



Caregiver Adoption of Virtual Reality in Dementia Care: A Qualitative Study

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Abstract

This study examines the application of virtual reality (VR) therapies in dementia care through a systematic literature review and a qualitative analysis of caregiver responses from six aged care facilities in Australia. A PRISMA-guided review identified key technological trends, with VR emerging as a promising intervention alongside monitoring systems and robotics. The NASSS framework was applied to evaluate factors influencing technology implementation, highlighting challenges in long-term adoption, organizational readiness, and value propositions such as efficacy and scalability. To further understand VR's real-world impact, nine semi-structured caregiver interviews were analysed using the Gioia method. Findings revealed seven aggregate dimensions, with VR strongly supporting social connection, emotional engagement, behavioural management, and memory recall. Caregivers emphasized that personalized and culturally meaningful content, such as nature scenes, seasonal activities, and reminiscence-based experiences, enhanced therapy outcomes and resident participation. Despite benefits, barriers including physical discomfort, fear of unfamiliarity, and lack of training were noted, particularly for residents with advanced dementia. Early exposure, shorter sessions, and tailored content were key drivers of adoption. This study underscores that successful VR integration requires user-centred design, ongoing adaptation, and alignment with care routines, highlighting the critical role of frontline staff in translating technological potential into meaningful dementia care outcomes.

Keywords Dementia care · NASSS framework · Virtual reality (VR) · Gioia methodology

Introduction

Worldwide, dementia affects over 57 million people, with prevalence expected to rise steeply as populations age, particularly in low-and middle-income countries (World Health Organization, 2021, 2023). Recent World Health Organization reports highlight dementia as a leading cause of disability and dependency in older people and emphasise its growing economic burden, with global costs estimated at around US\$1.3 trillion in 2019 and projected to increase substantially in the coming decades (World Health Organization, 2025). Together, these trends frame dementia as a major global health and social policy priority that requires innovative, person-centred approaches to long-term care and support (World Health Organization, 2021, 2025).

Information technologies have emerged as essential tools for addressing the complex challenges in dementia care. The rise in dementia cases has prompted new technological solutions aimed at enhancing the quality of

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life for individuals living with dementia while alleviating the burden on caregivers and healthcare professionals. These technologies, encompassing both patient-centric and caregiver-centric approaches, possess the potential to transform dementia care by providing support that fosters independence, safety, social engagement, and overall well-being (Bhargava & Baths, 2022).

Patient-centric technologies include augmented reality or virtual reality (AR/VR), interactive games, and robotic systems, wearable devices, all designed to engage individuals living with dementia in ways that support cognitive and physical health. Wearables and smart devices, such as smartphones and smartwatches, provide continuous monitoring of physical activity, nutrition, sleep, and stress levels, thereby promoting active aging and self-management. Research by Thorpe et al. (2019) suggested that such technologies, especially step-tracking devices, can motivate individuals with early-stage dementia to increase activity levels, contributing to improved mobility, mood, and reduced anxiety.

VR and AR applications also hold promise in dementia care, particularly in cognitive rehabilitation and managing behavioural symptoms. VR systems, such as those developed by Matsangidou et al. (2023a, b), have been shown to reduce psychological symptoms and improve the residents' well-being in durable care facilities. Although AR technology is still emerging, its lower immersion compared to VR may make it more suitable for elderly users, as it is generally more tolerable and causes fewer side effects (Dickinson et al., 2023). However, the widespread adoption of augmented reality (AR) in dementia care has been limited, largely due to concerns about ease of use for elderly adults, who may struggle with wearable interfaces, and ongoing issues around data privacy, including how personal health information is collected, stored, and shared (Dickinson et al., 2023).

For caregivers, technology solutions such as embedded sensors and health monitoring systems offer substantial support. Caregiver-centric technologies include home-based sensors that track physiological data and provide alerts in real-time, which can be especially beneficial for monitoring individuals with severe dementia. Anwar et al. (2023) developed an RF sensor-based wearable for early detection of conditions linked to vascular dementia, representing a new approach to proactive health management. Enshaeifar et al. (2020) introduced a digital system that enables health monitoring remotely by allowing healthcare providers to securely access in-home activity and health data. This platform's clinical interface offers caregivers a comprehensive view of daily routines and health metrics, enabling timely interventions without compromising patient privacy.

Despite their advantages, integrating information technologies into dementia care raises ethical concerns, primarily around privacy, data security, and patient autonomy. Studies highlight

that users and caregivers should be fully informed about data collection protocols, with the option to restrict access to sensitive information (Lee-Cheong et al., 2022). Addressing these challenges is essential to building public trust in the use of technology for dementia care (Frisardi et al., 2022).

While implementation frameworks such as the Technology Acceptance Model (Meiland et al., 2017) have been proposed, few studies systematically examine how stakeholders accept, reject, or struggle to integrate these technologies into dementia care practice (Windle et al., 2023). The lack of applying theoretical frameworks in emerging technology-assisted dementia care research led to fragmented understandings of how contextual factors, such as facility infrastructure, staff competencies, policy environments, and funding models, either enable or constrain VR implementation (Bhargava & Baths, 2022). Most notably, existing studies tend to prioritize experimental outcomes or pilot usability metrics without sufficiently addressing the complex sociotechnical dynamics that underpin long-term adoption and scalability in care environments (Chung-Chih et al., 2024; Windle et al., 2022). Furthermore, caregiver practices, facility routines, and front-line resource constraints are insufficiently explored as determinants of VR use (Baudin et al., 2024; Windle et al., 2022). While there is emerging consensus that cultural relevance and therapy personalization are key factors in determining resident receptivity to VR, these aspects are often not built into system architecture or content libraries (Matsangidou et al., 2023a, b; Brooks et al., 2024; Dickinson et al., 2023). To address this gap, this review applies the NASSS framework developed by Greenhalgh et al. (2017), a comprehensive model evaluating seven domains crucial for successful technology implementation in health contexts.

These seven domains include: (i) Condition and Illness: examining the characteristics of illness (e.g. dementia) and how technologies can address such needs; (ii) Technology: evaluating usability, compatibility, and adaptability; (iii) Value Proposition: assessing stakeholder demand and perceived benefits; (iv) Adopter System: exploring roles, readiness, and resistance; (v) Organization(s): considering structural capacity and innovation readiness; (vi) Wider System: encompassing regulatory and policy environments; and (vii) Embedding and Adaptation Over Time: evaluating the technology's ability to evolve with changing care demands.

Research aims and questions The aim of this study is to evaluate the role of VR technology in dementia care, exploring user preferences to enhance personalised VR therapy solutions. Specifically, the study seeks to:

- (i) Examine the advantages and limitations of virtual reality (VR) technology in dementia care in comparison to other assistive technologies.

- (ii) Investigate the key factors that influence the adoption of VR-based therapies in aged care settings.
- (iii) Assess caregivers' perceptions of the effectiveness of VR therapy for residents living with dementia.

These objectives are guided by the following research questions:

RQ1: What are the primary benefits and limitations of using VR technology in dementia care compared to other assistive technologies?

RQ2: What are the main drivers and barriers affecting the adoption of VR therapies in aged care facilities?

RQ3: How do caregivers perceive the effectiveness of VR therapy for residents living with dementia, and what strategies can be employed to tailor VR experiences to residents' unique needs and care plans?

This study brings an Information Systems (IS) perspective to dementia care by using NASSS as an organising framework to integrate evidence from (1) a PRISMA-guided systematic review of technology-enabled dementia care and (2) a qualitative study of caregivers using VR therapies in Australian aged care facilities. Rather than treating NASSS as an after-the-fact labelling device, we mobilise its domains to (a) structure the literature review, (b) sensitise this qualitative analysis, and (c) theorise factors that interact with technological and organisational complexity from caregivers' interview.

This study extends prior VR/dementia research in three ways. First, we situate VR within the broader landscape of dementia technologies, comparing its value propositions and implementation challenges to those of sensors, robotics, telehealth, assistive tools, and other digital solutions. Second, we foreground caregiver perspectives on VR adoption and use, identifying how staff make local adjustments to manage behavioural symptoms, integrate VR into care routines, and negotiate financial and safety constraints. Third, by combining NASSS with Gioia methodology, we develop aggregate dimensions, that refine how the NASSS domains can be re-conceptualised in the context of dementia care.

