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Assistive Technology and the Relationship It Creates with Informal Caregivers Providing Care to Community-Dwelling Older Adults with Dementia: A Systematic Review

By

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THESIS

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Abstract

Background: Dementia presents significant health and care challenges around the world. Caring for people with dementia could adversely impact the informal caregiver's physical, psychological, and financial health. As such, various technologies have been developed to help minimize the burden and improve the well-being of caregivers when caring for people with dementia. These assistive technologies include motion detectors, tracking systems, telehealth, and caregiver platforms, to name a few. However, caregivers' experiences are often ignored when designing these assistive technologies. This review focuses on published literature on informal caregivers' providing care to persons with dementia and whether assistive technologies aid in reducing caregiver burden.

Methods: The systematic review involved a systematic search of the OVID Medline database following pre-defined inclusion and exclusion criteria in identifying appropriate quantitative, qualitative, and mixed-method studies meeting the objective.

Results: The studies reported the potential to reduce burden and stress among caregivers. However, while providing care to persons with dementia, there was no significant change in the stress reduction or amount of burden the caregivers experienced with the AT intervention.

Conclusions: From the review, it was evident that various assistive technologies have positive and negative effects when used in dementia care. As such, assistive technology interventions should be customized for specific settings and caregivers.

Keywords: dementia, assistive technology, informal caregivers, the burden

Chapter 1. Introduction

Significance of The Problem:

Dementia cases have been rising around the world for many decades. Despite the estimates that more than 81.1 million people will be diagnosed with dementia by 2040, the awareness of its symptoms is still low (Strivens et al., 2020). Strivens et al. defined dementia as a complex acquired brain condition that lowers cognitive functioning levels due to cognitive domain impairment. According to The Lancet Neurology (2021), more than 50 million people are diagnosed with dementia, with 10 million cases reported annually. While dementia cases continue to rise, there is still no effective, universally accepted treatment for dementia. People rely on family caregivers to save costs. Nevertheless, family caregivers remain the primary caregiver for patients around the globe. However, these caregivers can sometimes feel stressed, depressed, and have other mental health challenges due to their lack of knowledge about managing these cases. In addition, caring for dementia patients is overwhelming and can result in physical, emotional, and economic pressures (Sri et al., 2022). There is a need for alternative and innovative measures to care for dementia patients. The researcher conducted a systematic review of literature that evaluated various assistive technologies supporting the informal caregiver while minimizing the caregiver burden. This systematic review explains the role of assistive technology (AT) in helping informal caregivers such as relatives in caring for community-dwelling older adults with dementia.

Assistive Technology to Support Dementia Care:

Assistive technology (AT) helps improve care for people with dementia. It helps informal caregivers to persons with dementia and persons with dementia become more independent,

improves their quality of life, and enhances their safety. Technology helps informal caregivers to persons with dementia improve their risk management and customize patient support. In line with this suggestion, Williams et al. (2018) suggested that AT would assist the informal caregiver in becoming more supportive and ensure that the patient with dementia remains within the community. Sri et al. (2022) defined *assistive technology* as tools, devices, and systems that a person can use to improve and maintain their functional capabilities and independence, thus helping them address their physical, communication, and cognitive difficulties. These assistive technologies include reminders, domestic systems, automatic lights, and alarm systems (Williams et al., 2018). These systems use remote controls and phones to monitor patients' movements and activities and facilitate therapeutic interventions.

There are several types of assistive technologies, including pervasive telecare and surveillance systems. Pervasive telecare technologies encompass motion detectors, pressure sensors, and temperature and inactivity-detecting sensors. These sensors automatically relay the signal to a caregiver or the monitoring center, thus enabling real-time access to assistance. Surveillance technologies ensure that the patient is monitored constantly using the Global Positioning Systems (GPS) or electronic tracking chips. The technology alerts the caregiver of the position of the patient. Sri et al. (2022) explained that the alarm systems could help locate people with dementia whenever they leave home. Other assistive technologies, such as touchscreen devices, include entertainment features such as music and apps, thus improving their quality of life. More devices have emerged in the market in the recent past, which create a fluid environment for dementia patients, thus supporting their convenient living (Williams et al., 2018). Several studies have been conducted investigating how AT helps people with dementia. These studies suggest that caregivers could use AT to look after a person with dementia

(Williams et al., 2018). Despite these technological developments, little is known about their effectiveness and the caregivers' experiences while using them. This review intends to narrow the literature gap, predominantly looking at AT from the caregiver's perspective. The review offers essential insights into how AT influences caregivers' functions. The findings could be important for caregivers and people living with dementia when considering AT solutions and helping informal caregivers provide care.

Statement of the Study purpose

The Primary Objectives of this Review Are:

- Explain the different types of AT for people with dementia
- Detail the effectiveness of AT in supporting the well-being, and quality of life of people with dementia
- Explain how AT solutions help in reducing the informal caregivers' burden when caring for people with dementia

In the following chapter, the results of the systematic review are presented.

Chapter 2. Systematic Review

Research Design and METHODS:

Key terms with the assistance of a medical librarian were used to identify how assistive technology solutions affected informal caregivers providing care to community-dwelling older adults diagnosed with dementia. Studies published between January 1, 2010, and March 4, 2022, were identified in Ovid MEDLINE. See Table 1: Research Key Terms

Table 1: Research Key Terms

Key Terms	
Assistive Technology	Telemedicine, remote sensing technology, remote, home monitor, sensor, sensing, telemonitor, tele-monitor, assist, self-help, video recording, audiovisual recording, video recording, video, camera, videoconferencing
Dementia	Alzheimer's Disease, memory disorder, cognitive dysfunction, memory or cognitive or cognition, memory disorder, loss, dysfunction, decline, or impairment
Caregivers	Caregivers, spouses, adult children, caregiver, caregivers, caregiving, caregiver, informal or family or families or spouses, partner, adult-daughter, adult son, adult child, dependent, relative, sibling, or folk, caregiver burden, burden, burnout, exhaust, wellness, well-being, health

Criteria for Considering Studies for This Review:

The search yielded approximately three-hundred-and fifty-two articles. One article was removed because of duplication, leaving three-hundred-and-fifty-one articles. The researchers reviewed the abstracts of the retrieved sources, and nine articles met the study's inclusion and exclusion criteria (as mentioned below). Due to the large number of results generated by this search, titles and abstracts were scanned, and articles were selected based on relevance. See the

PRISMA flow diagram in Figure 1 to break down what articles were screened and accepted into this systematic review.

