A Systematic Review of IS Literature in Dementia Care: An Application of the NASSS Framework

Zhengyang Feng
School of Computer Science
University of Technology Sydney
Ultimo, NSW, Australia
Zhengyang.feng@student.uts.edu.au

Jayan Chirayath Kurian
School of Computer Science
University of Technology Sydney
Ultimo, NSW, Australia
jayanchirayathkurian@uts.edu.au

Mukesh Prasad
School of Computer Science
University of Technology Sydney
Ultimo, NSW, Australia
mukesh.prasad@uts.edu.au

Nimish Biloria
School of Architecture
University of Technology Sydney
Ultimo, NSW, Australia
nimish.biloria@uts.edu.au

Priya Saravanakumar
School of Nursing and Midwifery
University of Technology Sydney
Ultimo, NSW, Australia
priya.saravanakumar@uts.edu.au

Research In progress

Abstract

The application of technologies in healthcare offers substantial benefits for stakeholders. Due to the recent advances in emerging technologies, these benefits are further improved for individuals experiencing chronic conditions, especially people living with dementia. Healthcare professionals, especially caregivers, could be assisted by such technologies in the monitoring and recording of health conditions of patients. However, the trend and type of technologies applied in dementia care and a comprehensive analysis of such technologies in dementia care are limited. Therefore, this study uses the PRISMA approach to examine previous studies, identify gaps, and outline research directions. In addition, the NASSS (non-adoption, abandonment, scale-up, spread and sustainability) framework was used as a tool for analysing healthcare technologies in dementia care. From the analysis, we identified five themes to support future research in dementia care. The key challenges associated with technologies in dementia care are ensuring interoperability, understanding economic and ethical implications, and aligning with patient and caregiver needs. In future studies, expanding the literature review could provide valuable insights into the significance of all the seven domains of the NASSS framework.

Keywords: Technology, dementia care, caregivers, NASSS framework

1. Introduction

In recent years, Australia has been grappling with an alarming surge in dementia cases, which is the second leading cause of death nationwide and will become the primary cause soon (Australian Institute of Health and Welfare, 2022). The scale of the issue is overwhelming, with over 421,000 Australians currently living with dementia, whereas the number is projected to be more than double by 2054 without significant medical breakthroughs (Dementia Australia, 2023). Distressingly, this trend has also extended to the younger demographics, with nearly 29,000 individuals experiencing early onset dementia, the figure is expected to climb substantially over the coming decades (Dementia Australia, 2024). The burden extends beyond those directly affected, with an estimated 1.6 million Australians involved in dementia care, underscoring the widespread societal impact of the condition (Dementia Australia, 2024). Furthermore, a substantial number of individuals living with dementia are residing within communities, presenting unique challenges for support and care services. Within aged care facilities, cognitive impairment is prevalent, affecting over two-thirds of residents, highlighting the critical need for emerging technologies to address the challenges of dementia care and support in Australia (Dementia Australia, 2024).

In addressing the complex challenges posed by dementia in Australia, Information Technologies play a crucial role in providing innovative solutions to support people living with dementia, their caregivers, and healthcare professionals (Bhargava & Baths, 2022). The rising prevalence of dementia has sparked a technological revolution in dementia care, with a focus on both patient-centric and caretaker-centric solutions. The patient-centric solution contains various technologies, such as wearable devices, virtual reality (VR), augmented reality (AR), interactive games and robots. Additionally, embedded sensors and health monitoring systems could be the major examples of caretaker-centric solutions (Bhargava & Baths, 2022).

Integrating Information Technologies in dementia care offers numerous benefits such as enhancing patient independence, safety, social engagement, mood, and overall quality of life (Bhargava & Baths, 2022). These technologies facilitate activities of daily living, encouraging healthy aging and reducing the burden on caregivers (Lee-Cheong et al., 2022). Health monitoring capabilities enable timely intervention by professional and informal caregivers, potentially improving health outcomes and

reducing healthcare costs. There are several challenges that have been discussed in the context of ethical practices and legal frameworks that safeguard the rights of people living with dementia (Lee-Cheong et al., 2022; Vollmer Dahlke & Ory, 2020). The major challenges are ensuring patient privacy, confidentiality, and security, which might decrease the confidence and trust of the public in these innovative technologies (Bhargava & Baths, 2022; Frisardi et al., 2022; Lee-Cheong et al., 2022). For instance, individuals and caregivers must be informed about the data collection protocols and should have the option to restrict the collection of sensitive information (Lee-Cheong et al., 2022).

Wearables and smart devices, offer an innovative approach to tracking and managing lifestyle habits, including physical activity, nutrition, sleep, and stress levels. Thorpe et al. (2019) suggest that it would be promising and feasible to adopt smartphones and smartwatches in the cognitive rehabilitation for people with early-stage dementia. The participants in the study were motivated to increase their activity by tracking their step count, along with substantial improvements in mobility and mood, reducing patient anxiety and caregiver burden. These devices provide actionable insights, allowing patients and caretakers to make informed decisions about the type of healthcare interventions and lifestyle adjustments.

Technologies like VR (Virtual Reality) and AR (Augmented Reality) aid in cognitive rehabilitation, while interactive games and robots enhance independence and daily living activities for people living with dementia. Matsangidou et al. (2023) suggest that VR has significant potential as a therapeutic tool in dementia care, especially in reducing behavioral and psychological symptoms of people living with dementia. They have created a VR system that effectively meets the needs of people with mild to severe dementia in long-term care facilities. Their contribution was in the design, implementation, and utilization of VR technology in dementia care. Although wearable AR headsets are still considered emerging and less user-friendly for aged people, Dickinson et al. (2023) found that AR is more tolerable than VR, with fewer side effects, whereas its reduced immersion is considered beneficial for older people. However, due to concerns about the ease of use, privacy, and data collection practices, AR has still not been widely utilized and implemented in dementia care.