Methods

We adopted a sequential, mixed-methods research design that integrates a PRISMA-guided systematic review with a qualitative inquiry informed by the NASSS framework and Gioia methodology. The systematic review (2020 to mid-2024) provided a theoretically informed map of technology-enabled dementia care, identifying which

NASSS domains are most (and least) addressed across technologies and study designs. Building on this landscape, we then conducted semi-structured interviews with caregivers in Australian aged care facilities that had implemented VR therapies.

The rationale for this integration is twofold. First, the review positions VR within a broader ecosystem of dementia technologies (e.g., sensors, robotics, telehealth), allowing us to compare its value proposition and implementation complexity with other solutions (NASSS Domains 1–4). Second, the qualitative phase deepens and contextualises these patterns by examining how frontline caregivers experience and actively shape VR implementation, revealing socio-emotional, cultural, and organisational dynamics that are often under-represented in the quantitative and experimental literature. Together, the two phases provide a richer, theoretically grounded understanding of VR adoption that neither approach could deliver alone.

In line with JARS-Qual guidance on transparent reporting of researcher context (Braun & Clarke, 2025), we briefly outline the positionality of the research team. The first author is a doctoral candidate in computer science with a background in information systems and emerging technologies, and led the systematic review, data collection, and qualitative analysis. Two co-authors are academics in computer science with expertise in health technologies, information systems, and mixed-methods research. Another co-author is based in architecture and contributes perspectives on human–environment interaction and experiential/spatial design relevant to VR therapies. A further co-author is based in nursing and midwifery and brings clinical and practice-based insight into dementia care and aged-care workflows. This interdisciplinary team informed the framing of VR as a sociotechnical intervention and supported reflexive discussion of the findings, helping to balance technological, design, and clinical viewpoints when interpreting caregiver accounts.

Systematic Review Following PRISMA

This study focused on a systematic literature review of information system technologies relevant to dementia care. We followed the PRISMA checklist to ensure a transparent and replicable process for identification, screening, eligibility, and inclusion of studies.

Databases and Search Strategy

Guided by an IS perspective, we searched AIS eLibrary, IEEE Xplore, Scopus, and PubMed for studies published between January 2020 and June 2024. The following search string was used: (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*”). Reviewed papers from all databases were exported into Excel for de-duplication and screening.

Inclusion and Exclusion Criteria

We included peer-reviewed empirical studies (journal articles and conference papers) that: (1) focused on people living with dementia or mild cognitive impairment (MCI); (2) reported on the design, implementation, or evaluation of a digital or technology-enabled intervention; (3) provided sufficient detail to assess at least one NASSS domain (e.g., condition characteristics, technology features, value propositions, adopter experiences); and (4) were published in English. We excluded review papers, editorials, purely conceptual work without empirical data, studies that addressed “healthy ageing” or non-dementia populations only, and papers where technology was mentioned but not used as a core component of the intervention.

Screening and Study Selection

The PRISMA flow in Fig. 1 summarises the four-stage process. An initial search retrieved 8,534 records. After removing 22 duplicates, titles and abstracts for 8,512 records were screened, resulting in 191 articles for full-text review. Full texts were assessed against the inclusion/exclusion criteria,

leading to 98 studies being retained for in-depth NASSS-based analysis.

Quality Appraisal

To ensure rigour, we conducted a structured quality appraisal using the following criteria i.e., clarity of research design, appropriateness of methods, and transparency of data collection/analysis. Each paper was rated independently by two members of the research team. Disagreements were discussed until consensus was reached. Studies were not excluded only on the basis of quality ratings, but also appraisal informed the weighting given to different findings in our synthesis and the focus on IS technologies in Dementia Care.

Data Collection

A total of nine participants (refer Table 1) were interviewed for this study, comprising seven females and two males, reflecting the gender composition commonly observed within the aged care workforce. Participants held diverse leadership and operational roles, including Senior Team Leader, Director, Facility Manager, Community Connect Leader, and Lifestyle Coordinator. They were drawn from six facilities (designated A through F) located across four Australian states: South Australia ($n=4$), Queensland ($n=2$), New South Wales ($n=2$), and Victoria ($n=1$). The facility A accounted for three participants, facility C for two, while facilities B, D, E,

Fig. 1 Article selection through the PRISMA approach

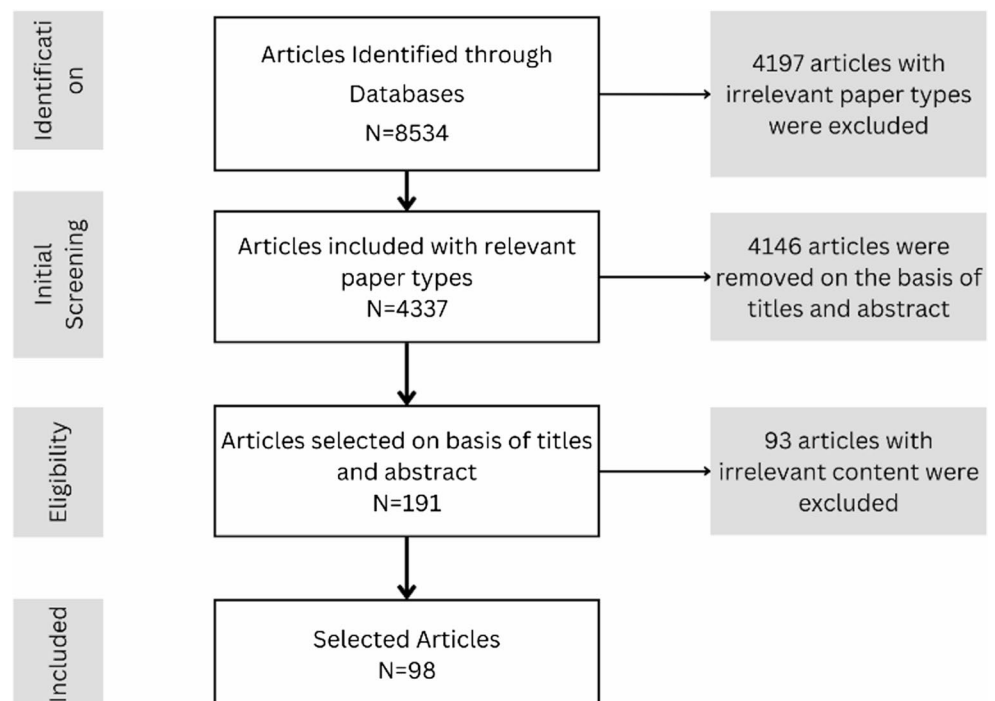


Table 1 Summary of interview candidates

Name No.	Gender	Profession Title	State	Facility
1	Female	Senior Team Leader	South Australia	A
2	Male	Director	Queensland	B
3	Female	Facility Manager	Queensland	C
4	Female	Community Connect Leader	South Australia	A
5	Female	Lifestyle Coordinator	Victoria	D
6	Male	Lifestyle Well-Being Coordinator	New South Wales	E
7	Female	Customer Wellness Coordinator	South Australia	C
8	Female	Manager	South Australia	A
9	Female	Leisure And Lifestyle Assistant	New South Wales	F

and F each contributed one participant. This purposive sampling strategy enabled the inclusion of varied perspectives from both metropolitan and regional settings. Participants' professional positions spanned administrative leadership, service coordination, and direct care oversight, thereby facilitating a comprehensive examination of organizational practices, care delivery models, and staff experiences. The heterogeneity of roles, facility contexts, and geographic distribution provided a robust foundation for capturing a nuanced understanding of the challenges and opportunities associated with aged care service provision, particularly in relation to technological and organizational innovations addressed in this research. Ethics approval for this study was obtained from the University's Human Research Ethics Committee (Approval No. ETH24-9828).

Methodology

The Gioia methodology was employed to ensure a systematic, rigorous, and transparent approach to qualitative data analysis and inductive theory development. Initially, researchers engage in open coding by extracting first-order concepts directly from participants' terms and expressions, maintaining the informants' perspectives. This phase emphasizes preserving the participants' voice to ensure authenticity and reduce researcher bias (Magnani & Gioia, 2023; Kumar & Shirish, 2023). Following this, researchers engage in second-order analysis, interpreting the first-order codes through a more abstract, theoretical lens to identify emerging second-order themes. These themes represent the researchers' conceptual insights into the underlying patterns in the data, thereby initiating the theorization process. Subsequently, related second-order themes are further clustered into aggregate dimensions that capture higher-level conceptual domains, providing a structured framework to explain the phenomenon under study.