Inclusion Criteria:

Original peer-reviewed papers were based on randomized controlled trials (RCTs) published between January 1st, 2010 and March 04, 2022 that focused on assistive technology intervention; the target populations were community-dwelling older adults living with dementia and their informal caregivers. The caregivers must be informal such as their family members or friends, and not be paid, such as nursing home staff. Studies must include the diagnosis of dementia. All types and stages of dementia were included in this review.

Exclusion Criteria:

The research excluded systematic reviews, opinion/perspective papers, persons with dementia who resided in assisted living or nursing homes, studies that fell outside of the selected dates listed within the inclusion criteria, and studies focused solely on patient-directed interventions. Studies conducted within hospital-based environments or where the technology intervention was unclear and not written in English were also excluded.

Data Collection and Analysis:

The researcher adopted the PRISMA checklist for systematic reviews to inform the data extraction process (Page et al 2020). PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) refers to an evidence-based minimum set of items intended to help researchers report a wide array of systematic reviews and meta-analyses. The PRISMA checklist assesses the benefits (Rethlefsen et al., 2021). Additionally, the PRISMA flow diagram provides a visual summary of the screening process and records the number of articles identified. It ensures that the data selection process is transparent in reporting the researcher's decisions at

different systematic review stages. The goal of the data extraction was to explore the various characteristics of the included studies. The assessed characteristics include the purpose of the study, the participants, the methodological design, the setting, and assistive technology intervention. The researcher also assessed the experiences of people with dementia and their caregivers according to the studies and the study outcomes. See Table 2, that summarizes the nine articles with the caregivers' experiences with the assistive technology (AT).