Safety and security are paramount for people living with severe dementia or those living alone. Technologies, such as embedded sensors, might help monitor home activities and alert caregivers on emergencies. Anwar et al. (2023) have created a

novel, low-complexity wearable sensing system using RF (radio frequency) sensors for the early detection of conditions associated with vascular dementia. Health monitoring systems utilise sensors to track physiological data, offer real-time alerts and provide effective management plans. Enshaeifar et al. (2020) have developed a digital platform for remote healthcare monitoring and support in dementia care. The key feature of this platform is a clinical interface, which could be accessed by a monitoring team, which allows the care team to review in-home activities and physiological data securely, while maintaining the privacy of people living with dementia.

One of the limitations of the above studies is the lack of theoretical approaches used in analysis. Hence, the NASSS framework, developed by Greenhalgh et al (2017), has been chosen in this review to analyse technologies used by stakeholders in dementia care. This framework is a critical tool in health informatics for analysing and predicting the success or failure of healthcare technologies in real-world settings. NASSS stands for Non-adoption, Abandonment, Scale-up (e.g. local demonstration), Spread (e.g. application used in a new setting), and Sustainability (e.g. long-term use of an application), and it is structured around 7 domains. These domains are Condition and Illness, Technology, Value Proposition, Adopter System, Organization(s), Wider System, and Embedding and Adaptation Over Time. The "Condition and Illness" domain assesses the complexity of the medical condition and the technology's ability to meet healthcare requirements. The "Technology" domain examines characteristics, usability, and knowledge into existing systems, along with its adaptability to different contexts. The "Value Proposition" considers the perceived benefits among stakeholders, such as technology value and demand-side value to determine whether they are compelling enough for adoption. The "Adopter System" focuses on the preparation and role of stakeholders and potential resistance to the technology. "Organization(s)" evaluates the implementing organization's readiness, leadership support, financial health, and openness to innovation. The "Wider System" focuses on external influences like policies and regulations that affect the technology's application and implementation. Finally, "Embedding and Adaptation Over Time" assesses how the technology evolves, and adapts to changing healthcare needs, requiring ongoing updates, and training to remain effective. By providing a comprehensive view of these factors, the NASSS Framework offers valuable insights

into why certain healthcare technologies succeed or fail, guiding the design and implementation of effective health interventions.

Despite the growing adoption of technologies in dementia care, there remains a significant gap in the systematic evaluation of these technologies from a holistic, multi-stakeholder perspective. Existing literature tends to focus on individual technological solutions without addressing usability and effectiveness of these technologies. In addition, they often lack theoretical grounding, limiting the generalizability of findings. The NASSS framework, a widely recognized model for evaluating healthcare technologies, has been underutilized in dementia care research, particularly in assessing the multi-dimensional factors that influence technology adoption. This study aims to bridge these gaps by applying a rigorous systematic review using PRISMA and evaluating dementia care technologies through the lens of the NASSS framework to provide a structured understanding of their adoption, challenges, and future research directions.

Specifically, the objectives of this study are:

- Identify and categorize different technologies used in dementia care and their primary functions.
- Evaluate the challenges associated with these technologies in terms of usability, integration, and safety considerations.
- Analyse stakeholder perspectives, including caregivers, healthcare professionals, and people living with dementia, regarding technology adoption.
- Identify research gaps and propose future research directions to enhance the development and implementation of dementia care technologies.

Based on the above discussion, it is evident that there is an imminent need for research and development in the field of technologies for dementia care. Such initiatives will address the existing challenges and fully realize the potential of technologies in improving the lives of those affected by dementia. Therefore, this systematic review will shed insights into the intersection of technology and dementia care using the lens of NASSS framework. The PRISMA approach used to select relevant articles for this study is outlined in the next section.

2. Methods

2.1. Searching String

The literature search was conducted in the first six months of 2024. The following keywords and logical operations were used in the search: (dementia) AND ((care) OR ("aged care") OR ("elderly care")) AND ((technolog*) OR (application*) OR (system*) OR ("assistive technolog*") OR ("digital tool*") OR ("smart system*") OR ("healthcare technolog*")). The search was restricted to publications from 2020 to 2024 and the PRISMA method was used to structure the search. The decision to focus on studies published between 2020 and 2024 is based on the rapid advancements in technology within dementia care over the past five years. The field has seen significant developments in digital health solutions, and artificial intelligence, which were not as prevalent in earlier literature. Additionally, the COVID-19 pandemic accelerated the utilization of remote monitoring and assistive technologies.

2.2. Study Selection

This research has an Information Systems focus and hence initial literature was limited to information systems databases - AIS eLibrary, IEEE, and Scopus. Firstly, 955 articles were retrieved which was restricted to journal and conference papers. 193 items were excluded for the following reasons, including non-academic sources (e.g., webpages, and opinion pieces) or studies that did not focus on technologies. The title and abstract screening have further excluded 677 articles since they lacked direct relevance to dementia or assistive technologies or focused on unrelated fields such as general aged care. Finally, a full-text examination eliminated another 68 papers, leaving 17 articles which were focused on the use of technology in dementia care.

However, these 17 articles were not enough for transverse and longitudinal analysis. Therefore, the literature search was extended into the medical database – PubMed. A 4-step PRISMA process shown in figure 1 was adopted to gather relevant articles. The initial phase of the review involved retrieving 7,601 articles from PubMed, focusing primarily on journal articles and conference papers with a particular focus on technology in dementia care. This targeted selection led to the exclusion of 4,026 papers that included webpages, book chapters, and reviews.

