A SYSTEMATIC LITERATURE REVIEW OF MOBILE APPLICATIONS TO ASSIST PEOPLE WITH MILD TO MODERATE DEMENTIA IN THEIR DAILY LIVES

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ABSTRACT

The popularity of smartphones has made mobile apps an essential tool for people in managing their daily lives. Helping people with dementia to make good use of mobile apps can reduce the stress on the patient's family and society. Mild and moderate dementia can be eliminated Mild and moderate dementia may be mitigated through simple teaching and human-centered design approaches that accommodate individuals with difficulty using mobile apps. This paper aims to identify the functionality and usability of mobile apps for people with dementia by reviewing mobile apps that assist people with mild to moderate dementia in their daily lives. The study searched the literature in five databases - Pubmed, Web of Science, SpringerLink, Taylor & Francis, and IEEE Xplore - and conducted a quality assessment. This review found that mobile applications to assist with daily living primarily support people with dementia with shopping and payment, location, image storage, medication reminders, and social interaction. A personalised user interface based on the profile and condition of the person with dementia can enhance usability. Preliminary findings suggest that mobile apps for people with dementia can address daily living needs, increase independence, and ease the stress of home care.

Keywords: *Assistive Technology, Mobile Application, New Media Art, People With Dementia.*

1. Introduction

Dementia is a decline in several areas of mental functioning, such as memory, reasoning, and language. People with dementia (PwD) experience varying degrees of disruption in their daily lives (Ballard *et al.,* 2011). With the rate of population ageing increasing and the number of PwD expected to reach 130 million by 2050, the World Alzheimer's Report identified this as the most significant public health and social care challenge facing the world in the future (Prince *et al.,* 2015). Dementia has led to increased economic pressure on governments, communities, and families, with the cost of dementia care rising to US$2 trillion globally in 2015, which could overwhelm social services and health systems in the future (World Health Organization, 2017). Awareness of dementia is increasing, but the diagnosis and care of

dementia continues to bring social isolation and stigma (Garand *et al.,* 2009; Urbańska *et al.,* 2015).

There are still no effective medications that can treat or stop the progression of dementia (Lyketsos *et al.,* 2006), so non-pharmacological treatments are widely used as an intervention, including music therapy, reminiscence therapy, activity therapy, and aromatherapy. Moreover, as PwD need multifaceted support, these approaches can manage the patient's symptoms (Douglas *et al.,* 2004). The mobile health (mHealth) sector has proliferated in recent years, and people are using mobile apps on their phones or tablets to improve their physical health and seek medical care (WHO Global Observatory for eHealth, 2011). Many mobile apps for dementia exist, such as those that provide cognitive training, dementia diagnosis, or music therapy. Research has demonstrated that using health apps affects the physical, mental, and social health of PwD in several ways (Brown & O'Connor, 2020).

This article found extensive research on mobile applications developed for PwD following a pre-search, with some systematic literature reviews providing a more comprehensive summary of mobile app interventions in the healthcare experience of PwD but lacking a focus on the everyday lives of PwD. Given the findings and focus reported in previous reviews, this systematic literature review aimed to explore the functionality, development, and evaluation of mobile apps as presented in existing studies. The aim is to provide new research guidelines and care ideas for researchers and caregivers. This led to the following review questions for this review.

RQ1: What aspects of daily life do mobile apps support PwD?

RQ2: How can mobile apps developed for PwD be evaluated?

2.   Methodology

2.1   Eligibility Criteria

A review of mobile applications that assist in the daily lives of people with mild to moderate dementia was conducted using the PRISMA recommended systematic review methodology and quality criteria. Before the search, the inclusion and exclusion criteria for this review were first tailored based on the research questions presented in this paper. Research into the design of mobile apps for PwD is extensive, with numerous studies primarily aimed at providing medical interventions for PwD or screening for and preventing dementia. The studies related to these mobile apps have mainly focused on the last five years; therefore, no time frame for publishing articles was specified for this search. This article aims to find solutions to help PwD in their daily lives and maintain the dignity and human rights of PwD. With these aims in mind, the two authors deliberated and developed the inclusion and exclusion criteria in Table 1.