Figure. 1: PRISMA Flow Diagram

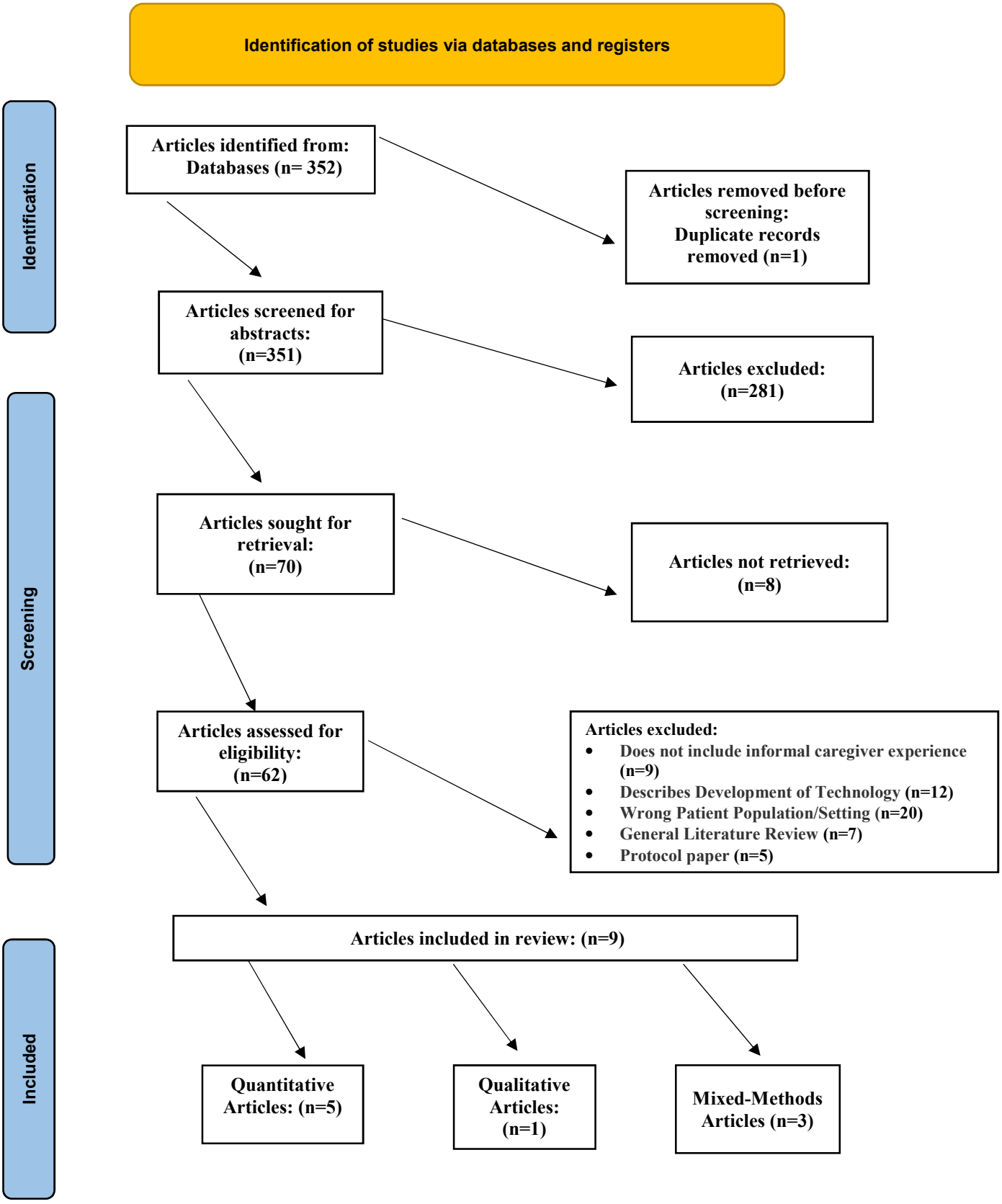

Table 2: Caregiver Experiencer

Authors	Study Design	Assistive Technology Intervention	Caregivers Experiences
Schaller et al. (2015)	Qualitative RCT, pilot study	The eHM Dementia Portal (eHM-DP)	• Provided new insights into the interactive and needs-oriented web portal, • Empowering for caregivers • Assists in decision-making
Torkamani et al. (2014)	Quantitative RCT, pilot study	Computerized platform, ALADDIN	• Positively impacted the performance of informal caregivers and clinicians • Significant improvement in the informal caregiver's quality of life due to a reduction of burden and distress • Useful monitoring of persons with dementia (PwD) and facilitating their contact with other professionals
Núñez-Naveira et al. (2016)	Quantitative RCT, pilot study	UnderstAID Application	• Participants found the application to be technically and educationally acceptable. • Modification of the application is needed to meet national, social, and cultural interests.
Shaw et al. (2020)	Quantitative RCT	FamTech Care Intervention	• Improved dementia management; including behaviors • Increased understanding of disease expectations • Increased performance with ADLs (bathing, dressing, and eating).
Hastings et al. (2018)	Quantitative RCT pilot experiment	Telehealth	• Greater engagement with communication, and interactions • Using video technology was preferred over telephone calls. • Informal caregivers had an increased overall positive attitude towards day-to-day life.
Mitchell et al (2020)	Mixed-Method RCT	Remote Activity Monitor (RAM)	• Provided caregivers a sense of security • Findings have important clinical implications regarding family care
Gaugler et al. (2019)	Mixed-Method RCT	Remote Activity Monitor (RAM)	• Systems could work in specific settings, especially among patients in the earlier stages of dementia • Decreased worrying, improved peace of mind
Gaugler et al. (2021)	Mixed-Method RCT	Remote Activity Monitor (RAM)	• Caregivers varied in their ability to customize the RAM system so that it suited their needs over time. • The system helped prevent crises for the care recipient
Williams et al. (2021)	Mixed-Method RCT	FamTech Care Intervention	• Intervention was acceptable, easy to use, and effective among caregivers • Reduced depression (caregivers) • Intervention was described as useful and identified adaptations to enhance feasibility

RESULTS

Description of Studies:

Of the nine included articles in the research, four were quantitative, four were mixed methods, and one article was qualitative. All the studies were randomized controlled trials (RCTs). The articles ranged from 2014 to 2022 and focused on different assistive technologies (AT) types. All the informal caregivers were at least 18 years of age. The data used in these studies was gathered using surveys, observations, questionnaires, and focus groups. Six studies [Williams et al. (2021), Shaw et al. (2020), Mitchell et al. (2020), Gaugler et al. (2021), Gaugler et al. (2019), Hastings et al., 2018)] reported on the ethnicity of the participants. All the studies reported on the dementia type and severity. They also described the informal caregivers' relationship between the caregivers and those with dementia. The relationships included family members such as spouses, children, siblings, and neighbors, and friends. It highlighted how various technologies could help informal caregivers achieve the objectives highlighted in this review. Table 3 reviews the nine articles and highlights the primary outcome for each article.

Table 3: Primary Outcomes

Authors	Study Design	Assistive Technology Intervention	Sample	Primary Outcomes
Schaller et al. (2015)	Qualitative RCT, pilot study	The eHM Dementia Portal (eHM-DP)	42 informal caregivers of PwD	Caregivers indicated a high degree of perceived support. In total, 89 % of caregivers would use the eHM-DP if access were provided. The primary benefits participants perceived were the acquisition of individualized information, computerized interaction between caregivers and providers, empowerment in health-related decisions and comprehensive insights into the progress of the disease.
Torkamani et al. (2014)	Quantitative RCT, pilot study	ALADDIN	30 informal caregivers of PwD	A significant improvement in the quality of life of the caregivers, with some reduction in caregiver burden and distress.The platform was useful in monitoring the patients and facilitating contact with other professionals. Access to and use of the ALADDIN platform was rated positively by carers and clinicians.
Núñez-Naveira et al. (2016)	Quantitative RCT, pilot study	UnderstAID Application	61 informal caregivers of PwD	33.3% of the caregivers were satisfied with the application and around 50% of the participants assessed it as pedagogically acceptable. After using UnderstAID the caregivers significantly decreased their depressive symptomatology.
Shaw et al. (2020)	Quantitative RCT	FamTech Care Intervention	43 informal caregivers to PwD	Improvements were observed across the three categories (*managing dementia behaviors, understanding disease expectations, and performing activity of daily living care*) however, not all changes were statistically significant.
Hastings et al. (2018)	Quantitative RCT pilot experiment	Telehealth	40 informal caregivers and 40 PwD	80% of participants preferred video-delivered care instead of telephone calls for older adults with dementia and their informal caregivers.
Mitchell et al (2020)	Mixed-Method RCT	Remote Activity Monitor (RAM)	30 informal caregivers to PwD	The data suggested that RAM technology offered ongoing monitoring and provided caregivers with a sense of security. Considerable customization was needed so that RAM was most appropriate for PwD. The findings have important clinical implications when considering how RAM can supplement, informal caregiving.
Gaugler et al. (2019)	Mixed-Method RCT	Remote Activity Monitor (RAM)	30 informal caregivers to PwD	Growth curve models showed no direct or moderation effect of RAM on dementia caregiver outcomes.
Gaugler et al. (2021)	Mixed-Method RCT	Remote Activity Monitor (RAM)	132 informal caregivers to PwD	The RAM system did not significantly affect caregiving outcomes. Caregivers who utilized RAM technology and cared for relatives with: (a) less severe cognitive impairment; and (b) difficulty navigating around the home were more likely to indicate statistically significant increases in competence and self-efficacy.
Williams et al. (2021)	Mixed-Method RCT	FamTech Care Intervention	43 informal caregivers to PwD	Most caregivers reported benefits from participation. Caregivers found the support to be helpful and effective. Caregivers of persons with more severe dementia were more likely to report that video recording intruded on their privacy.