Subsequent screening involved a title examination of the remaining 3,575 articles which then ascertained their direct relevance to the application of information technology or digital technologies in dementia care. The articles which merely mentioned dementia or technologies without a direct link or discussed unrelated topics such as healthy ageing was discarded, which resulted in removing another 3,469

articles. The final phase involved an in-depth review of the abstracts and full texts of the 106 articles that met the initial criteria. This rigorous criterion which focused on the unique and direct application of technologies in dementia care resulted in the further exclusion of 25 articles. In the final stage, 81 articles were selected for analysis. In total, 98 articles were selected from the four (i.e. AIS eLibrary, IEEE, Scopus and PubMed) databases. The PRISMA steps followed to select articles from the PubMed database is outlined below.

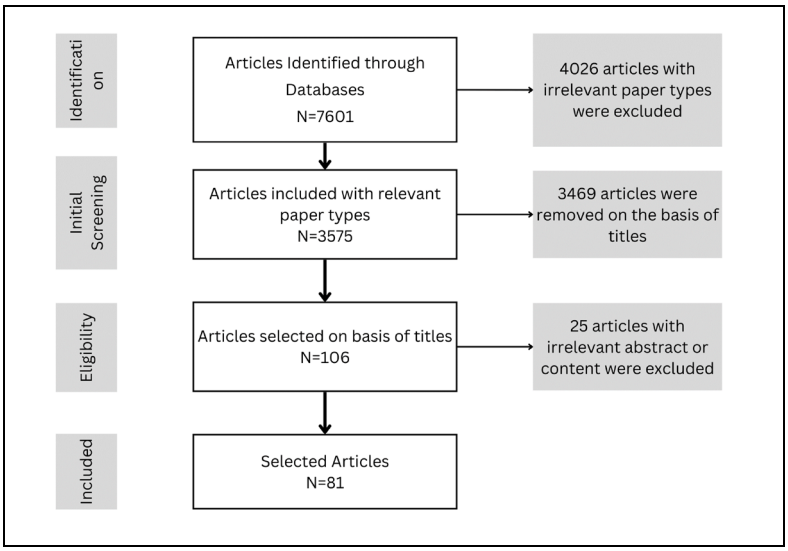

Figure 1 PRISMA steps

2.3. Thematic Analysis

To ensure a systematic thematic analysis on the adoption of various technologies on dementia care, Braun & Clarke's (2006) thematic analysis approach was followed. First, an in-depth review of the 17 selected papers from the information systems databases (AIS eLibrary, IEEE, and Scopus) was conducted to extract key findings related to technology adoption in dementia care. Next, initial coding was performed, identifying key characteristics, technological requirements, and adoption factors relevant to the NASSS framework. These codes were then clustered into broader themes, reflecting emerging challenges, value propositions, and stakeholder perspectives. The identified themes were iteratively refined to ensure internal coherence and alignment with the research objectives. Finally, the themes were synthesized into a cohesive narrative, highlighting key research gaps and future directions. The themes emerged from the literature, ensuring a data-driven approach, with the NASSS framework guiding their alignment with broader adoption and sustainability challenges in dementia care.

3. Findings

3.1. Distribution over time

As illustrated in Figure 2, studies related to technologies used in dementia care have uncovered specific trends, which reflect the evolving nature of research in this field. There was a significant upward trend in publication numbers from 2020 to 2022, which reached its peak in 2022 with 29 publications. However, the number of publications declined in 2023. It must be noted that only papers published in the first half of 2024 were considered in this review.

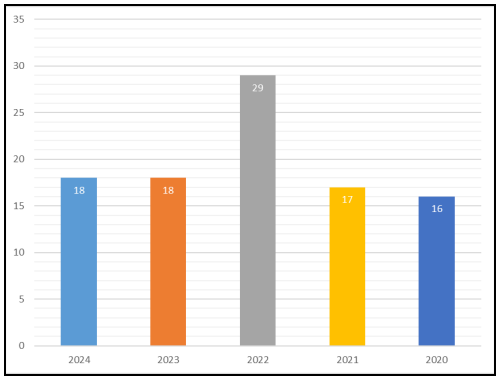

Figure 2 Number of papers across years

3.2. Distribution over technologies

In terms of technologies, there are 11 different technology groups defined by the Aged Care Research & Industry Innovation Australia (ARIIA, 2024). Research on various technologies used in dementia care highlights a diverse landscape as shown in Figure 3. Sensors and Monitoring Technology topped the list with 21 publications which represent 22% of the total number of publications selected in this study. Robots, with 13 publications (14%), reflected substantial interest with respect to the use of advanced technologies. There were 12 publications (12%) captured with a focus on Augmented or Virtual Reality. Assistive Technologies and Wearable Technologies, each had 10 publications (10%), and their focus was on people living with dementia. Studies on Telehealth was found in 9 publications (9%). Both Artificial Intelligence, Smartphones and Mobile Apps, with 7 publications (7%) each, was relevant with respect to health management. On the other hand, there were also publications focusing on Smart Homes, Care Management Systems, and Social Engagement Technologies, which were under 10% in total. This diverse spread of technologies illustrates a multi-faceted approach to dementia care, emphasizing the need to integrate innovative technologies to enhance patient outcomes and to support caregivers.