The entire process is visually presented through a data structure diagram, typically moving from first-order concepts at the base, through second-order themes, to aggregate dimensions at the top. This hierarchical structuring enhances the transparency of the analytic process and strengthens the traceability from raw data to theoretical contributions. Finally, the findings are synthesized into a coherent narrative, often supported with illustrative quotations from the data, to demonstrate robust data-to-theory linkages and substantiate theoretical claims (Magnani & Gioia, 2023; Kumar & Shirish, 2023). Through these systematic steps, the Gioia methodology ensures both empirical richness and conceptual rigor, enabling the generation of novel and credible theoretical insights. The Fig. 2 below illustrates the step-by-step analytical procedure used in this study to derive 1st-order concepts, 2nd-order themes, and aggregate dimensions through NVivo coding and theory-centred interpretation, following the Gioia methodology.

Findings

Overview of Findings and Integration Across Phases

The results are organised in three parts. First, we describe temporal and technological trends in the dementia care literature, highlighting which NASSS domains are most frequently addressed. Second, we present a NASSS-informed synthesis of the 98 studies, focusing on how different technologies (including VR) are positioned in relation to condition characteristics, technology features, value propositions, and adopter systems. Third, we report the Gioia-derived aggregate dimensions from caregiver interviews and show how these extend and nuance the NASSS domains for VR in real-world aged care settings. Throughout, we connect literature-derived patterns (systematic review) with caregiver-reported experiences (qualitative phase) to derive more generalizable yet contextually grounded insights into VR adoption in dementia care.

Distribution Over Time and Technologies

Figure 3A shows an overall increase in dementia care technology publications between 2020 and 2022, peaking at 29 papers in 2022. A decline appears in 2023, and only studies published in the first half of 2024 are included, which may limit visibility of the most recent work.

Figure 3B summarises the distribution of the 98 studies across 11 technology categories (ARIIA, 2024). Sensors and Monitoring Technology is the most frequently examined ($n=21$; 22%), followed by Robotics ($n=13$; 14%) and Augmented/Virtual Reality ($n=12$; 12%). Assistive

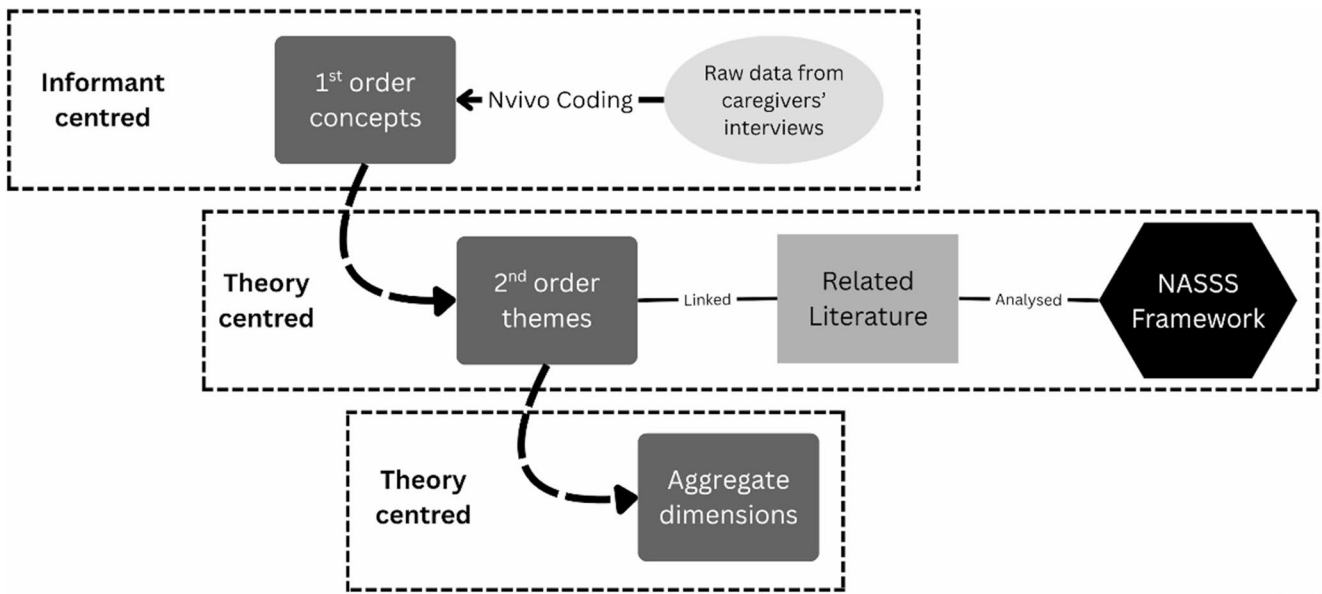


Fig. 2 Analysis procedure of gioia methodology

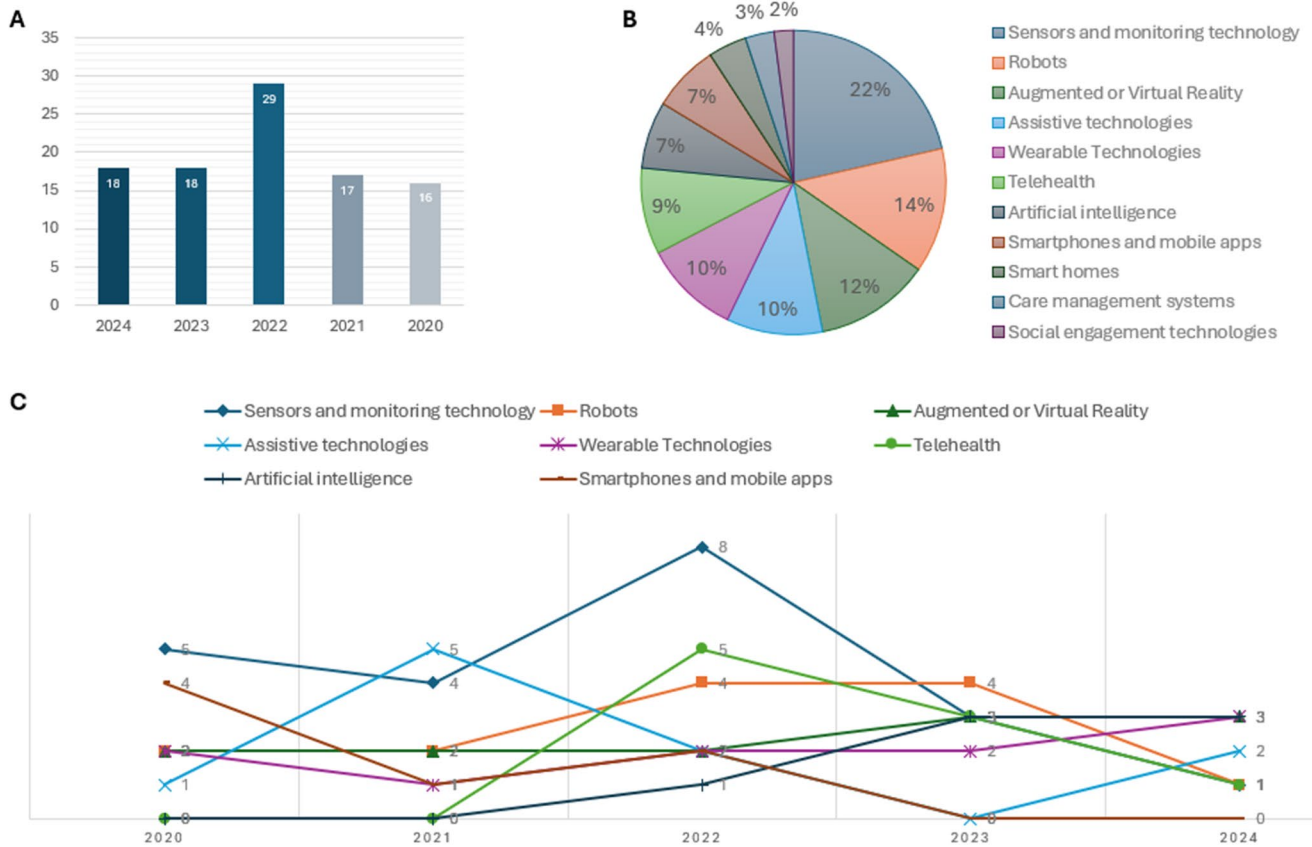


Fig. 3 Analysis on reviewed paper

Technologies and Wearable Technologies each appear in 10 studies (10%), Telehealth in 9 (9%), and Artificial Intelligence and Smartphones/Mobile Apps in 7 each (7%). Smart Homes, Care Management Systems, and Social Engagement

Technologies together account for the remaining publications, each representing under 10% of the total.