Risk of Bias in Included Studies:

Since the review included quantitative, qualitative, and mixed-methods research approaches, the researcher applied the Mixed Methods Appraisal Tool (MMAT) to assess the research's quality (See Appendix D). MMAT scores for all nine studies included were assessed. While the score was a subjective appraisal of the quality of the research methods, it helps to identify the potential biases of the study design. All the studies met the quality percentage for the quantitative and qualitative studies. In the case of mixed-method studies, the lowest score for the two components was taken as the study score, as the overall score cannot exceed the lowest component score. This implies that a study could have a solid quantitative component and a weak qualitative component or vice versa.

The single qualitative study (Schaller et al. (2015) scored higher than other studies as it considered results within a particular context and the researcher's influence. It is important to note that the researcher influences data collection and interpretation of results in qualitative studies. Nevertheless, the RCTs scored poorly on blinding and allocation concealment. The four RCT pilot trials [Schaller et al. (2015), Núñez-Naveira et al. (2016), Torkamani et al. (2014), Hastings et al. (2018)] suffered bias risks associated with a high attrition rate. Though these included studies had various strengths and weaknesses, they answered the research questions that they were set to answer and were rich in findings. The results were consistent with the questions that this systematic review set out to answer.

Table 4: Quality Assessment of the included studies using Mixed Methods Appraisal Tool (MMAT)

Author(s), Year	Qualitative				Quantitative Description				Mixed Methods		
	Source of data relevant to objectives	Analysis process relevant to objectives	Consideration of findings relate to context	Consideration of findings relate to researchers' influence	Sampling strategy relevant to objectives	Sample representativeness	Measurements appropriate	Acceptable response rate	Mixed methods research design relevant to objectives	Integration of results relevant to objectives	Consideration of limitations associated with this integration
Schaller et al. (2015)	1	1	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Torkamani et al. (2014)	N/A	N/A	N/A	N/A	1	1	1	1	N/A	N/A	N/A
Núñez-Naveira et al. (2016)	N/A	N/A	N/A	N/A	1	1	1	1	N/A	N/A	N/A
Shaw et al. (2020)	N/A	N/A	N/A	N/A	1	1	1	1	N/A	N/A	N/A
Hastings et al. (2018)	N/A	N/A	N/A	N/A	1	1	1	1	N/A	N/A	N/A
Mitchell et al (2020)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	0
Gaugler et al. (2019)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	0
Gaugler et al. (2021)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	0
Williams et al. (2021)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	0

Results of the MMAT Scores: Table presenting the ratings of each study

Synthesis of Results:

As already highlighted, the included research is quantitative, qualitative, and mixed-methods studies. The nine studies were subjected to synthesizing the results—the narrative analysis aimed to present a descriptive summary of findings from the included studies. The process included theme identification in line with the objectives of the systematic review. The researcher compared different insights from the studies and enhanced understanding of different

aspects of informal caregivers' experiences using assistive technologies from these themes. Schaller et al. (2015) indicated that descriptive qualitative studies encompassed theme descriptions and the aggregation of appropriate methods. It applied the interpretive method in analyzing the contents of the qualitative studies. Since the qualitative and mixed-method studies in the systematic review have thin descriptions of the aggregative approach for qualitative synthesis.

The analysis process began with the reading and familiarization of the included studies. The second step was to investigate the informal caregiver's experiences using the selected studies. The final step was placing the AT into themes. Table 4 summarizes the themes based on each assistive technology's functionalities that support the informal caregiver providing care to persons with dementia.

Table 4. Summary of themes based on the functionalities provided by the assistive technology to support informal caregivers

Type of Assistive Technology Theme	Schaller et al. (2015)	Torkamani et al. (2014)	Núñez-Naveira et al. (2016)	Shaw et al. (2020)	Hastings et al. (2018)	Gaugler et al. (2021)	Gaugler et al. (2019)	Williams et al. (2021)	Mitchell et al (2020)
	eHM-DP	**ALADDIN**	**UnderstAID Application**	**FamTech Care**	**Video Support***	**RAM**	**RAM**	**FamTech Care**	**RAM**
GPS Tracking						✓	✓		✓
Task Management	✓		✓	✓					
Education	✓	✓	✓	✓	✓			✓	
Caregiver Communication Platform	✓	✓	✓	✓	✓			✓	
Monitoring in Home Activity	✓					✓	✓		✓
Monitoring Patient Environment		✓				✓	✓		✓
Managing Aggressive Behaviors		✓				✓	✓		✓
Telehealth	✓	✓		✓				✓	

*Video Enhanced Management (Video Calls Technology)

Question 1: What are the different AT interventions for people with dementia?

There are multiple assistive technology applications that caregivers could use to reduce their burden and stress. From the nine included studies, the researcher identified six unique technology interventions such as the UnderstAID Application (Núñez-Naveira et al., 2016), Remote Activity Monitor (RAM) system (Gaugler et al., 2021, Gaugler et al., 2019, Mitchell et al., 2020), video calls technology (Hastings et al., 2018), FamTechCare Intervention (Williams et al., 2021, Shaw et al., 2020), the eHM Dementia Portal (eHM-DP) (Schaller et al., 2015), and the computerized platform, ALADDIN (Torkamani et al., 2014). The AT available for people with dementia can help improve caregiver outcomes. The AT comprises a broad mix of active and passive devices that support interaction between the person with dementia and the caregiver from

these included studies. The devices had several uses, including electronic medication reminders, safety devices, and timekeeping devices (Hastings et al., 2018).

The identified AT devices and systems were for safety and security as they included video technologies to track the patient and home safety devices. They also included devices to support the orientation of people living with dementia. In this review, six studies evaluated AT to support basic activities of the person's daily living, such as walking and entertainment. The pilot studies [Schaller et al. (2015), Núñez-Naveira et al. (2016), Torkamani et al. (2014), Hastings et al. (2018)] reviewed the aids that could help people with cognitive impairment to live a more fulfilled life. AT improved the quality of life for the person with dementia by improving safety and independence, but the AT devices also had positive outcomes for the caregivers. For instance, it reduced the burden and stress of caring for troublesome people with dementia (Schaller et al., 2015). It helped address their behaviors, such as aggression and resistance (Williams et al., 2019). The six ATs identified in the nine articles [FamTech Intervention, ALADDIN, Telemedicine, Remote Activity Monitoring, UnderstAID Application, e-HM-DP] will be further explained in the following paragraphs.