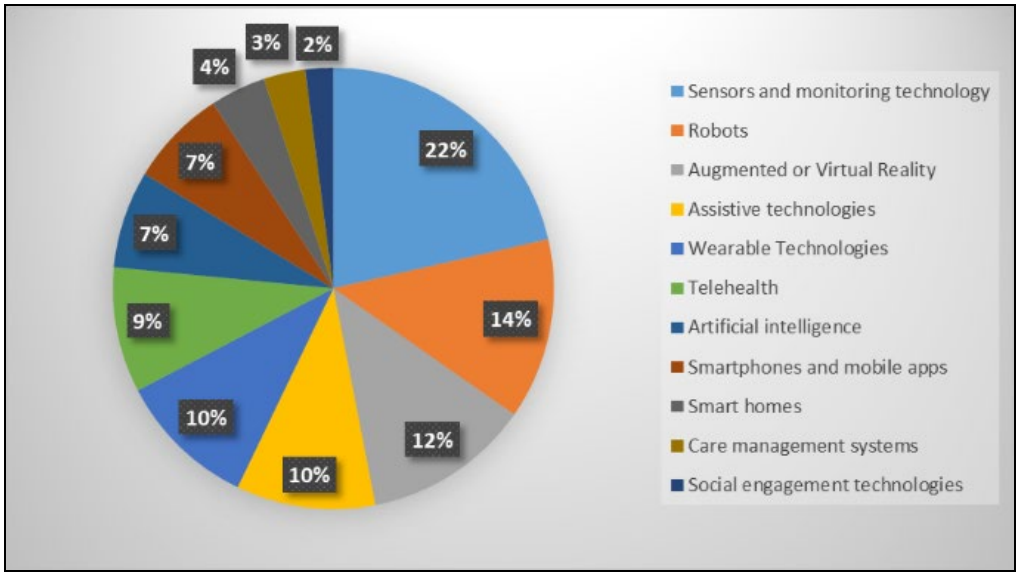

Figure 3 Number of papers across technologies

3.3. Research trend over time for various technologies

The distribution of technologies over time in Figure 4 exhibits patterns of various dementia care technologies over time, which reflects the evolving priorities and advancements within this field. It is evident that research on dementia care technologies experienced an increase in publications from 2020 to 2022. The number of publications was the highest in 2022, which could indicate a period of intense innovation and development. Specifically, Sensors and Monitoring Technology reached the highest number of publications in 2022 before significantly declining, suggesting a technological readiness level from design to implementation. Research in the Robotic field similarly maintained a consistent interest which could indicate ongoing innovations after the COVID-19 pandemic. Augmented or Virtual Reality has shown a relatively consistent and a gradual upward trend, reflecting its importance for cognitive and therapeutic purposes. There is a cyclical pattern examined in assistive technologies over time, and the fluctuation could possibly be affected by external factor such as cost, and government investment, mentioned in WHO report (World Health Organization, 2022). Overall, these trends suggest that while certain technologies have reached a maturation point, others are emerging in dementia care research, driven by ongoing technological advancements and changing healthcare needs.

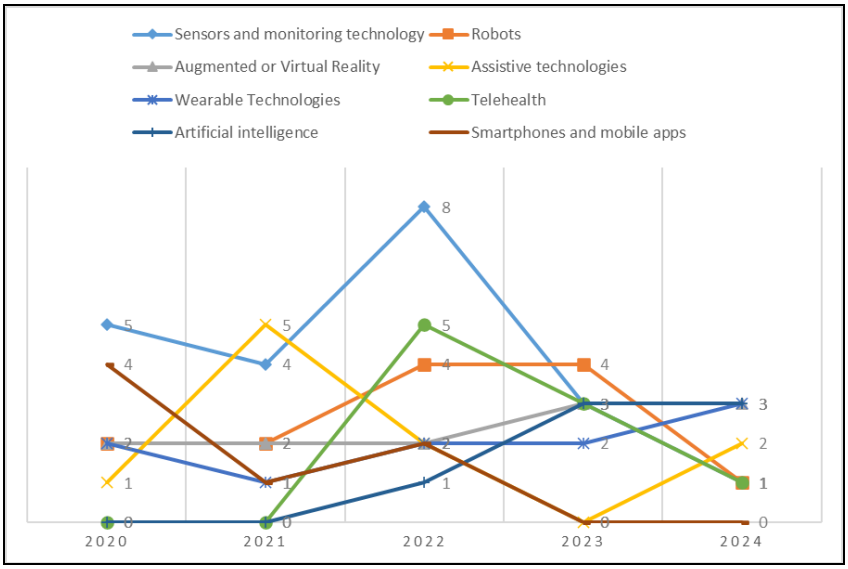

Figure 4 Number of Papers across technologies over time

3.4. Distribution over research methods

In terms of distribution over research methods, an article has been counted multiple times if it has adopted multiple methods. In that case, articles may appear in multiple categories. Among the Information Systems studies, 17 articles utilized a mixed methods approach, showcasing a preference for integrating both qualitative and quantitative methods. Among the articles, 14 were qualitative, emphasizing the importance of understanding the experiences and perspectives of those affected by dementia. 12 articles employed randomized controlled trials, and 11 adopted quantitative methods, reflecting an emphasis on rigorous, empirical evaluations of technologies. Additionally, 11 articles focused on design and implementation research, highlighting the development and enhancement of practical solutions. Eight articles used case study methodologies to investigate specific instances, while 7 articles included experimental research, testing hypotheses under controlled conditions. Pilot studies appeared in 5 articles, indicating the exploration of new interventions on a smaller scale. Prospective observational studies and cross-sectional surveys were the least common, each featured in 2 articles, suggesting a reduced dependence on observational data. Overall, the distribution of research methods underscores a need for multifaceted approach in advancing dementia care technologies, combining empirical rigor with experiential insights.