Table 1. Inclusion and Exclusion Criteria for the Systematic Review.

	Inclusion/exclusion Criteria
Population	PwD or dementia caregivers must be included in the study as participants. Older people who include only cognitive impairment or PwD who cannot be clearly identified are excluded from the literature.
Mobile applications	Apps must be usable on mobile devices such as phones and tablets. Exclude apps in other products such as fridges, rice cookers, and smart robots.
Objectives	Mobile applications must be intended to assist in everyday life. Articles with the purpose of medical intervention or dementia detection are excluded.
Type of study	The type of learning and the effectiveness of that learning method must be explicitly mentioned in the study.
Results	Studies must report the relevant findings of participants.
Language	The research must be published in peer-reviewed English journals or conference proceedings.

2.2 Search Strategy

The search keywords for this review were refined based on the research questions, and the search terms should appear in the title or abstract. As mobile apps developed for PwD are recent products, no date of publication of the literature was specified. The search was conducted from May 3 to May 15, 2022, and the databases selected for this search were Pubmed, Web of Science, SpringerLink, ACM, and IEEE Xplore. The authors manually searched the reference lists of included studies and screened articles citing these papers to help identify additional relevant studies. Table 2 documents the search terms used for this review and the results for each database.

Table 2. Database and Search Results.

Database	**Pubmed**	**Web of Science**	**SpringerLink**	**ACM**	**IEEE Xplore**
Search1	(dementia OR Alzheimer's OR Lewy bodies OR multi-infarct dementia）				
Results	310,402	319,042	211,248	3,299	4,194
Search2	(mobile application OR user interface OR iPad OR Android)				
Results	48,381	256,374	222,988	623,219	196,940
Search3	Search1 AND Search2				
Results	249	232	1,838	1,967	79

2.3 Screening and Data Extraction

The authors independently conducted article screening, first removing duplicates and articles in the literature review category; papers that were not peer-reviewed did not meet the inclusion criteria for this review. The authors then performed a preliminary reading of the titles and abstracts of the eligible articles to determine if they met the review criteria, and the screening and data extraction process are shown in Figure 1.

2.4 Quality Assessment

The authors conducted a quality assessment of the articles included in the review to investigate whether they contributed to the daily lives of PwD and whether they would be helpful for future relevant research. The authors tailored five questions (QA) for this quality assessment; each paper was assessed against these five questions and whether the study met quality standards.

QA1. Is there a clear research objective?

QA2. Are the mobile application features proposed by the study adequately described?

QA3. Are the design and iterative process of the mobile application adequately described?

QA4. Does the study have complete outcome data?

QA5. Do the results of the evaluation match the objectives of the study?

Each paper is graded by answering quality assessment questions and given a grade based on the total score for quality. Grades were divided into three categories, with studies that fully met the criteria for the questions receiving a score of "2" and studies that partially met the quality criteria receiving a score of "1". Studies that did not meet the criteria or were not mentioned in the literature received a score of "0". Results scoring "8" or above were considered high quality. Results with scores of "6" and "7" were considered to be of moderate quality, and results with scores of "5" or less were considered to be of low quality. Results with a score of "5" or below are considered to be of low quality. Considering the quality assessment scores, zero studies did not meet the quality criteria, and these results were ultimately excluded from this review.
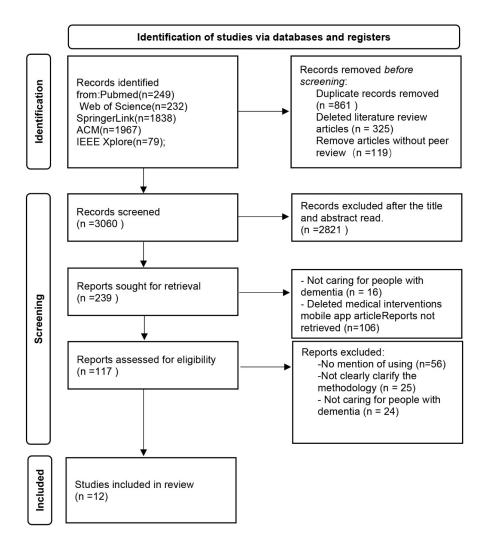

Figure 1. Flowchart of the Literature Search and Selection Processes.