FamTech Intervention:

With FamTech, caregivers submit challenging care situations to expert caregivers through video recordings. They then received feedback from an interventionist and solutions to all challenges (Williams et al., 2019). Linking family caregivers to dementia care experts using video-recording technology proved effective and efficient in reducing burden, depression, and disturbance while increasing competence (Williams et al., 2019). Furthermore, caregivers cite FamTech Care as easy to use while rating expert feedback as effective as it helps them address care challenges in a timely and efficient manner (Williams et al., 2021).

ALADDIN:

ALADDIN is a computerized healthcare platform enabled by technology. ALADDIN transforms patient care by integrating cutting-edge technology like blockchain, big data, and AI (Torkamani et al., 2014). ALADDIN offered educational material about dementia to caregivers, such as signs and symptoms and how to manage them (Torkamani et al., 2014). Such information played a crucial role in enhancing the caregivers' knowledge and competence in caring for their loved ones. Additionally, ALADDIN significantly reduced caregiver burden by providing the opportunity to constantly contact and communicate with clinicians who offered their support through remote monitoring. ALADDIN showed that communication and feedback between trained facilitators and caregivers could alleviate caregiver burden by teaching the essence of harnessing positive emotions in coping with stress. This, consequently, leads to positive outcomes for the caregivers and enhanced ability to take care of their loved ones (Torkamani et al. (2014). ALADDIN also incorporates telemedicine which is becoming increasingly popular in assisting with the home management of people/persons with dementia (PwD) by offering services to the carers that may enhance their ability to care for their relatives for longer (Torkamani et al. (2014).

Telemedicine/Video Support:

Telemedicine, also known as video support, is the exchange of medical information from one location to another. Modern technologies and networks enable formal caregivers to visit their clients, often via live video or still pictures collected and stored on a computer for future reference (Shaw et al., 2020). Any medical provider or institution may utilize telemedicine or a form of video support to get rapid access to emergency professionals, specialists, and further

education and information. It is the technique to share all assets with any healthcare facility around the globe. Telemedicine is used to connect caregivers and providers to aid in caring for a person with dementia in the safety and convenience of a home environment (Torkamani et al., 2014).

Remote Activity Monitoring (RAM):

RAM technology operates by monitoring a person with dementia while still residing in the home to keep them safe. RAM technology includes emergency mobile devices, wearable sensors, webcams, sensors, and GPS tracking devices (Núñez-Naveira et al., 2016), to name a few. RAM is utilized to track and monitor users for behaviors and challenging situations that could lead to adverse events while residing within the home (Mitchell et al., 2020). RAM consists of motion detectors or sensors that are placed throughout the home. Bathrooms, doors, kitchens, and bedrooms are monitored to keep the person with dementia safe. The RAM would alert the caregivers to activity that was not normal, either by telephone or email. Once a baseline period has been established, significant variations from that trend are signaled to caregivers using algorithms devised by the RAM supplier. Thus, caretakers are alerted to atypical activity trends that may signal a potential health concern (Gaugler et al., 2021, Gaugler et al., 2019, Mitchell et al., 2020).

UnderstAID Application:

A patient portal, a platform for managing patients' medical treatment. The online application allows patients to keep records of their health care provider visits, medical tests, billing information, and medications, among other things (Núñez-Naveira et al., 2016). Patients may also send queries to their provider via email using the site. This platform allows the user to

provide current and up-to-date information regarding the care of the person with dementia. The UnderstAID application is accessible through any device with an internet connection. The application also has a learning section that focuses on five modules and information on 15 different topics. The UnderstAID application also has daily task reminders, calendars, appointments, and medication management (Núñez-Naveira et al., 2016).

The eHealthMonitor Project- Dementia Portal (eHM-DP):

The eHM Dementia Portal (eHM-DP) was developed for the home-based dementia care setting. The eHM-DP is the electronic management of health information for better, safer, and more effective treatment (Schaller et al., 2015). The eHM-DP is an interactive web portal for dementia care. It seeks to deliver personalized support for informal caregivers of people with dementia in a home setting (Schaller et al., 2015). The overall aim of eHM is to provide individualized, personal health knowledge relevant to dementia stakeholders, accompanied by an improvement in the quality and acceptance of electronic health care services (Schaller et al., 2015).

Question 2: How effective is AT in supporting the well-being and quality of life of people with dementia?

The included studies suggested many measures to improve the informal caregiver's well-being outcomes, such as minimizing burden and stress. As indicated in Table 2, some measures did not significantly impact the caregiver's outcomes. However, these studies proved the value of assistive technology interventions such as RAM systems and video calls in managing dementia patients' activities. Núñez-Naveira et al. (2016) described how these interventions could be improved and customized to realize improved outcomes for the caregivers. From the quantitative

RCT trials, the review suggested that assistive technologies were somewhat or very useful in improving the operations of caregivers (Shaw et al., 2020). While they reported no significant changes in the reported caregiver's distress or burden, they also indicated no adverse events from AT incorporation in managing people with dementia. The RCTs suggested using AT to existing alternatives in specified settings, especially to improve the security and safety of people with dementia. The qualitative and mixed-method studies offered more significant insights into the need to use AT systems or applications (Williams et al., 2021, Shaw et al., 2020). Though the quantitative studies reported no significant change in outcomes, the caregivers concurred that the devices helped them improve the safety of the patients. They appreciated the incorporation of these devices into the management of dementia.

Question 3: How do AT solutions help in reducing the caregivers' burden when assisting people with dementia?