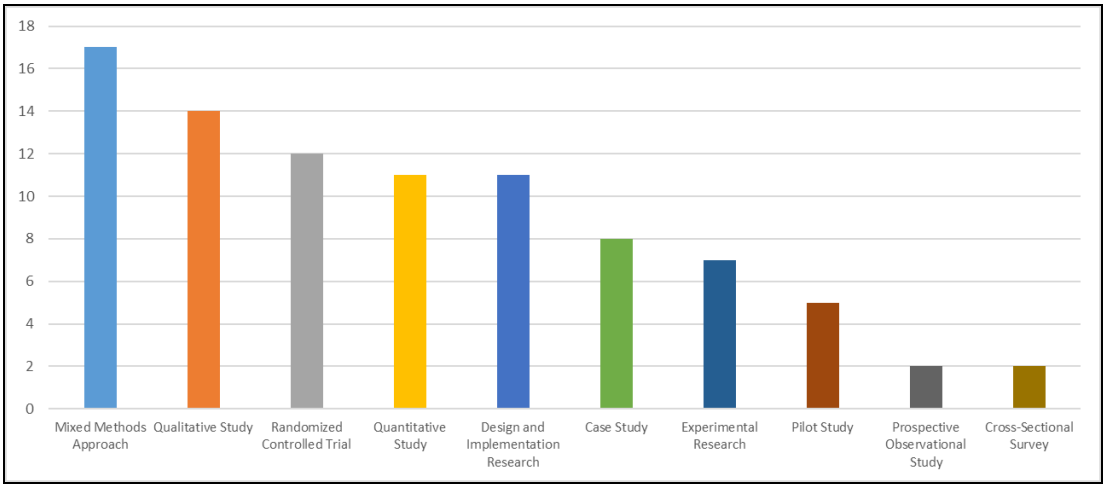

Figure 5 Number of papers across research methods

3.5. Theoretical evaluation based on the NASSS framework.

The NASSS framework was used as a theoretical assessment tool for evaluating the 17 Information Systems studies on dementia care technologies which include sensors and monitoring technology, virtual reality, augmented reality, smart homes, and wearable devices. There are 7 domains in the NASSS framework. Domain 1 (Condition and Illness – 1A,1B) of the NASSS framework examines the nature, characteristics, and impacts of dementia, assessing the extent of details provided about the illness. Domain 2 (Technology – 2A, 2B,2C,2D) evaluates the key features, associated knowledge, required support, and supply model of the technology, from basic to highly integrated levels. Domain 3 (Value Proposition – 3A,3B) considers the business case and value from both developers and user perspectives, focusing on desirability, efficacy, safety, and cost-effectiveness. Domain 4 (Adopters – 4A,4B,4C) analyses the perspectives of various stakeholders, including patients, caregivers, and healthcare providers, assessing their readiness and willingness to adopt the technology. Domain 5 (Organization – 5A,5B,5C,5D,5E) examines the suitability of a technology within existing organizational structures, considering workflow integration and resource allocation. Domain 6 (Wider System – 6A) examines the broader system context, including regulatory, policy, and market factors that influence the adoption and diffusion of the technology. Lastly, the Domain 7 (Embedding and Adaptation Over Time – 7A,7B) assesses the sustainability and adaptability of the technology over time. In the absence of extensive theory-based reviews in the adoption of technologies in dementia care, this comprehensive evaluation aids in understanding the adoption and spread of dementia care technologies in Information

Systems research. The domain questions (i.e. 1A to 7B) used in this study are adopted from the work of Greenhalgh et al., 2017). The analysis using the NASSS framework is outlined below in Table 1.

Articles	**Research Samples**	**Technology**	**NASSS Assessment High match (H), Basic match (B)**
Ambika et al. (2023)	N/A	Wearable Technologies	H: 1A,3A,3B; B: 1B, 2A, 2B, 2C, 4A
Appel et al. (2022)	Veterans with cognitive impairment	Virtual Reality	H: 2C, 3B; B: 1A, 1B, 2A, 2B, 3A, 4B, 4C, 7A
Fixl et al. (2021)	Healthy people from Poland and Austria	Assistive technologies	H: 1A, 2A, 2B, 3B; B: 1B, 2C, 3A, 4A
Gaikwad et al. (2023)	Aged People Suffering from Dementia	Sensors and monitoring technology	H: 3A, 3B; B: 1A, 1B, 2A, 2B, 2C, 6
Garcia-Constantino et al. (2021)	N/A	Smart homes	H: 2B; B: 1A, 1B, 2C, 3B, 4A,4B
García-Requejo et al. (2022)	N/A	Sensors and monitoring technology	H: 1A, 2A, 3A, 3B; B: 2B, 4A
Hamilton et al. (2021)	N/A	Augmented Reality	H: 2C, 3A; B: 1B, 2A, 2B, 3B, 4A, 4B
John et al. (2023)	Healthy users	Virtual Reality	H: 1A, 2A, 2C, 3A, 3B; B: 2B, 4A, 4B
Kocher et al. (2022)	Healthy users	Virtual Reality	H: 3B; B: 1A, 2A, 2B, 3A
Matsangidou et al. (2022)	People living with dementia, medical and paramedical personnel.	Sensors and monitoring technology	H: 1A, 2B, 3B; B: 1B, 2A, 2C, 3A, 4A, 4B
Megalingam et al. (2022)	People living with dementia and mentally unstable dementia patients	Sensors and monitoring technology	H: 1A, 2A, 2C, 3A, 3B; B: 1B, 2B, 4A, 4B
Moreno and Martínez (2023)	People with Acquired Brain Injury (ABI)	Robots	H: 2B, 3B; B: 1B, 2A, 3A, 4A, 4B
Pandhi andre Tiwari (2022)	N/A	Smartphones and mobile apps	H: 1A, 2A, 3A; B: 1B, 2B, 2C,
Perimal-Lewis et al. (2020)	Caregivers, Research Staff, Business Partners, older adults.	Smartphones and mobile apps	H: 1A, 3B; B: 1B, 2B, 3A,
Pratama et al. (2020)	People living with dementia or Alzheimer	Sensors and monitoring	H: 2A, 3A, 3B; B: 1A, 1B, 2B,

		technology	4A, 6
Schweiger and Wolff (2023)	N/A	Robots	H: 2B; B: 1A, 2A, 3A, 3B
Tarbert and Singhatat (2023)	Elderly people	Wearable Technologies	H: 2A, 3B; B: 1B, 2B, 3A