2.5   Data Synthesis

Eligible papers were read in their entirety to extract key findings from the study objectives, participants, findings, and discussion sections. There are three stages to this data synthesis. First, this synthesis distils the critical points of each article included in the review. Secondly, the hardware, functionality, and design approach of the application adaptations presented in the study were reviewed. Finally, the paper categorises the resulting data in a standardised form, as shown in Table 3(a) until Table 3(e).

Table 3. Details of Included Studies (a).

Author	Research objectives	Methods	Participants	Mobile application	Findings	Quality assessment score
Savita *et al.* (2018)	The study's objectives are to identify gaps in the current provision of assistive technology for PwD and propose improvements to facilitate the daily lives of PwD.	Data collection: questionnaire; user testing: focus groups	Four PwD; aged between 41 and 65 years.	The primary function of the MyDem app is to help PwD identify everyday objects and to encourage PwD to retrieve lost memories through photographs.	This mobile app for PwD provides support to help increase freedom, enhance memory and reduce the stigma of forgetting basic things.	QA1:1 QA2:2 QA3:0 QA4:2 QA5:1 Total Score:6
Aljojo *et al.* (2020)	The study's objectives are to improve the quality of life of people with mild to moderate Alzheimer's disease and reduce the burden on the patients themselves and their caregivers.	Data collection: expert interviews; implementation and testing: questionnaires. Data analysis: questionnaire content analysis	177 caregivers and 177 people with Alzheimer's disease participated in the questionnaire.	The app features face recognition, task reminders, pictures, and GPS location.	This application dramatically supports the daily life of PwD, improves daily communication and maintains the patient's safety.	QA1:2 QA2:2 QA3:0 QA4:1 QA5:1 Total Score:6

Table 3. Details of Included Studies (b).

Author	Research objectives	Methods	Participants	Mobile application	Findings	Quality assessment score
Jung *et al.* (2020)	The study's objective was to evaluate the feasibility and effectiveness of a mobile application for diet assistants to provide meal planning and related skills training for caregivers and PwD.	Data collection: App collection of user-profiles, focus group interviews. User testing: controlled experiment, group interviews.	23 pairs of caregivers and PwD participated in the test	The app features four sections: pre-meal help, meal help, post-meal help and feeding help.	Findings suggest that mobile apps do not significantly impact dementia; meal options for PwD are potentially helpful.	QA1:2 QA2:2 QA3:2 QA4:1 QA5:2 Total Score:9
Griol and Callejas (2016)	The research aims to propose a framework that allows the development of context-aware multimodal conversational agents to base mobile applications for people with Alzheimer's disease, helping them to enhance their relationship with their environment.	Data collection: interviews and focus groups. Data analysis: analysis of questionnaire results.	17 participants with an average age of 58.7 years participated in the assessment	The app offers multimodal interaction with voice, visual, and haptic modes, providing six training modules for PwD.	The results of the application evaluation show that the multimodal interface is adaptable and scalable to the user and interaction environment.	QA1:2 QA2:2 QA3:2 QA4:2 QA5:2 Total Score:10

Table 3. Details of Included Studies (c).

Author	Research objectives	Methods	Participants	Mobile application	Findings	Quality assessment score
Muñoz *et al.* (2021)	The study aims to promote social experiences between PwD in nursing homes and others through play.	Data collection: observation of users and visits to staff; prototyping: collaborative design. User testing: test data recording and analysis, interviews with staff.	21 PwD. Six males and 15 females. Ages range from 72 to 89 years. Most participants had moderate dementia.	The app offers skill-based games as well as art and music for PwD。	The findings suggest that the mobile app can provide a wide range of meaningful and engaging activities for PwD; and help caregivers understand the skills, interests and social skills of care centre residents while creating meaningful social interactions.	QA1:2 QA2:2 QA3:1 QA4:2 QA5:2 Total Score:9
Yu *et al.* (2019)	The study's objectives were to assess the impact of a gaming app on the social, life and mood of PwD.	Data collection: a pilot study with 2-3 participants tested for post-test data collection and evaluation.	The average age of the 80 participants was 82.1 years, 58% of whom were female.	The app is a mobile multimedia and gaming platform that, in addition to communication, also offers reminiscence therapy for PwD.	Findings suggest that memory problems can improve emotional and social interactions in PwD. Mobile app-supported recall increases the translation of reminiscence therapy from research to practice.	QA1:2 QA2:2 QA3:2 QA4:2 QA5:2 Total Score:10
Lasrado *et al.* (2021)	The study aimed to promote the well-being and relationship quality of couples where one partner has dementia and to investigate the feasibility and acceptability of the proposed application.	Non-randomised feasibility design to evaluate a mobile app intervention in couples with a partner diagnosed with dementia over three months Data analysis: thematic analysis using deductive methods	A total of 44 couples participated in the user test.	The app offers interaction with family neighbours, planning events, sharing photos and music, and managing schedules.	The results show that the app can be used to address all aspects of daily life and interaction in the relationship of couples in which one partner has dementia.	QA1:2 QA2:2 QA3:1 QA4:2 QA5:2 Total Score:9

