Can be provided by government
Purves B.A., et al.	The computer serves not only as a capture device for historical stories, but as an integral member of that conversation.	Increased communication

Table A1. *Cont.*

Authors	Facilitators	Facilitator Themes
Kerssens C., et al.	Helped them relax, enjoy life and reminisce whereas it did not make them feel monitored or watched, nor did they find it to be irritating; brought back good memories	Increased wellbeing
Woodberry E., et al.	Sense-Cam showed recall improvement over time in four out of six pts; improved his confidence since he was more assured that he would have something to talk about in social situations	Increased self-confidence
Corbett A., et al.	Not reported	Not reported
Adolfsson P., et al.	EPDs helped in structuring everyday life events; positive impact of the device on independence, including increased autonomy and self-regulation of everyday activities, as well as enhanced well-being and participation in work and school; respondents needed and received help in organizing such things as time planning/management and in managing time; respondents' improved volition	Increased independence Increased wellbeing
Mao H., et al.	Caregivers stated that they would use AT if the technologies were accessible and the cost reasonable; caregivers preferred technologies that prevented accidents or emergencies over technologies that informed them of the occurrence of an accident or that only managed the consequences	Caregivers want AT

Table A2. Map of Observations for Barriers to Barrier Themes.

Authors	Barriers	Barrier Themes
Cruz-Sandoval D. and Favela J.	Not reported	Not reported
Thomas N.W.D., et al.	Not reported	Not reported
Kenigsberg P.A., et al.	Cost, Forget how to use it, Complex design, Used infrequently, Liability in case of damage or injury	Cost Users forget how to use them Complex interfaces Liability concerns
Czarnuch S., et al.	Cost	Cost
Billis A., et al.	Pushing buttons does not always give the desired action, Tend to forget, Social stigma, ethical reasons, Not user friendly, Technical terminology	Complex interfaces Users forget how to use them PWD do not want AT Ethical concerns Technical literacy
Lancioni G.E., et al.	Not reported	Not reported
Lancioni G.E., et al.	Not reported	Not reported
Olsson A., et al.	Technical problems frustrate users, Frequent charging of batteries, Poor sound quality on motion sensor	Complex interfaces Poor sound quality Limitations of device

Table A2. *Cont.*

Authors	Barriers	Barrier Themes
Nauha L., et al.	False alarms, Complex interface, Sound quality	Development must improve capabilities Complex interfaces Poor sound quality
Holthe T., et al.	Timing is important (before it is too late), Because dementia is progressive technology helpful yesterday may be too complicated today, Does not always work properly, In Norway it can take time for AT to be repaired, Information overload, False alarms, Can be buggy, The more complicated the interface the less likely of the success	Degenerative nature of AD complicates timing of AT used Development must improve capabilities Needs more government involvement Complex interfaces
Wilz G., et al.	Not reported	Not reported
Valdivieso B., et al.	Not reported	Not reported
Collins, M.	Client's reduced cognitive and physical abilities (e.g., visual impairments), and the client's decreased willingness to use AT	Degenerative nature of AD complicates timing of AT used PWD do not want AT
Asghar I., et al.	Some PWDs don't like to adopt ATs as they believe these do not fulfill their requirements, compromise their privacy and result into reduced social circle; small size of texts and fonts used by these ATs as a challenge for them. The small text and font size made it hard to read instruction and act upon them; the volume and heavy weight of smart watches used by the participants made it difficult for them to carry these all the time; participants found learning the operations of reminders based ATs rather difficult and considered it as a challenge for getting proper benefits	PWD do not want AT Font size Limitations of device
Jouvelot P., et al.	Listening pose is not sufficient and needs to be improved	Development must improve capabilities
Thoma-Lürken T., et al.	Problems within three domains were consistently described as most important: informal caregiver/social network-related problems (e.g., high load of care responsibility), safety-related problems (e.g., fall risk, wandering), and decreased self-reliance (e.g., problems regarding self-care, lack of day structure)	Safety
Kouroupetroglou C., et al.	The fact that MARIO presents verbally all options in a series of questions seem to confuse the PWD, especially those in more advanced stages of the disease.	Degenerative nature of AD complicates timing of AT used Development must improve capabilities
Jiancaro T., et al.	UCD practices have been developed for user groups with relatively homogeneous characteristics. People with dementia, for example, are a diverse group, and even small subsets of this group tend to have a greater diversity of functionality than is found in groups of able young people	Degenerative nature of AD complicates timing of AT used Cost
Jarvis F., et al.	51% (n = 40) overall reported they had not prescribed AT because a client may wander; a lack of awareness by health professionals regarding the different types of AT available has been cited as a barrier to accessing the appropriate equipment in a timely manner for persons with dementia and their carers. Cost	Lack of awareness of availability of AT Cost