Table 1 Summary of reviewed articles

The theoretical assessment of various dementia care technologies, based on the NASSS framework, reveals significant insights into their alignment with the key domains. The Domain 1 (Condition and Illness) examines the nature of dementia, focusing on its characteristics and major impacts rather than specific comorbidities. Several studies, such as those by Appel et al. (2022) and Gaikwad et al. (2023), address these aspects by involving participants with cognitive impairments and dementia, providing detailed information on the chronic disease. In Domain 2 (Technology), the assessment encompasses key features, associated knowledge, support required for effective use, and the supply model. Technologies like Sensors and Monitoring (Gaikwad et al., 2023; Megalingam et al., 2022) and Virtual Reality (John et al., 2023; Kocher et al., 2022) were evaluated highly for their innovative integration and specific knowledge, often achieving level 2 in features and knowledge (2A, 2B). These technologies also demonstrate comprehensive support structures (2C). The Domain 3 (Value Proposition) evaluates both the business case and user demand. Technologies such as Wearable Technologies (Ambika et al., 2023; Tarbert and Singhatat, 2023) and Robots (Moreno and Martínez, 2023; Schweiger and Wolff, 2023) exhibit strong business models and high desirability, efficacy, and safety, often reaching level 2 in both developer's business case (3A) and demand-side value (3B). This robust alignment across NASSS domains underscores the potential effectiveness and market viability of these technologies in addressing the complex needs of dementia care.

Based on the analysis using the NASSS framework, researchers often focused on the Questions - 2A and 3B, as illustrated in Table 1. This indicates a primary interest in the key characteristics and demand-side value of technologies for dementia care. Key characteristics serve as the foundation of innovative technology, while understanding the demand-side value highlights the potential for technology utilisation, particularly in dementia care. By emphasizing these aspects, researchers can better assess and enhance the adoption and effectiveness of these healthcare technologies in dementia care.

3.6. Themes from Analysis

The components of the NASSS framework were used to analyse the overarching themes evident across the literature. The following 5 themes have been identified.

Theme 1: **Technology Optimization**. The analysis of technologies in dementia care reveals a significant focus on enhancing care outcomes through digital tools. A key focus is on the integration and prioritisation of monitoring and interaction technologies, with 22% of studies dedicated to sensors and monitoring devices. This underscores their role in continuous care and real-time health monitoring for dementia patients. This aligns with the study's research objectives by addressing the primary functions of these technologies (Objective 1) and how these technologies can associate with safety considerations (Objective 2).

Robots have also received considerable attention for their potential therapeutic benefits through interactive engagement. Additionally, immersive technologies such as augmented and virtual reality were explored for cognitive engagement and symptom management. Supportive technologies, including assistive and wearable devices, emphasise empowering dementia patients to maintain independence and safety in daily life activities. The growing importance of telehealth underscores the relevance of remote care delivery, particularly during situations like the COVID-19 pandemic.

However, research gaps have been found, including a need for comparative analysis to determine which technologies offer the most significant benefits. There is a lack of emphasis on the long-term adoption and sustainability of these technologies, including maintenance costs and integration into existing healthcare management. Only limited studies have integrated multiple technologies into holistic care models which must be addressed in future research. Further research which examines the impact of these technologies on caregivers, addressing their burden, stress, and daily activities at the workplace is also necessary to mitigate caregiver shortage in the aged care sector.

Theme 2: **Technological Advancements in Elderly Care**. The analysis of dementia care technologies reveals an evolving landscape, with a surge in published works reaching its peak in 2022. This could be driven by technological advancements in recent years and the wide-spread implementation of healthcare technologies during the recent pandemic. However, a decline in 2023 suggests a consolidation phase that could be attributed to the implementation of technologies. The key trends include the maturation of sensors and monitoring technologies, continued interest in robotics due

to social distancing and workforce shortages, and a growing focus on augmented and virtual reality technologies for cognitive and therapeutic applications. Despite these developments, there are still significant research gaps. There is a need to study the integration and interoperability of new technologies within the existing healthcare infrastructures and their interaction with other care processes in health care management. The economic and ethical implications of adopting such technologies, including cost-benefit analyses and considerations around continuous surveillance in robotics require more comprehensive research. Additionally, there is a lack of emphasis on patient and caregiver perspectives, with limited studies focusing on stakeholder feedback and experiences especially in dementia care. Furthermore, understanding user experiences is crucial for ensuring the usability and long-term acceptance of technologies in dementia care.

Theme 3: **Multidimensional Research Approaches**. The study of dementia care technologies showcases a comprehensive research approach, with a strong preference for mixed methods, reflecting a trend toward integrating qualitative and quantitative methods. Qualitative studies capture the lived experiences of those affected by dementia, essential for designing user-centered technologies. Empirical evaluations through randomized controlled trials and quantitative studies ensure the reliability of data and technology efficacy. However, significant research gaps remain. There are limited studies on the scalability of successful interventions, which is essential for transitioning technologies from pilot studies to full-scale deployment. Furthermore, the underutilisation of prospective observational studies and cross-sectional surveys limits valuable insights into the ongoing needs and impacts of technologies on broader population, which are essential for understanding technology adoption and usage in diverse cultural settings.

Theme 4: **Technology Characteristics**. The analysis of papers using the NASSS framework indicates a major focus on Domain 2A, which examines the key characteristics of technologies. This domain assesses the fundamental properties and functionalities of technologies, such as usability, reliability, and performance, which are crucial for their success in real-life care environments. Studies frequently emphasise these core attributes to ensure that technologies meet the specific needs of dementia care without adding complexity to users' lives. For instance, Fixl et al. (2021) highlighted the importance of seamless integration and robust data management in assistive technologies, addressing the critical components of Domain

2A. Similarly, John et al. (2023) explored virtual reality technologies to assess cognitive processing and dexterity, showcasing their potential therapeutic benefits for elderly people. However, there is a need for studies on the long-term usability and adaptability of technologies to understand how technologies perform over time and adapt to users' needs. Additionally, there exist a lack of cross-technology comparison studies to determine the most beneficial technology that can address the specific needs of patients and caregivers in dementia care. Addressing these gaps is essential for designing task-technology fit guidelines, ensuring ongoing and sustained effectiveness for stakeholders in dementia care.