Figure 3C depicts how these categories vary over time. Sensors and Monitoring Technology peaks in 2022 ($n=8$)

and then declines. Robotics remains present throughout the review period, while Augmented/Virtual Reality shows a gradual increase. Assistive Technologies, Wearables, Telehealth, Artificial Intelligence, and Smartphones/Mobile Apps display fluctuating but continued activity, indicating ongoing interest across multiple technological approaches to dementia care.

Theoretical Evaluation Based on the NASSS Framework

Domain 1: The Condition According to the NASSS framework, the first domain for analysis is termed ‘the condition or illnesses’. This domain encompasses the nature of the illness, its sociocultural factors, and any comorbidities associated with it. Within the NASSS framework, the analysis under Domain 1 A, focused on the nature of condition or illness, reveals that dementia research spans a wide range of disease stages and subtypes, each presenting distinct symptoms and progression patterns. Alzheimer’s disease (AD) is the most prevalent form, characterised by memory loss and confusion. Vascular dementia often causes stroke, affecting decision-making and mood. Frontotemporal dementia impacts personality and behavior on younger individuals. Dementia with Lewy bodies involves visual hallucinations, Parkinsonism, and cognitive fluctuations, while Parkinson’s disease (PD) dementia follows motor symptoms. Mild Cognitive Impairment (MCI) may precede dementia, showing

early memory and cognitive changes. These types highlight dementia’s varied impacts based on affected brain areas. Other types include alcohol-related dementia, Creutzfeldt-Jakob disease, and Huntington’s disease (HD) (Robinson et al., 2015).

In this review, only a few types of dementia have been identified through the analysis of various studies using Domain 1 A assessment of the NASSS framework. These conditions include AD, MCI, PD, and HD, as shown in Fig. 4A. Additionally, papers that do not explicitly specify the type of dementia are considered to focus on general dementia (GD), indicating a non-specific dementia type.

Figure 4B illustrates the relationship between various technological applications and neurological conditions, with a clear emphasis on “General Dementia” (GD), a category used when studies do not specify a single type of dementia. Instead of targeting a particular condition, GD encompasses multiple types or an undefined dementia population. This general classification is associated with a wide range of technologies, including Wearable Devices, Virtual Reality, Telehealth, and Social Engagement Technologies, indicating that these innovations are broadly applicable across different dementia types.

There would be several reasons why many studies choose not to specify a single dementia type as their target. One major factor might be the overlap in symptoms and progression patterns among different forms of dementia, which

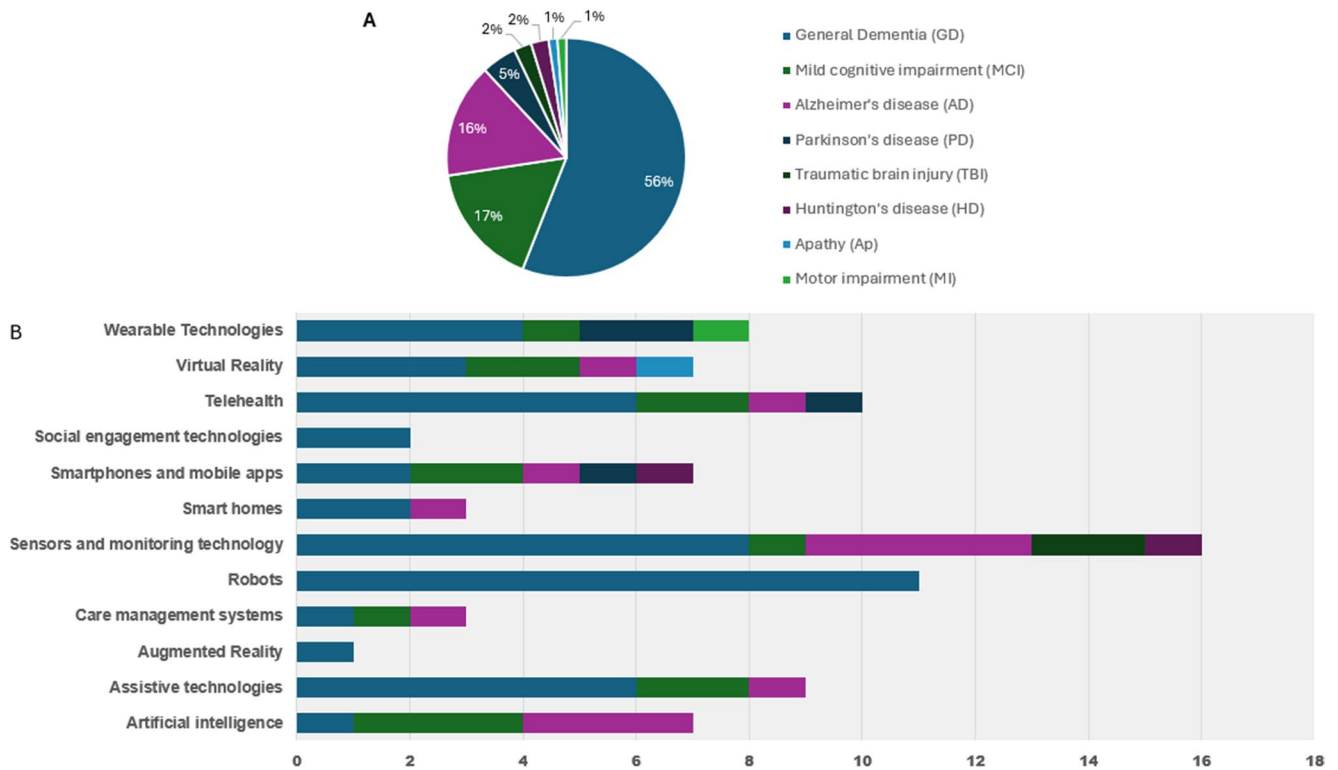


Fig. 4 Distribution of diseases with technologies

allows certain technologies, such as wearable devices or telehealth, to be effective across multiple conditions (Pietro, 2019). Researchers might also aim to develop solutions that are accessible and useful for various patient groups, acknowledging that a standardised approach can address multiple needs within the dementia community. Additionally, studies in this field might encounter challenges in accessing large, condition-specific populations, leading researchers to focus on broader dementia populations for practical reasons.

Mild Cognitive Impairment (MCI) also shows strong associations with several technologies, particularly Wearable Technologies, Virtual Reality, and Assistive Technologies. MCI is often considered an early stage of cognitive decline, so research tends to focus on early interventions that may slow progression and support patients in maintaining their independence.

In contrast, the connection between technology and specific diseases like PD, Traumatic Brain Injury (TBI), and HD is relatively weaker. This may be due to the limited availability of disease-specific studies or because research in these areas often prioritises other therapeutic approaches. However, specialised efforts do exist, as seen in Lipsmeier et al. (2022), which addresses Huntington's disease with a targeted technological focus.

Artificial Intelligence (AI) and Assistive Technologies are also strongly linked to GD and MCI, suggesting that much of the research aims to improve general cognitive support and early dementia care rather than focusing on specific conditions. Han et al. (2022) expands this scope by exploring Alzheimer's disease and related dementias (ADRD), addressing a broad category that encompasses various cognitive disorders.

This trend toward generalization in dementia research reflects a desire to develop versatile, scalable solutions that can benefit a wider population, acknowledging the overlapping needs and symptoms among different types of dementia. However, such a broad strategy could hinder the development of targeted interventions that address the unique challenges of specific diseases, suggesting an area for future research.

In the NASSS framework, Domain '1B' pertains to the sociocultural factors and comorbidities associated with dementia. However, an examination of existing studies reveals that many studies do not explicitly address these factors, often overlooking the broader clinical and socio-cultural context in which dementia care occurs. Comorbidities are particularly significant, as they commonly affect older adults with dementia and can influence the efficacy and safety of healthcare technologies designed for this population.

Studies such as those by Chary et al. (2024), Fan et al. (2024), and Rawtaer et al. (2020) identify common physical comorbidities associated with dementia, including hypertension, diabetes, and cardiovascular diseases. These conditions not only compound the health challenges faced by individuals with dementia but also may alter the outcomes of diagnostic and therapeutic interventions due to increased complexity in care needs. On the other hand, research by Campani et al. (2022) and Ruggiero et al. (2023) highlights mental health conditions, especially depression and anxiety, as critical comorbidities for dementia patients. These mental health issues are particularly impactful, as they can exacerbate cognitive symptoms and reduce patients' quality of life, underscoring the need for integrated care approaches.