Table A2. *Cont.*

Authors	Barriers	Barrier Themes
Dethlefs N., et al.	Balancing difficulty of task with advanced stage of dementia	Degenerative nature of AD complicates timing of AT used
Wang R.H., et al.	Users do not want a robot, It could decrease interaction with care giver	PWD do not want AT Could decrease interaction with caregiver
Toots A., et al.	Walking aids appear to conceal changes over time in gait speed	AT could mask changes in gait over time
Bahar-Fuchs A., et al.	Not reported	Not reported
Kiosses D.N., et al.	Not reported	Not reported
Soilemezi D, et al.	Not reported	Not reported
Me R., et al.	Intervention not yet in production, Would only be worn a few hours	Development must improve capabilities
Teunissen L., et al.	Patients were fascinated by the device, but PWD needed active encouragement to interact with it.	Degenerative nature of AD complicates timing of AT used
Darragh M., et al.	Cost	Cost
Garzon-Maldonado G., et al.	Not reported	Not reported
Fardoun H.M., et al.	Difficulties of reading information in a small screen or taking a proper photo (Some patients were unable to point the smart watch in the right angle to capture the person's face. Some others even forgot to tap the screen to take the photo)	Font size
Newton L., et al.	Not reported	Not reported
Lazarou I., et al.	Not reported	Not reported
Egan K.J. and Pot A.M.	Education about AT Not enough government involvement Reimbursement from insurance Progressive nature of disease Cost	Users forget how to use them Needs more government involvement Cost Cost Degenerative nature of AD complicates timing of AT used

Table A2. *Cont.*

Authors	Barriers	Barrier Themes
Wolters M.K., et al.	Not reported	Not reported
Hattink B.J., et al.	Rosetta system has many technical problems Difficult to understand System was perceived to be complex and hard to work with; Rosetta-portal site which was judged very user-unfriendly, since it often did not work during the trial, gave errors and required persons to try and log-in multiple times	Development must improve capabilities Complex interfaces
Adolfsson P., et al.	Professionals at all levels should provide knowledge on the manageability of the EPD to the user; participants were in most need of the EPDs outdoors, but the outdoor climate often prevented using the device effectively; deficiencies in the EPDs could be related to software issues or that the product was not flexible; product assortment was sometimes seen as limited; did not always have access to software updates and thus could not use the programs that were available in their mobile phone; participants also wished that the technology could be regarded as a natural and obvious support system;	Development must improve capabilities
Czarnuch S., and Mihailidis A.	Complex setup	Complex interfaces
Jupiter T.	Three participants immediately returned the device.	PWD do not want AT
Boger J., et al.	Not reported	Not reported
Jawaid S., and McCrindle R.	Not reported	Not reported
Arntzen C., et al.	Not reported	Not reported
Gibson G., et al.	Those ATs provided by social services are helpful, but the process of obtaining them is very impersonal, Cost	Could decrease interaction with caregiver Cost
Purves B.A., et al.	Not reported	Not reported
Kerssens C., et al.	Care recipients' inability to use the companion independently due to physical limitations; companion not offering a feature the caregiver had counted on; caregivers ignoring or muting all scheduled shows and not using interventions on demand; care recipients ignoring interventions even when they noticed them and perceived them as positive; care recipients' unwillingness to share experiences with the caregiver; couples not having enough time or availability to experience the interventions due to circumstances	PWD do not want AT
Woodberry E., et al.	One participant felt SenseCam brought attention to him, which he was embarrassed by (didn't want to wear it)	PWD do not want AT
Corbett A., et al.	Not reported	Not reported
Adolfsson P., et al.	Not reported	Not reported
Mao H., et al.	Persons with dementia are unlikely to use any unfamiliar devices; client-prompting devices were perceived as less useful	PWD do not want AT

Table A3. Map of Observations for Medical Outcomes to Outcome Themes.