Table 6. Details of Included Studies (d).

Author	Research objectives	Methods	Participants	Mobile application	Findings	Quality assessment score
Rai *et al.* (2021)	The study's objectives are to provide cognitive stimulation and social interaction for PwD and caregivers through a mobile application.	Test method: A multicentre, single-blind, feasibility randomised controlled trial.	61 pairs of PwD and caregivers participated in the test	The app has three versions and offers several interactive games and social interaction features, including sound, art, life and more.	The findings suggest that well-designed touchscreen interventions can improve the well-being of PwD and benefit the quality of the relationship between PwD and their caregivers.	QA1:2 QA2:2 QA3:2 QA4:2 QA5:2 Total Score:10
Welsh *et al.* (2018)	The study aims to promote communication between older and younger PwD.	Data collection: expert review workshop Test method: Control group experiment	Two families involved in the assessment	The app supports PwD to interact with young people, guiding users to share digital media such as photos, music and videos with others.	Applying this technique has a broader impact on intergenerational relationships than simply encouraging the frequency of dialogue.	QA1:2 QA2:2 QA3:2 QA4:2 QA5:2 Total Score:10
Xiao *et al.* (2013)	The study's objectives are to provide a positioning tool for PwD, where users can complete independent outdoor trips under the supervision of a caregiver.	System evaluation: reliability testing, usability testing	Ten users participated in the test, including six experts	Fisheye lens frame grabber, compass and GPS camera	The test results show that users are quickly informed about their trips' current location and status and that the app is sufficient to solve the main problem of elderly detection.	QA1:2 QA2:2 QA3:0 QA4:1 QA5:1 Total Score:6

Table 7. Details of Included Studies (e).

Author	Research objectives	Methods	Participants	Mobile application	Findings	Quality assessment score
Morrissey *et al.* (2017)	The study aims to help PwD lead more meaningful and socially connected lives in their local communities.	Data collection: workshop series Data analysis: inductive thematic analysis	Workshop for 12 community caregivers and PwD	The app allows users to find, rate and review dementia-friendly locations (parks, shops, cafes).	The research suggests that designers need to translate empathy into action, playing to the strengths of PwD and positioning them to have the ability to make decisions around their life circumstances.	QA1:2 QA2:0 QA3:2 QA4:1 QA5:2 Total Score:7
Machesney *et al.* (2014)	The study's objective is to alleviate the isolation of PwD living in the community.	Data collection: user surveys, home visits	Thirteen PwD, age range 65-93 years.	A virtual pet companion that can interact with the user	The study concluded that virtual pets could reduce loneliness in PwD, and there were significant positive changes in the attitudes and demeanour of users and family members who took part in the test.	QA1:1 QA2:2 QA3:1 QA4:1 QA5:0 Total Score:6

The articles listed in this review focus on the use of technology to support individuals with dementia and their caregivers. The interventions discussed include mobile applications, conversational agents, virtual pets, reminiscing therapy apps, and cognitive stimulation therapy apps. While the studies varied in design, ranging from feasibility studies to randomized controlled trials, the majority received moderate to high quality scores. These scores justify the assertion that the articles provide valuable insights into the development and evaluation of technology-based interventions for people with dementia.