The absence of a specific focus on sociocultural factors and comorbidities in the literature reflect a gap in understanding the full scope of patient needs. Given the prevalence of chronic diseases and mental health conditions in aging populations, incorporating these factors into the design and evaluation of healthcare technologies is essential for providing comprehensive and effective support for people living with dementia. This holistic perspective could lead to more effective, adaptable solutions tailored to the diverse challenges of dementia care.

Domain 2: The Technology The technology domain in healthcare includes various hardware, software, and data-driven components that power innovative solutions for patient care and management. As highlighted in NASSS Domain 2 A, recent technologies exhibit a range of capabilities, particularly in monitoring, assessment, and cognitive engagement. Many studies emphasise the use of sensors, machine learning, and interactive features, focusing on real-time monitoring and early detection of changes in patients' health status.

For instance, the Roche HD Monitoring Platform, as discussed by Lipsmeier et al. (2022), enables continuous data collection, providing quantitative measures that facilitate early detection of health fluctuations, particularly for degenerative diseases like Huntington's. This platform is instrumental in delivering precise insights through a combination of sensors and machine learning algorithms, which are crucial for personalised health management.

Technologies that incorporate gamified elements, such as those in the MINI robot developed by Aysan Mahmoudi et al. (2022) and cognitive exercises highlighted in Day et al. (2022), engage users more actively, promoting better adherence to therapeutic exercises. These tools leverage precise metrics, like the objective measurement of finger movements, to track cognitive and motor functions in users,

providing an engaging way to assess and maintain cognitive health.

Advanced data analytics and artificial intelligence (AI) are extensively employed to derive actionable insights, improving diagnostic accuracy and enhancing early detection of cognitive and neurological decline. For example, Abbas Saad et al. (2023) developed algorithms capable of identifying genetic markers and predicting disease progression, which are essential for personalised treatment planning. Similarly, the VR system created by Matsangidou et al. (2023a, b) offers a unique experience for individuals with mild cognitive impairment (MCI), allowing them to interact within customizable virtual environments, thereby engaging them in meaningful cognitive exercises.

However, customization options in these technologies remain limited. While several tools demonstrate impressive diagnostic and engagement capabilities, only a few provide users with personalization features that adapt to individual needs. For example, the personalised information delivery system by Fan et al. (2024) focuses on tailored educational content, yet broader customization options in terms of interface, features, and content selection are lacking across most platforms. This limitation suggests an opportunity for technology developers to enhance adaptability, making these tools more responsive to diverse user profiles and preferences.

In healthcare technology, Domain 2B of the NASSS framework focuses on the type of knowledge that a technology integrates and utilises. This domain examines how technologies leverage various forms of data and expertise to enhance patient care, diagnostics, and management. Many healthcare technologies bring in clinical knowledge, demographic insights, and specialised algorithms to better address specific health needs, often tailoring their functionality based on user profiles or specific conditions. For example, the machine learning algorithms studied by Zhang et al. (2024) utilise health and demographic data to predict disease progression and patient outcomes. This integration of predictive analytics allows the technology to adapt to each user's health trajectory, making it particularly valuable for managing chronic and progressive conditions, where anticipating changes in health status can guide more timely interventions.

Other technologies bring in psychosocial and cognitive support knowledge. For instance, the videoconferencing tool described by Brooks et al. (2024) in their work on social engagement technologies is designed to support counselling sessions for people living with dementia. This tool incorporates knowledge about effective psychosocial interventions and dementia care principles, creating an environment that fosters social connectivity and mental health support, which is crucial in managing conditions that impact cognitive

and emotional well-being. Similarly, assistive technologies explored by Baudin et al. (2024), such as digital calendar displays, use time management and cognitive assistance knowledge to help individuals with dementia or mild cognitive impairment maintain daily routines, thereby promoting independence and reducing caregiver strain.

Domain 2 C, on the other hand, examines the knowledge and support required for users to operate these technologies effectively. This includes the level of digital literacy, technical expertise, and any external support users may need to benefit fully from the technology. Many healthcare tools require users to have a foundational understanding of digital interfaces or seek support from caregivers or healthcare providers to maximise their utility. For instance, the machine learning algorithms used by Zhang & Xu (2024) demand technical expertise to interpret data outputs accurately. This can be a barrier for general users, so the system is often designed for use by trained healthcare professionals who can effectively leverage its insights in clinical settings.

Similarly, social engagement technologies, like the videoconferencing system in the study of Brooks et al. (2024), require users or caregivers to have basic proficiency in using video calls and navigating online platforms. While this technology may offer significant psychosocial benefits, its effectiveness is contingent upon the user's familiarity with digital communication tools, highlighting the need for technical support, particularly among older adults with limited experience in digital interactions.

For assistive technologies, like the digital calendar display described by Baudin et al. (2024), users or their caregivers need at least a basic level of digital literacy to set up and manage the tool. This technology provides cognitive support by displaying structured daily information, but its success depends on the user's ability to interact with and personalize it as needed. Additionally, technologies like the MINI robot discussed by Aysan Mahmoudi et al. (2022) may require guidance from healthcare professionals or caregivers to ensure users engage with the cognitive exercises correctly, thus maximizing therapeutic benefits.

Domain 3: The value proposition The value proposition domain within the NASSS framework evaluates the value and viability of introducing or developing healthcare technology for key stakeholders, including clinicians, patients, and suppliers. This assessment considers the potential benefits each group may gain from these innovations. Domain 3A of the NASSS framework assesses the supply-side value proposition of a technology, including its scalability, flexibility, market differentiation, data-driven insights, cost-effectiveness and efficiency, alignment with business objectives, and perceived innovativeness (Greenhalgh et al., 2017). In analysing domain '3 A' across a range of

healthcare technologies, two key aspects emerge: scalability and flexibility ($n=50$). These characteristics are especially critical for software and adaptable technologies that can be seamlessly integrated into diverse healthcare environments and modified to meet various patient needs. Such flexibility and adaptability are crucial as they allow technologies to serve a wide array of settings and user profiles.

For example, Yondjo & Siette (2024) highlight the benefits of web-based access, which enhances scalability and facilitates easy integration across multiple care environments. This approach emphasises the broad applicability of web-enabled solutions, making them accessible to different healthcare facilities. Villamil-Cabello et al. (2023) underscore the importance of scalability in mobile apps and compact devices, which extends the reach of these technologies to a larger audience by making them more portable and user-friendly. This approach helps keep the technology accessible to users with different levels of technical skill, promoting inclusivity in healthcare technology use. Similarly, Campani et al. (2022) designed their solution with scalability in mind, enabling mass production and distribution. By focusing on scalable design, they address the growing demand for accessible healthcare tools that can reach larger populations efficiently. This approach allows for increased availability and adoption, ensuring that the technology can benefit a broader demographic without extensive customization or resource demands.

Market differentiation and innovation ($n=24$) emerge as significant aspects, especially among technologies utilizing artificial intelligence (AI), virtual reality (VR), and advanced sensor systems. These technologies frequently offer distinct features that set them apart in a competitive landscape, often through specialised functions or unique integrations. For instance, Zolfaghari et al. (2024) highlight advanced sensor technologies that position a healthcare system as a distinctly innovative and competitive product. Sriram et al. (2021) described the integration of Internet of Things (IoT), AI, and wearable technologies with assistive devices as a method for advancing technological innovation and distinguishing products in the market. This combination of smart technologies enhances functionality and adaptability, addressing both patient needs and market demand.

Data-driven insights ($n=26$) form another vital dimension, as many modern healthcare technologies harness data through AI, machine learning, or sensor inputs to provide actionable insights. These technologies collect extensive data that enhances clinical decision-making, optimises patient care, and supports ongoing product refinement. For example, eye-tracking metrics can offer unique insights into patient engagement, allowing developers to tailor technology for improved usability and engagement, as explored

by Matsangidou et al. (2023a, b). Furthermore, detailed movement data captured through sensors enables more precise monitoring of patient activity, which can guide further research and innovation in patient care.