Authors	Medical Outcomes Reported	Medical Outcomes Themes
Cruz-Sandoval D. and Favela J.	Increased number of utterances and sustained conversations	Increased talking Increased talking
Thomas N.W.D., et al.	Zero effect on depression	No effect on depression
Kenigsberg P.A., et al.	Reduced sensory loss, Reduced isolation, Improved cognitive abilities (memory, judgment, decision making),	Reduced sensory loss Improved coping Improved cognitive abilities
Czarnuch S., et al.	Not reported	Not reported
Billis A., et al.	Increase in autonomy	Increased autonomy
Lancioni G.E., et al.	Increase in ADLs	Increased ADLs
Lancioni G.E., et al.	Increase in step frequency	Increased step frequency
Olsson A., et al.	Increase in autonomy, Increased self confidence	Increased autonomy
Nauha L., et al.	Not reported	Not reported
Holthe T., et al.	Increase in autonomy, Decreased stress	Increased autonomy Decreased stress
Wilz G., et al.	Improved emotional well-being, Fewer symptoms of depression, Fewer physical health symptoms, Improved coping, Improved behavior	Improved mood Improved depression Improved overall health Improved coping Improved behavior
Valdivieso B., et al.	Improved quality of life indicators	Increased ADLs
Collins, M.	fewer medication errors, Fewer falls, elopement, and fewer kitchen safety incidents	Fewer medication errors Fewer falls Improved behavior
Asghar I., et al.	The use of technology in combination with balanced human care can yield better results for the wellbeing of the PWD; some participants used ATs for health monitoring purposes. These devices helped them to monitor their physical conditions like blood pressure, heartbeat rate, diabetes level, etc., on a regular basis. This continuous health monitoring helped them to adapt a healthier life style	Improved overall health

Table A3. *Cont.*

Authors	Medical Outcomes Reported	Medical Outcomes Themes
Jouvelot P., et al.	Increased autonomy	Increased autonomy
Thoma-Lürken T., et al.	Not reported	Not reported
Kouroupetroglou C., et al.	Not reported	Not reported
Jiancaro T., et al.	Not reported	Not reported
Jarvis F., et al.	Not reported	Not reported
Dethlefs N., et al.	Not reported	Not reported
Wang R.H., et al.	Not reported	Not reported
Toots A., et al.	Improved gait	Increased step frequency
Bahar-Fuchs A., et al.	Increase in memory, Increase in global cognition, Increase in learning, Increase in mood	Improved memory Improved cognitive abilities Improved mood Improved memory
Kiosses D.N., et al.	Improved negative emotions, Significantly predicted reduction in suicidal ideation at follow-up interview	Improved mood Improved depression
Soilemezi D., et al.	All the carers recommended the use of equipment as a means to increased quality of life for both the carer and the person with dementia	Increased ADLs
Me R., et al. Teunissen L., et al.	Not reported Not reported	Not reported Not reported
Darragh M, et al.	Improve health and well-being of dementia patients; monitor psychological well-being,	Improved overall health
Garzon-Maldonado G., et al.	Not reported	Not reported
Fardoun H.M., et al.	Not reported	Not reported
Newton L., et al.	Not reported	Not reported
Lazarou I., et al.	Improvement in movement intensity, Improved cognitive function, Improved ADLs, Improved behavior	Improved cognitive abilities Improved behavior Increased ADLs

Table A3. *Cont.*

Authors	Medical Outcomes Reported	Medical Outcomes Themes
Egan K.J. and Pot A.M.	Not reported	Not reported
Wolters M.K., et al.	Improvement to cognitive decline	Improved cognitive abilities
Hattink B.J., et al.	Not reported	Not reported
Adolfsson P., et al.	Device enhanced their ability to concentrate and focus, resulting in less stress and forgetfulness	Decreased stress Improved memory
Czarnuch S., and Mihailidis A.	Not reported	Not reported
Jupiter T.	Improve hearing	Improved overall health
Boger J., et al.	Not reported	Not reported
Jawaid S., and McCrindle R.	Not reported	Not reported
Arntzen C., et al.	Not reported	Not reported
Gibson G., et al.	Not reported	Not reported
Purves B.A., et al.	Computer-mediated interactions enable greater engagement and more enjoyment than a traditional method of story capture.	Improved mood
Kerssens C., et al.	Made their daily lives easier and made helping their spouse easier	Improved coping
Woodberry E., et al.	Help patients recall past events	Improved memory
Corbett A., et al.	Significant benefit to activities of daily living in a group of adults older than 60 receiving both the online GCT and ReaCT interventions compared with control, over a period of six months	Increased ADLs Improved cognitive abilities
Adolfsson P., et al.	Use of EPDs seems to reduce the gap between the challenges the respondents encounter in everyday life and their cognitive disability, increased autonomy	Improved cognitive abilities Increased autonomy
Mao H., et al.	There were no medical outcomes; the study was done to view the caregivers' perception on the usefulness of AT devices	Not reported

Table A4. Map of Observations for Interventions to Intervention Themes.