The mixed-method and qualitative studies indicated that the caregiver's experiences with assistive technologies were largely positive. The technology supported the nature of interpersonal relationships between the caregiver and the person with dementia. The relationship improved as the patients could feel safer and more secure within their environment. They also supported their social interactions. As a result, the technology helped the caregiver function better and built a positive rapport with the person with dementia. Hastings et al. (2021) indicated that video calls assisted the person with dementia nurture more engaging relationships and maintaining social connections with family and friends. The caregivers became more independent and enjoyed their freedom better. The caregivers were able to gain more time to perform personal activities, thus improving work-life balance. According to Williams et al.

(2021), controlling devices such as restrictive access and alarm systems enable the caregiver and the person with dementia to engage in more meaningful activities, thus reducing their burden and distress. The studies indicated that various AT solutions could positively influence the ability of caregivers to assist people with dementia.

Safety is another essential objective when working with people with dementia. All the RCT trials included in the review showed that assistive technologies had the potential to improve the safety of people with dementia (Gaugler et al., 2021, Gaugler et al., 2019, Mitchell et al., 2020, Torkamani et al., 2014, Schaller et al., 2015, Shaw et al., 2020, Núñez-Naveira et al., 2016, Williams et al., Hastings et al., 2018). The caregivers indicated that the technology enhanced the ability of the person to stay within the community and maintain their physical safety. The caregivers can enjoy more privacy and autonomy (Gaugler et al.). According to these caregivers, the tracking devices support safety and reassure the caregiver of their independence (Hastings et al., 2018). They also improved the caregiver's quality of life and the person with dementia (Mitchell et al., 2020). The caregivers in the review indicated that the technologies allowed them to be independent and become more effective at assisting the patients (Gaugler et al., 2021, Gaugler et al., 2019). They removed the stress and burden often associated with caring for people with dementia (Shaw et al., 2020). The caregivers enjoyed improved mental well-being and ease of living with a person with dementia (Núñez-Naveira et al., 2016). The improved independence of the person with dementia positively impacted the caregiver. They reported benefits in reducing the burden of caring for people with dementia (Torkamani et al., 2014).

In the meantime, the RCT and pilot studies showed that the caregivers were unsure about the overall impact of new technologies such as UnderstAID Application, Remote Activity Monitor (RAM) system, video calling technology, FamTech Care Intervention, the eHM Dementia Portal

(eHM-DP), and computerized platform, ALADDIN, on their overall performance. While many of them believed that these technologies would enhance their experiences with providing informal care and potentially reduce stress and burden, they raised different concerns regarding their use currently. For instance, Shaw et al. (2020) indicated that some people with dementia could not use assistive technologies. Furthermore, they argued that they removed the 'human' component of care (Torkamani et al., 2014). Some caregivers assume that the ability of people with dementia to live everyday lives could be further worsened when assistive technologies are applied in all aspects of their lives. They insisted that these people be challenged cognitively (Torkamani et al., 2014). Additionally, people with dementia could lose some aspects of social care alone with just technology (Gaugler et al., 2021). Thus, they suggested that future technologies should prioritize customization for specific settings.

Chapter Three

Summary of Main Results:

This systematic review aimed to identify the various types and uses of assistive technology when dealing with people with dementia and describe their effectiveness and the caregivers' experience with their use. Since the studies covered the last eight years, they provided a comprehensive view of assistive technology intervention in dementia care. Usually, informal caregivers are unpaid and related to the person living with dementia. While the role of a caregiver could be rewarding to the person, they are more likely to feel overwhelmed due to a lack of planning and workload. Caring for a person could negatively impact their overall mental well-being and put them in distress. The reviews showed that this is usually the case when the caregiver has little experience. The RCTs suggested that assistive technology could provide

solutions that enable the caregivers to stay with the patient within the community. However, the caregivers still experience multiple challenges and the burden of responding to repetitive questions, incontinence, and aggression from people with dementia. Though these technologies did not fully address the behavioral problems, they assured them of improved safety and monitoring, thus reducing the burden.

The review identified emerging technologies such as RAM systems that could be applied in different aspects of dementia care management. Nonetheless, the caregivers' reported no statistically significant change in their outcomes due to the technological intervention. Considering the qualitative and pilot studies, it is impossible to determine the effectiveness, efficiency, and satisfaction of the assistive technology applications when they are still at the early stages of implementation. Furthermore, the well-being of a person is subjective; thus, it is difficult to precisely assess the impact of assistive technologies in the short term. Despite these uncertainties, the review highlighted that the caregivers of people with dementia preferred specific types of assistive technology components such as video calls and tracking devices. They argued for the customization of the technologies to respond to the specific needs of people with dementia depending on their condition. As such, assistive technologies encompassing medication reminders could help reduce the natural effect of burden and enhance caregivers' satisfaction (Gaugler et al., 2019, Mitchell et al., 2020).

Overall Completeness and Applicability of Evidence:

The current review met the procedures for systematic search under PRISMA guidelines. The review met the requirements for completeness, resulting in clear and consistent conclusions. The overall completeness of the review also resulted from the fact that the inclusion criteria were as inclusive as possible. This was done by ensuring the data gathered from the included studies

answered the research questions about the thematic analysis. While some of the studies were limited in design and sample size, they effectively answered the questions. Torkamaani et al. 2014 suggested there was a significant improvement in the quality of life of the caregivers, with some reduction in caregiver burden and distress. This was measured by a series of independent *t*-tests that were carried out to identify any differences between the caregivers in the platform and control groups at baseline. The comparisons revealed significant differences in carer burden [Zarit; $t(58) = 2.063$, $p = 0.044$] and QoL [QOLS, $t(58) = -2.286$, $p = 0.026$].