Additionally, Zhang et al. (2022) demonstrated how data on user behaviour and health outcomes, gathered through telehealth technologies, can refine and improve the intervention's effectiveness. This data-driven feedback loop allows developers to adjust and enhance their products continually, ensuring that the technology remains responsive to user needs and achieves better health outcomes.

Cost-effectiveness and efficiency ($n=14$) are common value propositions for remote monitoring, telehealth, and sensor-based technologies. These technologies aim to reduce costs and improve efficiency for healthcare providers by minimizing the need for frequent in-person visits, enabling timely interventions, and reducing the risk of long-term care. For instance, the potential for cost savings through widespread deployment is emphasised, highlighting the scalability of these solutions (Chung-Chih et al., 2024).

Finally, though not always explicitly framed as a business objective, many healthcare technologies ($n=18$) indirectly strive to enhance patient outcomes and quality of care. From reducing the risk of falls and improving patient safety to delaying or preventing the progression of diseases like dementia, these solutions ultimately strive to enhance the health and well-being of patients. This focus on patient-centred care underscores the fundamental purpose of healthcare technologies, to improve the lives of those who need it most.

The demand-side value proposition, assessed through Domain '3B' of the NASSS framework and illustrated in Fig. 5A, sheds light on the numerous strengths that emerging dementia care technologies provide for end-users. These technologies are evaluated based on their perceived value to patients, caregivers, and other stakeholders, focusing on benefits such as convenience, user-friendliness, enhanced quality of life, emotional support, and anxiety reduction. A large number of studies reviewed ($n=78$, 80%) revealed that these technologies are highly desirable to users, with most delivering meaningful improvements to the dementia care experience.

For example, Siette et al. (2024a, 2024b) developed a virtual reality (VR) application designed for cognitive assessment. This technology is not only effective in terms of diagnostic capability but is also engaging and enjoyable, leading to greater user satisfaction and adherence to therapy. The interactive nature of VR offers an immersive experience that can boost motivation and compliance, which are essential in therapeutic settings. Similarly, the robot created by Asl et al. (2022) was designed to evoke positive emotions and reduce negative feelings in users. Through

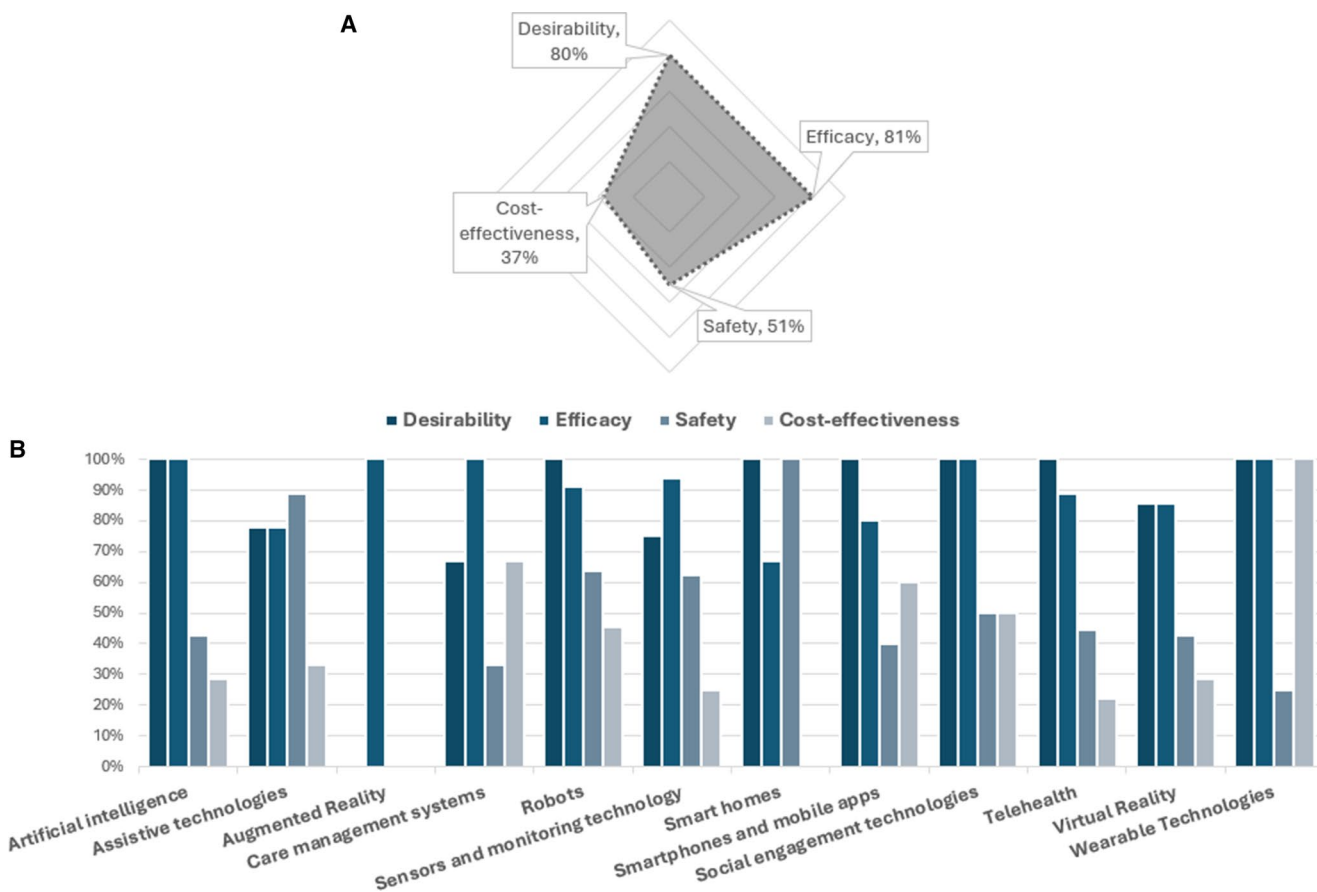


Fig. 5 Distribution of demand-side value proposition with technologies

meaningful engagement and companionship, this robotic solution enhances the emotional health of people with dementia, offering benefits beyond simple cognitive support by fostering a sense of connection and reducing feelings of loneliness.

In addition to emotional support and engagement, many of these technologies provide significant clinical advantages. Nearly all the reviewed studies ($n=79$, 81%) reported improvement in efficacy, such as improved cognitive functioning, better management of behavioural symptoms, and effective health monitoring. Advanced diagnostic tools driven by artificial intelligence (AI), like those developed by Watanabe et al. (2024), are pushing the boundaries of dementia diagnosis. These AI-enabled tools have demonstrated accuracy levels that surpass traditional diagnostic methods, particularly in identifying specific dementia subtypes, enabling clinicians to intervene earlier and tailor treatments more effectively. Additionally, Windle et al. (2022) introduced ‘iSupport,’ a digital support tool grounded in evidence-based practices and informed by theoretical models like person-centred care and cognitive-behavioural therapy (CBT). By integrating these principles, ‘iSupport’ offers caregivers valuable resources to enhance care delivery and

provides tailored cognitive and emotional support, potentially improving the overall caregiving experience.

Safety is another critical dimension of demand-side value, with more than half of the studies ($n=50$, 51%) marking the technologies as safe for end-users. Many of these tools use non-invasive methods, minimizing risks associated with traditional, more invasive procedures. Personalised interventions tailored to the unique requirements of each user further reduce the likelihood of adverse reactions, creating a safer and more controlled environment for dementia patients. However, some safety concerns still exist, as highlighted by Chung et al. (2021). In their study, a device that provided valuable monitoring data raised concerns among caregivers, particularly around the risk that patients might accidentally turn off the device.

Cost-effectiveness is another important factor, with nearly a third of the studies ($n=36$, 37%) identifying these technologies as cost-effective solutions. By enabling early detection and facilitating timely interventions, these tools have the potential to slow disease progression, reduce hospitalizations, and ultimately enhance quality of life. Early intervention can significantly reduce the overall costs associated with dementia care by minimizing the need for

emergency treatments or intensive care. For instance, the app developed by Lauraitis et al. (2020) is both free and self-administered, which adds substantial value by eliminating the need for specialised equipment or frequent clinical visits. This approach not only makes the app accessible to a broader population but also supports caregivers by reducing time and financial burdens, making dementia care more manageable.