3.   Results

With the rapid development of mobile apps, the number of relevant studies has started to increase in the last five years, with studies mainly focusing on the period between 2017 and 2021. A total of 12 studies were included in this review, and overall, the number of studies included in the review was small and of moderate quality. The locations of the studies included 4 in the UK, 2 in the USA, 1 in Spain, 1 in Finland, 1 in Saudi Arabia, 1 in Australia, 1 in Malaysia, and 1 in South Korea. All the mobile apps presented in the studies are applicable to smartphones, with five mobile apps also available for tablets (Lasrado *et al.,* 2021; Machesney *et al.,* 2014; Muñoz *et al.,* 2021; Rai *et al.,* 2021; Savita *et al.,* 2018). Three of the studies mention the use of machine learning techniques in developing the apps (Aljojo *et al.,* 2020; Savita *et al.,* 2018).

3.1   Functions of mobile applications

  a.   Location and navigation

Older people often need to go out alone daily, and not all PwD have access to 24-hour on-the-go companionship due to limited social resources (Fazio *et al.,* 2018). For people with early to mid-stage dementia, wandering and getting lost in familiar neighbourhoods can be a problem (Griol & Callejas, 2016; Marco *et al.,* 2008), so providing location or navigation services is a way to ensure that PwD can travel safely. Studies have suggested that a combination of maps, street views, and snapshots can help to provide a complete picture of the location of a person with dementia (Xiao *et al.,* 2013). The bracelet identifies whether the user has left a designated area and then sends an alert to the caregiver (Aljojo *et al.,* 2020). This would enable remote operation of the phone while locating the user's location to obtain real-time photos of the environment, allowing the family to obtain an accurate picture of the user's environment. At the same time, the person with dementia only needs to carry their smartphone with them.

PwD can often feel like a burden on society (World Health Organization, 2020). The dignity of PwD is enhanced by providing them with a more connected life in their local area. Morrissey *et al.* (2017) propose a mobile app called 'Care and Connect', which enables users to locate nearby dementia-friendly places and evaluate their facilities and services. With this app, users can easily navigate to these locations and provide feedback on their experiences. However, this feature requires help from the local community.

  b.   Communication and companionship

PwD suffer from a physical decline in addition to stress from mental stress, including an increased risk of loneliness (Górska *et al.,* 2018). Loneliness is caused by the lack of connection between PwD and society. Studies have demonstrated that increased loneliness with low social support exacerbates the risk of death in PwD (Poscia *et al.,* 2018). The Muñoz *et al.* (2021) study worked with elderly care centres to provide a mobile gaming app for PwD.

Users can play the game alone or with others, and the game features animals, places, clothing, and other common culture of older people to promote interaction between users and recall. Patients with dementia could quickly learn simple touchscreen interactions and interact with other residents in the care centre in a casual game for a positive shared social experience.

Pet-assisted therapy is emotionally beneficial, and robotic pet therapy has been shown to have a positive impact while reducing the adverse effects of pet ownership. In a study by Machesney *et al.* (2014) a virtual pet companion mobile application was proposed that allows users to talk, touch, and interact with a virtual pet.

For PwD, communication and reciprocal relationships are intuitively essential to maintain a sense of identity, but the reality is that most PwD feel isolated (Dawson *et al.,* 2015; World Health Organization, 2020). As the primary social sphere for PwD is their loved ones and caregivers, Lasrado *et al.* (2021) propose a social app called 'DemPower', which aims to improve the quality of daily life for a couple whose partner has dementia. The app focuses on daily life, with the couple managing their life plans through the mobile app, providing actionable suggestions for the user (Lasrado *et al.,* 2021). Communication between PwD and younger family members is more challenging, as younger people are often unable to cope effectively with the abnormal behaviour of older family members due to the disease (McNaney *et al.,* 2017). The 'Ticket To Talk' feature allows young people to create a profile of their elderly and family members to work together to improve the profile of older people and explore important moments in their lives. The app can also share music, photos, videos, and more (Welsh *et al.,* 2018).