Authors	Intervention	Intervention Theme
Cruz-Sandoval D. and Favela J.	Socially assistive robots	Social robots
Thomas N.W.D., et al.	Telehealth Home-based monitoring Ecological Valid, Ambient, Longitudinal and Unbiased Assessment of Treatment Efficacy in Alzheimer's Disease (EVALUATE-AD)	Telehealth
Kenigsberg P.A., et al.	Several ATs were explored: smart calendar clocks, social robots, auto lighting, computer, smartphone	Interview
Czarnuch S., et al.	Predictive model to predict survey results. Survey instrument addressed ATs and ADLs.	Predictive model
Billis A., et al.	Interviews about ATs	Interview
Lancioni G.E., et al.	Study 1–wireless Bluetooth earpiece linked to the tablet or smartphone. Study 2–walker with technology that provided stimulations and prompts	Mixed interventions
Lancioni G.E., et al.	Use of walker with AT	Walker with technology
Olsson A., et al.	Sensor technology with individually prerecorded voice reminders as memory support	Sensors with voice
Nauha L., et al.	Supportive devices and alarm systems	Interview
Holthe T., et al.	Interview to discuss experiences with AT	Interview
Wilz G., et al.	Telephone therapy for caregivers	Telephone
Valdivieso B., et al.	Telephone-based telehealth which adds technology for remote self-management	Telephone
Collins, M.	Interview	Interview
Asghar I., et al.	Interview	Interview
Jouvelot P., et al.	Lovely User Interface for Servicing Elders	Cognitive stimulation
Thoma-Lürken T., et al.	Interview to gain insight into the most important practical problems preventing people with dementia from living at home	Interview
Kouroupetroglou C., et al.	MARIO robot	Social robots
Jiancaro T., et al.	Exploratory survey with developers	Mixed interventions
Jarvis F., et al.	Cross-sectional survey asked about assistive devices for dementia patients	Interview
Dethlefs N., et al.	Natural language presentation (Wizard of Oz interface) of cognitive stimulation	Cognitive stimulation

Table A4. *Cont.*

Authors	Intervention	Intervention Theme
Wang R.H., et al.	Robots to assist in daily activities	Social robots
Toots A., et al.	Participants were randomized to the high-intensity functional exercise program or a seated attention control activity	Walker with technology
Bahar-Fuchs A., et al.	eHealth Tailored and adaptive computer cognitive training in older adults at risk for dementia	eHealth
Kiosses D.N., et al.	Two home-delivered psycho-social treatments, Problem Adaptation Therapy (PATH) and Supportive Therapy for Cognitively Impaired Older Adults (ST-CI)	Telehealth
Soilemezi D., et al.	Interview with carers in their home	Interview
Me R., et al.	Survey on caregivers to assess acceptability, wearability, setting suitability, usability, and general concepts about wearables for navigation for those with dementia.	Interview
Teunissen L., et al.	eHealth CRDL, an interactive instrument	eHealth
Darragh M., et al.	Survey about a homecare robot	Social robots
Garzon-Maldonado G., et al.	Survey instrument asked about a telephone assistive intervention	Telephone
Fardoun H.M., et al.	Analyzing pictures taken by a smart watch, which the patient carries, the person in front is recognized and information about him is sent to the watch.	Cognitive stimulation
Newton L., et al.	Survey instrument inquired about AT from providers, caregivers, and those with dementia	Interview
Lazarou I., et al.	Home monitoring	Tele-monitoring
Egan K.J. and Pot A.M.	Focus group to discuss AT	Focus group
Wolters M.K., et al.	Intelligent cognitive assistant	Cognitive stimulation
Hattink B.J., et al.	Integrates three previous AT research into one modular system which can support dementia patients. Pre-and post-test measures across three countries, questionnaires and interviews. Rosetta was installed in the homes of patients	Cognitive stimulation
Adolfsson P, et al.	Electronic planning devices	Electronic planners
Czarnuch S., and Mihailidis A.	Intelligent AT, random-decision forest (computer learning)	Cognitive stimulation
Jupiter T.	Hearing AT	Hearing AT