Together, these demand-side strengths, containing convenience, emotional support, efficacy, safety, and cost-effectiveness, highlight the transformative potential of emerging technologies in dementia care. These tools offer a multi-faceted approach to addressing the complex needs of dementia patients and their caregivers, providing both therapeutic and practical benefits. Technologies like VR and AI, with their capacity for engagement and accuracy, set new standards in user experience and diagnostic reliability. The emotional support provided by interactive robots and virtual applications reflects an important shift toward holistic care that prioritises the user's mental well-being alongside their physical health.

The emphasis on safety and non-invasive options suggests that developers are increasingly mindful of user comfort and risk management, striving to create technologies that are both effective and user-friendly. This aligns with a broader industry trend of designing patient-centred healthcare solutions. By incorporating user feedback and focusing on ease of use, these technologies become more accessible, which can lead to higher adoption rates and greater impact in dementia care settings.

Figure 5B presents an in-depth analysis of the emphasis placed on crucial value propositions, including desirability, efficacy, safety, and cost-effectiveness, as discussed in the reviewed literature on various dementia care technologies. The data highlights that desirability and efficacy are the most frequently discussed attributes, particularly for technologies like Artificial Intelligence (AI), Assistive Technologies, Care Management Systems, Sensors, Smart Homes, and Virtual Reality (VR). For these technologies, desirability and efficacy are highlighted in over 80% of the studies, underscoring that these innovations are perceived as valuable and beneficial by users. This focus on desirability reflects the importance of developing dementia care technologies that meet user expectations and preferences, while the emphasis on efficacy indicates a strong interest in ensuring these technologies are effective in supporting dementia care.

In contrast, safety and cost-effectiveness are less commonly addressed in the literature, indicating potential gaps in research and discussion. Safety considerations appear in over half of the reviewed papers for several technologies, such as Assistive Technologies, Robots, and Sensors and

Smart Homes, with mentions ranging from 50% to 100%. This indicates that while some technologies receive adequate attention regarding their safety, others may lack sufficient evaluation of their potential risks, an essential factor in healthcare settings where patient well-being is paramount. Notably, VR and Telehealth have relatively low safety mentions, with nearly 40% of the studies, respectively, discussing these concerns. This limited focus on safety in VR and Telehealth suggests a need for further research and evaluation to identify and mitigate any potential risks associated with these technologies, especially as they become more widely used in dementia care.

Cost-effectiveness is discussed in even fewer papers, which implies that while these technologies may offer functional and therapeutic benefits, their economic impact and long-term financial feasibility are not yet thoroughly explored. The limited attention to cost-effectiveness suggests that more research is needed to assess whether these technologies can provide sustainable solutions for dementia care at scale. In sum, while desirability and efficacy are well-recognised attributes in the literature, the focus on safety and cost-effectiveness needs to be expanded, especially for technologies that may impact sensitive aspects of patient care and healthcare budgets.

Domain 4 The adopter system In the NASSS framework, Domain 4, which is named as the adopter system, assesses the roles of key stakeholders and the impact of technology integration on the roles, practices, and responsibilities of healthcare providers. Specifically, Domain '4A' evaluates how technology integration reshapes staff roles, practices, and identities in healthcare settings. Approximately 73% of studies ($n=72$) indicated that technology adoption significantly affects these aspects, with adaptation of practices being the most common challenge, followed by changes in care responsibilities and how staff members perceive their roles within the organization. Staff often need to modify routines, rely more heavily on data, and take on new responsibilities as they manage technology-driven interventions. This transformation highlights the importance of training, support, and professional development to help staff successfully navigate these shifts and improve patient care outcomes.

In Domain '4B', both patients and caregivers are recognised as critical stakeholders in the technology adoption process, each with unique expectations and requirements. About 58% of studies ($n=57$) specifically addressed patient and caregiver expectations, with a primary focus on designing accessible, user-friendly technologies that meet their needs. Patients typically anticipate seamless, intuitive interactions with technology that support their

well-being and are easy to navigate. Compliance with care guidelines and active participation in health management are also vital to patient satisfaction, indicating a need for technologies that not only enhance care but also engage patients as active participants.

Caregivers, in turn, face distinct responsibilities in the technology adoption process. They are often tasked with overseeing patient interactions with the technology, monitoring usage, reporting significant changes, and encouraging patients to engage with the technology. The role of caregivers is pivotal in ensuring technology's efficacy and safety, and their support is crucial for motivating patients. This role highlights the need for comprehensive caregiver training programs and support resources, which are essential for successful technology adoption.

Other Domains Domains 5, 6, and 7 of the NASSS framework address organizational changes, broader contextual factors, and the long-term embedding and adaptation of technology, respectively. The limited focus on these domains in the reviewed studies may be due to several factors. Primarily, much of the existing research emphasises the technical features and value propositions of the technologies, often overlooking the wider organizational and contextual elements that are critical for successful implementation. This narrow focus means that the broader implications of introducing new technology into healthcare settings, such as changes in workflow, staff training, and organizational policies, are often not explored.

Additionally, many studies appear to be conducted within controlled environments or are limited to short-term trials, which restricts their ability to observe how these technologies are adapted and embedded over time. Without a long-term perspective, it is challenging to assess how well technology integrates into the daily practices of healthcare organizations and how it evolves to meet changing needs. Furthermore, organizational and contextual factors may be viewed as more abstract and harder to quantify, which can lead to them being underreported in academic literature that tends to favour measurable outcomes.

Qualitative Analysis of Caregiver Interviews

This study was based on 9 semi-structured interviews, which generated a total of 134 first-order concepts. These were further organised into 25 s-order themes, which were then distilled into 7 aggregate dimensions. The analysis followed the Gioia methodology, which provides a systematic approach to qualitative data interpretation by progressing from descriptive codes to higher-order theoretical constructs.

Additionally, conceptual proximity among themes led to the consolidation of several overlapping categories. For example, concepts relating to emotional well-being and social participation were grouped under Social Connection and Emotional Engagement, while those associated with behavioural control and therapy efficacy were categorised under Behavioural and Cognitive Management and Therapeutic Impact. Other dimensions emerged around barriers to adoption, safety concerns, cost considerations, and content preferences.

The Gioia framework facilitated the development of a data structure that reflects the voices of participants while also offering conceptual clarity. Specifically:

- First-order concepts represent informant-centric terms and expressions.
- Second-order themes reflect emerging theoretical patterns.
- Aggregate dimensions capture the overarching constructs relevant to the adoption of VR in dementia care.

Table 2 presents the full data structure derived from this analysis, offering insight into the complex interplay between resident experience, therapy design, implementation challenges, and adoption dynamics in dementia care environments.

Discussion

This section discusses the aggregate dimensions, and how these dimensions address the research questions.

This study used NASSS as a common lens to integrate insights from the PRISMA-guided systematic review and the qualitative Gioia analysis of caregiver interviews. Read together, the two phases show that complexity in VR adoption for dementia care does not reside in any single NASSS domain, but emerges from the interaction between condition characteristics, technology features, value propositions, and the adopter system. This review highlighted how dementia technologies, including VR, are often designed around cognitive and behavioral symptom management, whereas the interview data revealed that caregivers continuously adjust VR use in response to residents' dementia stage, comorbidities, and fluctuating emotional states. This alignment and misalignment between Domains 1 (condition) and 2 (technology) underscores the importance of "personalization capacity" as a critical technological attribute for VR in dementia care.

The NASSS framework also helps make sense of the socio-emotional and cultural dimensions captured in the aggregate themes Social Connection and Emotional