c.   Planning and reminders

The application has the function of setting reminders. Studies have shown that reminder devices can improve medication adherence in patients with mild dementia (Kamimura *et al.,* 2012), and it is very convenient to set reminders on smartphones that are carried by the elderly (Baric *et al.,* 2019; Zain, 2019). An 'Alzheimer assistant' proposed in a study by Aljojo *et al.* (2020) can remind users to complete necessary daily tasks. Research by Lasrado *et al.* (2021) provides advice and planning for couples' daily lives, and users can add reminders and manage their schedules in the programme's planning feature. A study by Jung *et al.* developed a comprehensive meal app for patients and nurses at a dementia care centre in Korea. The app provides meal advice for dementia patients and includes reminder functions such as meal reminders and meal plans (Jung *et al.,* 2020).

3.2   Evaluation strategies

a.   Feasibility testing

This review found that during the development of mHealth applications, studies focused on testing feasibility and assessing effectiveness based on the results. Testing in several of the studies focused on the feasibility of mobile applications. The periodicity of feasibility testing varied. The primary outcomes used in these studies were usability and user satisfaction, with studies emphasising that users were satisfied and that the interventions were feasible.

In a study by Xiao *et al.* (2013), ten users participated in the test, including six specialists and four students. The results of the questionnaire feedback were that the user could easily understand the current location of the person with dementia as fed by the mobile app, which illustrates the validity and intuitiveness of the app. Savita *et al.* (2018) conducted a user test with four PwD. All participants completed the test task, with only one person with the oldest dementia taking longer to complete due to limited motor skills. This demonstrated the usability of the programme. The participants all agreed that they could recognise everyday objects without relying on others using 'MyDem'. A study by Aljojo *et al.* (2020) conducted

an experimental usage survey with 100 users who answered a questionnaire after using the programme. The test results showed that users were confident in their abilities, believed in the system's effectiveness, and that the application was friendly, fast, and effective. A study designed to promote a social experience between PwD and visitors conducted usability tests with 21 residents and carers. The tests were conducted over three months, and the results showed that the games facilitated interesting binary interactions and provided residents with opportunities for conversation, reminiscence, and enjoyment (Muñoz *et al.,* 2021).

b. Outcome assessment

Three articles focused on evaluating caregiver-related outcomes and reported positive results from using the mHealth app in caregiver activities. Jung *et al.* (2020) used a mixed-methods study, including a control group study and feasibility assessment. The focus group interviews' results supported the mobile app's potential usefulness for caregivers of PwD, and the programme was suitable for caregivers requiring dietary-assisted education. Morrissey *et al.* (2017) used a series of workshops with participants to discuss revisions to the app, along with qualitative data analysis with one-to-one participation. The thematic analysis results indicated that the mobile app could be used to improve their living environment and that caregivers were fully empowered to use the technology. In addition, iterations of the mobile app need to account for the complex experience of living with PwD. A single-blind, randomised controlled trial evaluated 61 people with mild to moderate dementia and their caregivers. The results showed that caregivers using the mobile app rated the cognition and quality of life of PwD higher than the control group, and the programme was considered usable and enjoyable (Rai *et al.,* 2021). The Griol & Callejas study administered questionnaires to PwD and caregivers to assess their perceptions of the interaction. The evaluation observed that users felt that the system understood their intentions and suited their preferences. The final satisfaction level also indicated that the programme was working correctly (Griol & Callejas, 2016).

The study by Machesney *et al.* (2014) assessed 13 PwD who lived alone, with a range of assessments including cognition, loneliness, self-esteem, and quality of life being administered to participants at the site visit. The assessment showed that PwD displayed uncooperative and impatient attitudes at first prevention. A significant positive shift in patient attitudes occurred after one week of using the virtual pet. A pilot study used a control group experiment, assessed at weeks 6 and 12, and the outcome data were analysed using intention-to-treat analysis and analysis of covariance. The experiment's outcome was improved social interactions in the group using the mobile app (Yu *et al.,* 2019). To investigate the potential of mobile apps to support conversations between PwD and young people, Welsh *et al.* (2018) conducted separate studies in two settings: a home and a nursing home. The researchers conducted a thematic analysis after interviewing participants and showed that the app helped facilitate communication between older and younger people but that PwD required some teaching to use the app. Lasrado *et al.* (2021) used a non-randomised feasibility design to evaluate the use of " DemPower" after one spouse has dementia. The results showed that 86% of couples accessed the app's full functionality and spent an average of 8 hours using it. The app was useful in 90% of participants' daily lives.