The other studies suggested no significant change in the caregivers' outcomes due to AT's intervention. However, Schaller et al. (2015) suggested caregivers indicated a high degree of perceived support. In total, 89 % of caregivers would use the eHM-DP if access were provided. 33.3% of the caregivers were satisfied with the UnderstAID application and around 50% of the participants assessed it as pedagogically acceptable (Núñez-Naveira et al., 2016). After using UnderstAID the caregivers significantly decreased their depressive symptomatology (Núñez-Naveira et al., 2016). Shaw et al. (2020) showed there was improvements across the three categories: managing dementia behaviors, understanding disease expectations, and performing activity of daily living care. 80% of participants preferred video-delivered care instead of telephone calls for older adults with dementia and their informal caregivers (Hastings et al., 2018). Mitchell et al. (2020) suggested that RAM technology offered ongoing monitoring and provided caregivers with a sense of security. However, considerable customization was needed so that RAM was most appropriate for PwD. In the Gaugler et al. (2019) article, the authors research showed that the growth curve models had no direct or moderation effect of RAM on dementia caregiver outcomes. Following up with additional research, Gaugler et al. (2021) further mentioned the RAM system did not significantly affect caregiving outcomes. Caregivers

who utilized RAM technology and cared for relatives with: (a) less severe cognitive impairment; and (b) difficulty navigating around the home were more likely to indicate statistically significant increases in competence and self-efficacy. Williams et al. (2021) reported most of the caregivers reported benefits from the FamTech Intervention and that the caregivers found the support to be helpful and effective.

The findings could have resulted from the RCTs losing relevant data or not including the highest quality experimental design. The RCT trials were distinct in terms of study country and AT interventions. Despite this, it would not be easy to generalize these findings. Besides, some of the aspects of the intervention that were inconsistent with the review goals were excluded. When considering the limitations and nature of the data used, there is still a need for further studies on the suggested technological interventions before generalizing them to the entire population.

Quality of the Evidence:

All the studies were of high quality. They were consistent with the objectives that they were designed to achieve. For instance, the RCTs helped evaluate the caregivers' perceptions and experiences when using the assistive technology applications. The studies scored highly on clarity of focus, reliability, and validity in measuring the caregivers' burden using assistive technologies.

Limitations and Potential Biases in the Review Process:

The study reviewed multiple AT devices and measured outcomes from distinct population groups. The reviewer could not pool the results from all the studies. Furthermore, the studies

followed different methodological designs, i.e., quantitative, qualitative, and mixed-method approaches. The researcher also included only studies presented in the English language; thus, some suitable studies in other languages could have been ignored. The researcher scanned the reference lists of all studies included in the full-text review to address these limitations and potential biases. The researcher was confident that the review captured all the relevant studies meeting the inclusion criteria.

Agreements and Disagreements with Other Studies or Reviews:

The review suggested that some of the outcomes of AT devices or systems could not be sensitive enough for the caregivers to notice. There is a need to identify the AT interventions that can change how the users can feel. In line with this argument, Lynn et al. (2017) revealed that the inconsistency in the types of AT devices used in caring for people with dementia makes them difficult to evaluate and contrast. It also makes it difficult to classify these technologies. This observation was supported by other reviews and studies, which showed different ways of categorizing AT interventions for people with dementia (Lynn et al., 2017, McKechnie et al., 2014). For instance, these technologies could be classified based on their use, the stage of dementia of the person, functions, and availability, among others. As some of the caregivers in the RCT trials suggested, some of the AT technologies could be customized to attain the institution's goals or the home setting (McKechnie et al., 2014). It allows for more accessible and affordable AT interventions in non-institutional settings.

Whereas many AT interventions have been experimented with within institutional and lab-based settings, fewer interventions involve informal caregivers within community settings. Some of the interventions were general and thus suffered from design flaws. Studies failed to capture

the experiences of unplanned and unpaid caregivers in home settings concerning technological use in dementia care. Though the study suggested that assistive technology could be the most straightforward and least expensive approach to care within homes, it was clear that such technological advances were yet to take hold within such settings. It was evident from the Review that AT installation at the homes of people with dementia could be misconstrued as a one-off event, thus overlooking its potential as a continuous process of improving caregivers' outcomes. Similarly, the review showed that as users of assistive technology, the caregivers sometimes struggled to understand them. It was challenging for some users to engage with the technology within their home settings, leading to misunderstandings, thus reducing its effectiveness in reducing caregivers' burden (Sri et al., 2022).

The review revealed that caregivers had some concerns and fears regarding using various types of assistive technology. Some of the caregivers were unconvinced of the ability of these technologies to minimize their burden and stress when caring for people with dementia. Some of them insisted that these technologies could eliminate the human element in dementia care management, resulting in social isolation. In line with these arguments, McKechnie et al. (2014) explained that AT solutions such as tablet computers and other monitoring devices alerted the caregivers and gave them a sense of participation in the life of the person with dementia. However, with the increased use of technology the caregivers' became more absent when providing dementia care and management. While some caregivers suggested that this could be a good thing for mental well-being, no statistical evidence supported such claims. The RCT did not find evidence that AT solutions brought an integrated solution to caregivers and people with dementia. Marasinghe (2015) found that when the AT devices were used for specific functions

without integration with other technologies, they were more feasible and desirable. Caregivers preferred assistive technologies that were applicable for specific purposes.

AUTHOR'S CONCLUSION

Implications for Practice and Policy:

The reviewer recognized the rapid pace at which assistive technologies were used to manage various conditions, such as dementia were, advancing. From the review, one would recommend that AT interventions could be used to improve future outcomes for the caregiver and person with dementia. Although AT use in dementia care remains low, more research on AT solutions is needed to provide care for people living with dementia. AT would support caregivers, people with dementia, and families. As such, policymakers should identify appropriate technologies and adapt them into family-centered or community models. These interventions need to be geared toward achieving the person's specific needs living with dementia. Therefore, it is recommended that caregivers be trained on function-assisted domains such as tracking systems.

Additionally, the review suggests a shift in the design of AT interventions from the person with dementia perspective to a greater focus on the caregivers' needs. They should improve the outcomes for both the caregiver and the person with dementia. For example, AT should minimize the burden and stress among caregivers.

Implications for Research:

Due to multiple limitations, the included studies did not find statistically significant changes in the caregivers' burden and stress. This paper suggests that future studies focus on more AT devices and systems. It should consider combining different AT applications to offer more

significant support to the caregiver and enhance the person's quality of life with dementia. Future studies should emphasize AT solutions based on the specific experiences and challenges informal caregivers face during their care for people with dementia. These studies should consider the caregiver's ability to solve problems while considering AT use. The technological innovation should be designed to meet the person's specific needs with dementia.