Theme 5: **User Adoption impacted by Demand-side Value of Technologies**. The focus on Domain 3B within the NASSS framework underscores the importance of assessing the demand-side value of technologies in dementia care. Domain 3B examines how end-users perceive and value the technology in terms of desirability, efficacy, safety, and cost-effectiveness, which are critical factors for the adoption and sustained use of technology in real-life environments. Desirability involves the technology's appeal to users, particularly in terms of user-friendly design, accessibility, and the ability to meet the specific needs of targeted population, such as people living with dementia or older adults. Efficacy assesses the technology's effectiveness in achieving its intended purposes, such as improving communication, managing daily tasks, or ensuring patient safety. The safety aspect pertains to the technology's ability to operate without posing risks to users, crucial in settings involving vulnerable population. Cost-effectiveness considers both initial and ongoing operational costs, essential for scalability and accessibility. In relation to this domain, Perimal-Lewis et al. (2020) highlighted desirable design features in smartphones and mobile apps, such as large buttons and intuitive navigation, which are designed to cater the needs of older adults. The app’s efficacy was shown through simplified call functions and calendar reminders, aiding communication, and task management. Megalingam et al. (2022) emphasize the high desirability of sensor systems for dementia care due to its non-restrictive monitoring capabilities. The system's safety features prevent patients from wandering off, enhancing safety, and its low manufacturing cost makes it cost-effective for widespread adoption and use.

However, there is a need to conduct long-term impact assessments to understand how perceptions of desirability and efficacy evolve among stakeholders in elderly care. Other research gaps include comparative effectiveness and cost analysis, which could

support stakeholders in decision-making. Additionally, detailed examination of safety protocols and standards, especially in unsupervised settings are yet to be addressed. Furthermore, the cultural and contextual adaptability of these technologies is underexplored, which could be critical for their acceptance and effectiveness across diverse user groups. If these gaps could be addressed, the implementation and sustained use of dementia care technologies could be significantly enhanced, ensuring positive outcome for stakeholders in elderly care.

4. Conclusion

The five themes identified in this study highlights significant technological advancements and ongoing challenges in dementia care. Emphasis on monitoring and interaction technologies, robots, and immersive technologies such as augmented and virtual reality underscores their potential for improving care outcomes. However, several research gaps were found, particularly with respect to long-term adoption, comparative effectiveness, and holistic integration into existing care models. Specific trends were evident in dementia care which was driven by technological advancements and global healthcare shifts. There is a pressing need for research on the interoperability of new technologies, their economic and ethical implications, in addition to patient and caregiver perspectives to ensure their usability and acceptance in real-life environments.

A multidimensional research approach, blending qualitative and quantitative methods, is essential for capturing these technologies' comprehensive impact. Despite robust empirical evaluations, research gaps in scalability, integration into existing health care systems, and the impact on wider demographic could lead to further observational studies and cross-sectional surveys. The review of papers using the NASSS framework focused primarily on the two domains - key technology characteristics and demand-side value which provided a structured approach to evaluate health care technologies. Addressing the research gaps identified in this study can enhance dementia care technologies, improve the quality of life of patients living with dementia and more significantly, reduce the burden on caregivers. Therefore, future studies in this field are crucial for advancing effective and sustainable dementia care solutions.

5. Limitations

This review paper has several limitations which must be considered in the future work. First, more databases could be added to extend the insights from this review. Second, to emphasize on information systems studies, the AIS eLibrary database search could be extended into the past decade instead of five years. Including the senior scholar's basket of journals could also be considered. Lastly, the NASSS framework was applied to 17 studies from the Information System databases, while additional articles were excluded due to their focus on clinical outcomes, or patient well-being rather than adoption and scalability. Future research should consider applying NASSS to the other 81 studies, integrating clinical and technological perspectives for a more comprehensive understanding of dementia care technologies. This could provide further details on the significance of the domains of NASSS framework for future dementia care solutions.

6. Acknowledgement

We would like to acknowledge NeuronsVR for their invaluable support in providing specialised therapy for Aged Care and individuals living with Dementia through Virtual Reality (VR). We are particularly grateful for their contribution in offering VR training to two members of our research team, which has greatly enhanced our capabilities and enriched our research efforts.

References

Aged Care Research & Industry Innovation Australia (2024). https://www.ariia.org.au/knowledge-implementation-hub/technology-in-aged-care/types-technology-aged-care

Ambika, R., Deekshitha, S., Keerthana, N., & Vandana, K. (2023). Implementation of Wearable Device for Monitoring Alzheimer's Patients. 2023 International Conference on Smart Systems for applications in Electrical Sciences (ICSSES).

Anwar, U., Arslan, T., Hussain, A., Russ, T. C., & Lomax, P. (2023). Design and Evaluation of Wearable Multimodal RF Sensing System for Vascular Dementia Detection. *IEEE Transactions on Biomedical Circuits and Systems*.

Appel, L., Appel, E., Kisonas, E., Lewis, S., & Sheng, L. Q. (2022). Virtual Reality for Veteran Relaxation: Can VR Therapy Help Veterans Living With Dementia Who Exhibit Responsive Behaviors? *Frontiers in Virtual Reality*, *2*, 724020.