4.   Discussion

This review found that current research on mobile apps related to the daily lives of PwD is focused on economically developed regions, such as the UK, USA, and Europe. At the same time, the World Health Organization reports the highest number of PwD in the Western Pacific region in 2019 (20.1 million) and an additional 6.5 million PwD in Southeast Asia.

Most PwD are cared for informally in low- and middle-income countries, with the social care sector accounting for less than 15% of the cost of care (World Health Organization, 2015). PwD require more cost-effective and intelligent tools to improve their quality of life in the face of limited social resources, as well as to promote their independence of PwD (Cahill *et al.*, 2007).

Several studies have concluded that a closer connection to the community can be maintained by involving PwD in daily activities (Aljojo *et al.,* 2020; Griol & Callejas, 2016; Morrissey *et al.*, 2017; Welsh *et al.,* 2018; Yu *et al.,* 2019). The mobile applications identified in this review were mainly used for social interaction, location, companionship, scheduling, medication reminders, and meal assistance. For caregivers or family members, the focus of these mobile apps is on monitoring the location of the person with dementia, assisting the person with dementia with medication and meals, assisting the person with dementia with scheduling, and becoming more aware of the dementia condition (Jung *et al.,* 2020; Lasrado *et al.,* 2021; Rai *et al.,* 2021; Savita *et al.,* 2018).

The studies included in this review were each designed with different learning methods and objectives. Usability testing tests whether a piece of software accurately achieves its intended effect, and analysing user usage data yields intuitive and valid results (Xiao *et al.,* 2013). Interview and informal discussion methods are intuitive and help identify performance problems and user preferences in mobile applications. Mixed methods studies are suitable for assessing user experience, technical performance, and usability (Muñoz *et al.,* 2021; Welsh *et al.,* 2018). Developing mobile applications for PwD requires a good understanding of user needs. However, PwD often has trouble answering interview questions due to cognitive abilities and memory loss problems. Several studies have interviewed caregivers and experts on PwD to obtain more comprehensive information to improve the usability of mobile apps for PwD (Lasrado *et al.,* 2021; Morrissey *et al.,* 2017; Muñoz *et al.,* 2021; Savita *et al.,* 2018).

The current review also found that artificial intelligence techniques such as machine learning are gradually beginning to be used in this field (Aljojo *et al.,* 2020; Savita *et al.,* 2018). The mobile application proposed in the study by Aljojo *et al.* (2020) has face recognition and standard object recognition functions, where machine learning is applied to analyse a sample of a person's face, recording features and identifying objects based on the features that have been recorded. This feature helps PwD identify forgotten loved ones and everyday objects. Studies have shown that the app makes PwD more confident when socialising. At present, researchers have focused on machine learning algorithms to predict human life expectancy. In the future, researchers can try to apply the algorithm to predict the duration of dementia (Mansur Huang *et al.,* 2021; Pisal *et al.,* 2022).

A limitation of this literature review is the current rapid technological development of mobile applications and the small sample size of only 12 articles included in this review. Many programmes available in the mobile app market to assist older adults may equally apply to PwD. However, comprehensive data on these mobile apps' development and testing was unavailable.

5.   Conclusion

The main objective of this study was to explore the functionality and evaluation methods of mobile applications that assist in the daily lives of people with mild to moderate dementia. A systematic literature review was conducted to summarise previous studies' findings and shortcomings and provide recommendations for future research development. The findings of this review suggest that people with mild to moderate dementia have some ability to live independently and that some regions are starting to develop age-friendly and dementia-

friendly communities. The market for mobile apps to help PwD live independently is becoming increasingly promising as reliance on mobile devices such as smartphones increases. Mobile applications currently have great potential for the daily lives of PwD, but there is insufficient social and financial attention for this population.

Author Contribution

Author1 wrote the research methodology, conducted the statistical analysis, and interpreted the results. Author2 proposed the literature review topic and supervised the article's writing.

Conflict of Interest

The authors have no conflicts of interest to declare.

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