Table A4. *Cont.*

Authors	Intervention	Intervention Theme
Boger J., et al.	Self-reporting by asking participants to rate how difficult they found using the tap to be through a verbally administered, single four-point Likert scale question	Interview
Jawaid S., and McCrindle R.	Computerized Help Information and Interaction Project (CHIIPS) program	Cognitive stimulation
Arntzen C., et al.	Incorporation of AT into everyday life for young people with dementia	Interview
Gibson G., et al.	Semi-structured interviews on everyday use of AT	Interview
Purves B.A., et al.	Computer Interactive Reminiscence Conversation Aid (CIRCA)	eHealth
Kerssens C., et al.	Companion (touch screen technology) that delivers non drug, psychosocial intervention	Social robots
Woodberry E., et al.	Wearable camera to improve memory	Cognitive stimulation
Corbett A., et al.	Compared evidence-based reasoning and problem-solving cognitive training (ReaCT), general cognitive training (GCT), and a control treatment	Cognitive stimulation
Adolfsson P., et al.	Interviewed with support from a study specific guide to explore the subjective experiences of people with cognitive disabilities in relation to the use of EPDs	Interview
Mao H., et al.	Questionnaires to determine high perceived usefulness vs low perceived usefulness	Interview

Table A5. Observations of Bias, Country of Origin, Statistics Used, and Quality Assessment.

Authors	Bias within Study	Effect Size	Country of Origin	Statistics Used	JHNEBP Quality Assessment	
					Strength of Evidence	Quality of Evidence
Cruz-Sandoval D. and Favela J.	Single site location	N/A	Mexico	Split-middle trend line	III	B
Thomas N.W.D, et al.	Very small sample	N/A	Canada	Descriptive only	III	B
Kenigsberg P.A., et al.	Bias in judgment	N/A	Netherlands	Language processing	IV	B
Czarnuch S., et al.	Single site location	N/A	Canada	Descriptive only	III	B
Billis A., et al.	Single site location Selection bias (all participants had experience with technology)	N/A	Greece	Language processing	III	B

Table A5. *Cont.*

Authors	Bias within Study	Effect Size	Country of Origin	Statistics Used	JHNEBP Quality Assessment	
					Strength of Evidence	Quality of Evidence
Lancioni G.E., et al.	Small sample	Not reported	Unites States	Kolmogorov-Smirnov test	II	B
Lancioni G.E., et al.	Convenience sample at one facility only, which limits the external validity	N/A	Italy and Ireland	Kolmogorov-Smirnov test	II	B
Olsson A., et al.	Convenience sample at one facility only, which limits the external validity	N/A	Sweden	Language processing	III	B
Nauha L., et al.	Tested only in Memory Help apartment or Home environment	N/A	Finland	Carers of older people in Europe (COPE) score of caregivers	II	B
Holthe T, et al.	Convenience sample at one facility only, which limits the external validity	N/A	Norway	Language processing	III	B
Wilz G., et al.	Sample in one country only	Cohen's d = 0.2 (small effect)	Germany	Latent variable structural equation model (SEM)	I	A
Valdivieso B., et al.	Sample in one country only	N/A	Spain	Language processing	II	B
Collins, M.	Small sample size and all participants from Piedmont Triad area of North Carolina; the only inclusion criteria for participating in the current study was being an occupational therapy practitioner	N/A	United States		III	B
Asghar I., et al.	Small sample size	N/A	Pakistan	None listed	III	B
Jouvelot P., et al.	Small sample in one country only	N/A	France	Language processing	III	B
Thoma-Lürken T., et al.	Not a random sample; participants only had space of sticky note to write answer (could have missed out on more descriptive/clear answers);	N/A	Netherlands	Language processing	III	B
Kouroupetroglou C., et al.	Small sample size	Not reported	Italy and Ireland	None listed	III	B
Jiancaro T., et al.	Exploratory survey	N/A	Canada	Descriptive statistics and Mann-Whitney U tests	III	B