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Appendix A: Literature Search Strategy

Database: Ovid MEDLINE(R) ALL <1946 to March 04, 2022>
Run date: 3/5/2022
Search Strategy:
---

1 exp Alzheimer Disease/ or alzheimer*.ab,kw,ti. (181885)
2 exp Dementia/ or dementia*.ab,kw,ti. (235704)
3 exp Memory Disorders/ (31719)
4 exp Cognitive Dysfunction/ (28714)
5 ((memory or cognitive or cognition) adj5 (disorder* or loss* or dysfunction* or decline* or impair*)).ab,kw,ti. (174843)
6 1 or 2 or 3 or 4 or 5 (419349)
7 exp Caregivers/ (44449)
8 exp Spouses/ or exp Adult Children/ (12622)
9 (caregiver* or care-giver* or caregiving or carer*).ab,kw,ti. (100337)
10 (informal or family or families or spouse* or partner* or adult-daughter* or adult-son* or adult-child* or dependent* or relative* or sibling* or folk*).ab,kw,ti. (4098795)
11 7 and 8 (1621)
12 8 and 9 (1582)
13 ((caregiver* or care-giver* or caregiving or carer*) adj10 (informal or family or families or spouse* or partner* or adult-daughter* or adult-son* or adult-child* or dependent* or relative* or sibling* or folk*)).ab,kw,ti. (29500)
14 7 and 10 (25430)
15 11 or 12 or 13 or 14 (38560)
16 exp Caregiver Burden/ (352)
17 (burden* or burnout* or exhaust* or wellness or well-being or health).ab,kw,ti. (2468414)
18 ((caregiver* or care-giver* or caregiving or carer*) adj5 (burden* or burnout* or exhaust* or wellness or well-being or health)).ab,kw,ti. (18461)
19 16 or 18 (18527)
20 15 or 19 (47398)
21 *Telemedicine/ or (telemedicine or tele-medicine or telehealth).ab,kw,ti. (40429)
22 *Remote Sensing Technology/ (2266)
23 ((Remote or home) adj5 (monitor* or sensor* or sensing or telemonitor* or tele-monitor*)).ab,kw,ti. (21672)
24 Self-Help Devices/ (5390)
25 ((assist* or self-help) adj5 (device* or technolog*)).ab,kw,ti. (38353)
26 exp Video Recording/ or (audiovisual recording* or videorecording* or video* or camera*).ab,kw,ti. (207917)
27 exp Videoconferencing/ or (video conferenc* or videoconference*).ab,kw,ti. (4331)
28 21 or 22 or 23 or 24 or 25 or 26 or 27 (303295)
29 6 and 20 and 28 (424)
30 limit 29 to (english language and yr="2010 -Current") (352)

Appendix B List of Abbreviations:

(PRISMA) Preferred Reporting Items for Systematic Reviews and Meta-Analyses
(AT) Assistive Technologies
(RAM) Remote Activity Monitoring
(eHM) The European eHealthMonitor Project
(MMAT) Mixed Methods Appraisal Tool
(RCTs) Randomized Controlled Trials
(GPS) Global Positioning Systems
(PwD) Persons with Dementia
(ICT) Information and Communications Technology
(ADRD) Alzheimer's disease and related dementias

Appendix C PRISMA 2020 Main Checklist

Topic	No.	Item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page i
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 5
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 7
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 9
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 8
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Appendix A
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Page 15
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 15

Topic	No.	Item	Location where item is reported
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 15
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 15
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Chapter 2
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Chapter 2
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item 5)).	Chapter 2
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Chapter 2
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Chapter 2
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Chapter 2
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Chapter 2
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Chapter 2
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Page 16
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Chapter 2

Topic	No.	Item	Location where item is reported
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 13
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Chapter 2
Study characteristics	17	Cite each included study and present its characteristics.	Chapter 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Page 27
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Chapter 2
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Page 16
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Chapter 2
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Chapter 2
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Chapter 2
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Chapter 2
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Chapter 2
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Page 25
	23b	Discuss any limitations of the evidence included in the review.	Page 25

Topic	No.	Item	Location where item is reported
	23c	Discuss any limitations of the review processes used.	Chapter 3
	23d	Discuss implications of the results for practice, policy, and future research.	Page 30
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	N/A
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	N/A
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	N/A
Competing interests	26	Declare any competing interests of review authors.	N/A
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

Appendix D Mixed Methods Appraisal Tool (MMAT)

Mixed Methods Appraisal Tool (MMAT)

Category of study designs	Methodological quality criteria	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?	✓			
	S2. Do the collected data allow to address the research questions?	✓			
	Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?	✓			
	1.2. Are the qualitative data collection methods adequate to address the research question?	✓			
	1.3. Are the findings adequately derived from the data?	✓			
	1.4. Is the interpretation of results sufficiently substantiated by data?	✓			
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?	✓			
2. Quantitative randomized controlled trials	2.1. Is randomization appropriately performed?	✓			
	2.2. Are the groups comparable at baseline?	✓			
	2.3. Are there complete outcome data?	✓			
	2.4. Are outcome assessors blinded to the intervention provided?	✓			
	2.5 Did the participants adhere to the assigned intervention?	✓			
3. Quantitative non-randomized	3.1. Are the participants representative of the target population?				*N/A*
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?				*N/A*
	3.3. Are there complete outcome data?				*N/A*
	3.4. Are the confounders accounted for in the design and analysis?				*N/A*
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?				*N/A*
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?				*N/A*
	4.2. Is the sample representative of the target population?				*N/A*
	4.3. Are the measurements appropriate?				*N/A*
	4.4. Is the risk of nonresponse bias low?				*N/A*
	4.5. Is the statistical analysis appropriate to answer the research question?				*N/A*
5. Mixed methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?	✓			
	5.2. Are the different components of the study effectively integrated to answer the research question?	✓			
	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	✓			
	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	✓			
	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	✓			