Australian Institute of Health and Welfare (2022). Dementia in Australia. AIHW, Australian Government. https://www.aihw.gov.au/reports/dementia/dementia-in-aus/contents/population-health-impacts-of-dementia/prevalence-of-dementia

Bhargava, Y., & Baths, V. (2022). Technology for dementia care: benefits, opportunities and concerns. *Journal of Global Health Reports*, *6*, e2022056.
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
Dementia Australia (2023). Dementia Prevalence Data 2024-2054. Australian Institute of Health and Welfare. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/ https://www.dementia.org.au/sites/default/files/2024-01/Prevalence-Data-2024-Updates-All-forms-of-dementia.pdf
Dementia Australia (2024, January 2024). *Key facts and statistics*. Dementia Australia. https://www.dementia.org.au/statistics
Dickinson, R., Kimball, J., Fahed, M., Chang, T., Sekhon, H., & Vahia, I. V. (2023). Augmented Reality (AR) in Dementia Care: Understanding its Scope and Defining its Potential. *The American Journal of Geriatric Psychiatry*, *31*(3), S132-S133.
Enshaeifar, S., Barnaghi, P., Skillman, S., Sharp, D., Nilforooshan, R., & Rostill, H. (2020). A digital platform for remote healthcare monitoring. Companion Proceedings of the Web Conference 2020,
Fixl, L., Parker, S., Starosta-Sztuczka, J., Mettouris, C., Yeratziotis, A., Koumou, S., Kaili, M., Papadopoulos, G. A., & Clarke, V. (2021). eSticky–An Advanced Remote Reminder System for People with Early Dementia. International Conference on ICT for Health, Accessibility and Wellbeing,
Frisardi, V., Soysal, P., & Shenkin, S. D. (2022). New horizons in digital innovation and technology in dementia: potential and possible pitfalls. *European geriatric medicine*, *13*(5), 1025-1027.
Gaikwad, V., Thopate, K., Chame, A., Jyoti, R., Arthamwar, V., & Khadde, M. (2023). A9G-based Dementia GPS Tracker. 2023 7th International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC),
Garcia-Constantino, M., Orr, C., Synnott, J., Shewell, C., Ennis, A., Cleland, I., Nugent, C., Rafferty, J., Morrison, G., & Larkham, L. (2021). Design and implementation of a smart home in a box to monitor the wellbeing of residents with dementia in care homes. *Frontiers in Digital Health*, *3*, 798889.
García-Requejo, A., Pérez-Rubio, M., Villadangos, J., & Hernández, A. (2022). Indoor-Outdoor Tracking and Activity Monitoring System for Dementia Patients. 2022 IEEE International Symposium on Medical Measurements and Applications (MeMeA).
Greenhalgh, T., Wherton, J., Papoutsi, C., Lynch, J., Hughes, G., Hinder, S., ... & Shaw, S. (2017). Beyond adoption: a new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. *Journal of medical Internet research*, 19(11), e8775.
Hamilton, M. A., Beug, A. P., Hamilton, H. J., & Norton, W. J. (2021). Augmented reality technology for people living with dementia and their care partners. 2021 the 5th International Conference on Virtual and Augmented Reality Simulations,
John, B., Subramanian, R., & Kurian, J. C. (2023). Design and Evaluation of a Virtual Reality Game to Improve Physical and Cognitive Acuity.
Kocher, S., Safikhani, S., & Pirker, J. (2022). Work-In-Progress—Exploring the Feasibility of Using Hand Tracking in VR Application for Memory Training

Exercises. 2022 8th International Conference of the Immersive Learning Research Network (iLRN),
Lee-Cheong, S., Amanullah, S., & Jardine, M. (2022). New assistive technologies in dementia and mild cognitive impairment care: A PubMed review. *Asian Journal of Psychiatry*, *73*, 103135.
Matsangidou, M., Frangoudes, F., Solomou, T., Papayianni, E., & Pattichis, C. (2022). Free of walls: Participatory design of an out-world experience via virtual reality for dementia in-patients. Adjunct Proceedings of the 30th ACM Conference on User Modeling, Adaptation and Personalization.
Matsangidou, M., Solomou, T., Frangoudes, F., Papayianni, E., & Pattichis, C. S. (2023). Offering Outworld Experiences to In-Patients With Dementia Through Virtual Reality: Mixed Methods Study. *JMIR aging*, *6*(1), e45799.
Megalingam, R. K., Kota, A. H., & Reddy, C. P. K. (2022). Indoor Tracking of Dementia Patients without GPS. 2022 2nd International Conference on Innovative Practices in Technology and Management (ICIPTM),
Moreno, L., & Martínez, P. (2023). Managing daily living activities for people with acquired brain injury using the DailyCare application. XXIII International Conference on Human Computer Interaction,
Pandhi, S., & Tiwari, R. (2022). Dementia Care: An Android Application for Assisting Dementia Patients. 2022 3rd International Conference on Intelligent Engineering and Management (ICIEM),
Perimal-Lewis, L., Maeder, A., Gordon, S., & Tieman, J. (2020). A tablet-based memory enhancement application for older users: Design approach.
Pratama, E. R., Renaldi, F., Umbara, F. R., & Djamal, E. C. (2020). Geofencing technology in monitoring of geriatric patients suffering from dementia and alzheimer. 2020 3rd International Conference on Computer and Informatics Engineering (IC2IE).
Schweiger, N., & Wolff, C. (2023). Robotic Support for Haptic Dementia Exercises. 2023 IEEE 11th International Conference on Serious Games and Applications for Health (SeGAH),
Tarbert, R. J., & Singhatat, W. (2023). Real world evidence of wearable smartbelt for mitigation of fall impact in older adult care. *IEEE journal of translational engineering in health and medicine*, *11*, 247-251.
Thorpe, J., Forchhammer, B. H., & Maier, A. M. (2019). Adapting mobile and wearable technology to provide support and monitoring in rehabilitation for dementia: feasibility case series. *JMIR formative research*, *3*(4), e12346.
Vollmer Dahlke, D., & Ory, M. G. (2020). Emerging issues of intelligent assistive technology use among people with dementia and their caregivers: A US Perspective. Frontiers in Public Health, 8, 191.
World Health Organization. (2022). *Global report on assistive technology*. WHO. https://www.who.int/publications/i/item/9789240049451