Table A5. *Cont.*

Authors	Bias within Study	Effect Size	Country of Origin	Statistics Used	JHNEBP Quality Assessment	
					Strength of Evidence	Quality of Evidence
Jarvis F., et al.	Study conducted in only one country	N/A	Australia	Language processing	III	A
Dethlefs N., et al.	Small sample	N/A	Scotland	Language processing	III	B
Wang R.H., et al.	Social desirability bias	N/A	Canada	Language processing	III	B
Toots A., et al.	None found	GROUP A: 4 month ES = −0.05, 7 month ES = 0.04; GROUP B: 4 month ES = 0.20, 7 month ES = 0.16; GROUP C: 4 month ES = 0.29 and −0.33, 7 month ES = 0.47 and −0.50; GROUP D: 4 month ES:.34 and −0.04, 7 month ES = 0.37 and −0.04	Sweden	Student *t*-test or the Pearson $\chi 2$ test, and Pearson correlation coefficients	I	A
Bahar-Fuchs A., et al.	Convenience sample in one city only	N/A	Australia	Descriptive and Cohen's d	I	A
Kiosses D.N., et al.	None reported	0.75	United States	None listed	I	B
Soilemezi D., et al.	Cross-sectional study and the data were derived from the perspectives of 13 carers, all White, conveniently selected, and heterogeneous in personal and housing conditions	N/A	United Kingdom	None listed	III	B
Me R., et al.	Study conducted in only one country	N/A	UK, Italy, and Malaysia	Language processing	III	A
Teunissen L., et al.	Person with dementia should live in residential department of the nursing home facility	N/A	Netherlands	Coding framework	III	B
Darragh M., et al.	Study conducted in only one city	N/A	New Zealand	Inductive thematic analysis	III	B
Garzon-Maldonado G., et al.	Study conducted in one country	N/A	Spain	Descriptive, *t*-test, and language processing	III	A

Table A5. *Cont.*

Authors	Bias within Study	Effect Size	Country of Origin	Statistics Used	JHNEBP Quality Assessment	
					Strength of Evidence	Quality of Evidence
Fardoun H.M., et al.	None found	N/A	Saudi Arabia	None listed	III	B
Newton L., et al.	Conducted in one region of one country only	N/A	United kingdom	Language processing	III	A
Lazarou I., et al.	Very small sample, performed at only four homes in the same city	Not reported	Greece	Paired-sample *t*-test	IV	B
Egan K.J. and Pot A.M.	Small sample	N/A	Switzerland	Language processing	IV	A
Wolters M.K., et al.	Performed at one location	N/A	United kingdom	Language processing	IV	B
Hattink B.J., et al.	Randomized controlled trial in Germany; matched groups in the Netherlands and Belgium; there were significantly more males in the control group than in the experimental group; The professional carers were all female	Small effect size	Netherlands, Germany and Belgium The Netherlands, Germany, and Belgium	*t*-test, Chi Squared, and ANCOVA	I	B
Adolfsson P., et al.	Small sample	N/A	Sweden	None listed	III	B
Czarnuch S., and Mihailidis A.	Performed at one location	Not reported	Canada	Random-decision forest, ANOVA, F-test	II	B
Jupiter T.	Performed at one location	Not reported	United States	*t*-test	III	B
Boger J., et al.	Only focused on tap usability;	Not reported	Canada	Likert scale	I	B
Jawaid S., and McCrindle R.	Small sample size	Not reported	United Kingdom	None listed	III	B
Arntzen C., et al.	Chosen perspectives were deemed suitable in forecasting how new technology is absorbed; small sample size	N/A	Norway	qualitative content analysis	III	B
Gibson G., et al.	Performed at one location	N/A	United kingdom	Language processing	III	B

Table A5. *Cont.*

Authors	Bias within Study	Effect Size	Country of Origin	Statistics Used	JHNEBP Quality Assessment	
					Strength of Evidence	Quality of Evidence
Purves B.A., et al.	Very small sample	N/A	British Columbia	Language processing	IV	B
Kerssens C., et al.	Small sample	N/A	United States	Barthel index	III	B
Woodberry E., et al.	Small sample size. Focused mainly on individuals suffering from AD	N/A	United kingdom	Chi-squared analysis of linear trend	III	B
Corbett A., et al.	Only people with access to computer; was biased toward individuals with higher levels of educational attainment; there was a significant dropout between months 3 and 6	0.26	United Kingdom	Histograms and normal Q-Q plots; mixed-effects regression model	I	A
Adolfsson P., et al.	Small sample size	N/A	Sweden		III	B
Mao H., et al.	Perspectives of people with dementia were not represented	N/A	Taiwan	None listed	III	B

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