Table 2 Aggregate dimensions and themes observed through data analysis

1st Order Concepts	2nd Order Themes	Aggregate Dimensions + Key Illustrative Quote
<ul style="list-style-type: none"> • Improved social interaction and connection • Increased engagement noticed by family members • Functional enrichment through immersive therapy • Decreased wandering & improved moods • Emotional benefits, including happiness & nostalgia • Meaningful emotional connections for residents • Inclusive VR for Cultural Well-being 	Social Engagement and Interaction	Social Connection and Emotional Engagement “This has really opened up conversations... the social interaction has really increased, and... there has been a real uplift in people’s emotional well-being.”
<ul style="list-style-type: none"> • Help reduce verbal repetition • Calm non-verbal and agitated residents, encourage reminiscence • Help with managing behaviours and reducing agitation of residents. • Using VR therapy to prevent behavioural escalations • Enhances memory recall, strengthens social interaction. • Helps residents recall childhood memories • Promotes reminiscing and emotional connections • An alternative to medication for behaviour management 	Cultural Considerations	Behavioural and Cognitive Management “With people who are non-verbal... it will calm them if they are upset... he was engrossed in it. Then he fell asleep.”
<ul style="list-style-type: none"> • Short VR sessions (6 min) maximise engagement • Residents loved their VR experiences • Longer sessions had no adverse effects, exceeding expectations • Primarily involving initial reluctance or behavioural concerns • Fears might lead to non-adoption • Participation declined at the start and was not pursued at any later stage. • Reduce activity management challenges • How to encourage residents to accept and use VR headsets • Simplifying VR setup to reduce resident confusion • Fear of heights is a limiting factor of therapy • Physical effects like dizziness after VR use • Loss of focus and unfamiliarity would lead to non-adoption • With shared use across multiple sites mitigating the expense • High cost and inability to run individualised sessions simultaneously • High-cost limits adoption of VR • Some residents experience eye strain or motion discomfort. • No major issues like cybersickness reported • VR headsets receive minimal complaints about comfort • No reports of cybersickness or discomfort • Staff training for safe VR implementation • Best practices to prevent risks during sessions • Limited effectiveness of VR for residents with advanced or severe dementia • Engaging residents with severe dementia • Importance of tailoring VR therapies to residents’ needs • Residents’ experiences and preferences could help with personalizing VR therapies 	Managing Resident Behaviours	Emotional and Behavioural Barriers “One resident said if things had got at height, then she wasn’t wanting to do it because she was scared of heights”
	Memory Recall and Reminiscence	
	Therapeutic Potential of VR	
	Session Duration and Resident Engagement	
	Resident Fear and Agitation	
	Need for Simplified or Interesting VR Experiences	
	Physical and Emotional Barriers	
	Cost as a Barrier	Financial and Safety Constraints “Cost could be prohibitive to some providers... we share those around the nine sites. It would be nice... to have one at every site.”
	Cybersickness and Motion Sickness Experience	
	Balancing Safety and Other Aspects	
	Effectiveness of VR on Dementia Stage	Therapeutic Impact “Whenever they put it on, we can see on the smile there... moving their head and everything... a lot of people say, ‘oh, I really enjoy it’.”
	Personalization and Adaptation of VR Therapy	
	Seamless Integration into Aged Care Plans	
	Drivers of Adoption	Adoption Factors “My staff are not particularly tech savvy, and they’ve all managed to use it quite easily and integrate it into their monthly programs.”
<ul style="list-style-type: none"> • Integration of the potential of VR into structured care plans • Help with seamless integration of VR therapies with care schedules and minimal impact • Requires detailed documentation of residents’ preferences and experiences • Adopting VR therapy during the early stages of dementia • Familiarizing residents with VR will help adoption • Adoption driven by mental stimulation and emotional engagement • Residents and staff’s emotional engagement drives the adoption • Staff time and managing behaviours will impact the VR adoption • Importance of staff training for implementing VR therapies • Financial barriers for aged care facilities and technical barriers for caregivers to adopt VR • Generation Gap and physical barriers for residents to adopt VR 	Barriers of Adoption	

Table 2 (continued)

1st Order Concepts	2nd Order Themes	Aggregate Dimensions + Key Illustrative Quote
<ul style="list-style-type: none"> • Recommended VR therapy includes cooking and familiar activities • Introducing practical (like gardening) and seasonal VR content (like Christmas carols) 	Preference for Seasonal and Familiar Activities	Content Preference and Cultural Relevance “We need to know the residents well... residents who like gardening, we... show them more of that... Residents don’t like animals, we don’t want to do the animals video... otherwise the result [is] just opposite.”
<ul style="list-style-type: none"> • Travel and experiential scenarios like Aerial photography are highly favoured • Popular content includes animals and travel therapies 	Preference for Nature and Travel-Based VR Content	
<ul style="list-style-type: none"> • Residents dislike fast-paced or motion-heavy videos (like skydiving) • Residents less interested in intensive therapies (like flying) 	Avoidance of Fast-Paced or Motion-Heavy Content	
<ul style="list-style-type: none"> • Understanding resident preferences by caregivers enhances therapy effectiveness • More cultural and localised VR therapies are required for residents • Therapy preferences for residents based on their stages of dementia 	Desire for Cultural and personalised Content	

Engagement, Behavioral and Cognitive Management, and Content Preference and Cultural Relevance. These dimensions illustrate how the demand-side value proposition (Domain 3) extends beyond symptom reduction or generic “enjoyment” to include residents’ sense of identity, cultural familiarity, and emotionally meaningful experiences. The systematic review showed that many technology studies emphasise efficacy and usability but often understate these socio-emotional aspects. Caregivers, by contrast, described VR as most valuable when it could reconnect residents with familiar places, roles, and activities, and least valuable when content felt generic, overwhelming, or culturally distant. In this way, the mixed-methods findings refine Domain 3 by foregrounding socio-emotional and cultural value as integral components of perceived benefit.

Across both phases, the adopter system (Domain 4) emerged as a pivotal site of complexity. The aggregate dimensions Adoption Factors, Emotional and Behavioral Barriers, and Financial and Safety Constraints show that caregivers are not passive recipients of VR, but active mediators who decide when, how, and with whom VR is used. They translate abstract value propositions into everyday practices by screening residents for suitability, pacing and tailoring sessions, managing fears and distress, and negotiating time and workload pressures. The systematic review indicated that many technologies implicitly rely on such mediation but rarely conceptualize it as part of the intervention itself. Our findings therefore extend Domain 4 by highlighting “caregiver mediation work” as a core mechanism through which VR is adopted, adapted, or abandoned over time.

Finally, while the empirical focus of this study was on Domains 1 to 4, the mixed-methods synthesis points toward important implications for Domains 5 to 7 (organizations, wider system, and embedding over time). Financial and Safety Constraints, for example, reflect organizational concerns about hardware costs, staffing, training, and risk

management, which directly influence whether VR remains a one-off pilot or becomes embedded in routine care. Similarly, the need to align VR sessions with funded care minutes and documentation requirements connects local adoption decisions to wider policy and funding structures. By situating these caregiver-level experiences within NASSS, the study shows that sustainable VR adoption in dementia care depends on aligning personalization capacity and socio-emotional value (Domains 1 to 3) with caregiver mediation and organizational support (Domains 4 to 5), within a broader system that recognizes VR as part of core, not discretionary, care (Domains 6 to 7).

VR as a Digital Disruptor in Dementia Care

VR demonstrates strong alignment with the value proposition domain (Domain 3) of the NASSS framework, offering multiple advantages for both patients and healthcare providers in dementia care. Studies by Siette et al. (2024); Siette, GuionSiette et al. (2024b); Yondjo & Siette (2024) highlight how immersive VR environments provide stimulating, interactive experiences that enhance patient engagement and motivation. These applications are consistently associated with high desirability, as patients find them enjoyable and easy to use, increasing adherence to therapeutic sessions. Furthermore, the efficacy of VR in supporting cognitive function, emotional expression, and communication has been well-documented, with Saredakis et al. (2021) reporting positive psychological effects during VR use in aged care settings.

In terms of market differentiation, the simulation-based diagnostic modules presented by Yondjo & Siette (2024b) showcase how VR can offer specialised and innovative healthcare solutions, setting them apart from more generic digital tools. Additionally, these technologies demonstrate scalability and flexibility, making them adaptable across a range of cognitive conditions and care environments. While

fewer studies directly address long-term safety or cost-effectiveness, early findings suggest that VR can serve as a non-pharmacological intervention for behavioural and psychological symptoms of dementia. This supports its role in reducing reliance on medication and fostering therapeutic engagement through immersive, tailored content. Collectively, the cited studies present a compelling case for VR as a high-value, patient-centred technology with significant potential for scalable, real-world integration into dementia care. Each of the aggregate dimensions identified through analysis of the caregiver interviews is discussed below.

Social Connection and Emotional Engagement

A prominent aggregate dimension identified in the dataset is Social Connection and Emotional Engagement, which encompasses the second-order themes of Social Engagement and Interaction, Emotional Benefits of VR, and Cultural Considerations. This dimension highlights how virtual reality (VR) therapy can facilitate social interactions and foster emotional connections within aged care environments. Existing literature underscores the importance of social participation and emotional stimulation in promoting psychological well-being for individuals with dementia (Bhargava & Baths, 2022; Matsangidou et al., 2023a, b). Consistent with these findings, caregiver interviews revealed that immersive VR interventions can help mitigate social isolation, promote engagement, and enhance emotional connections among residents.

Caregivers observed that residents became more communicative, socially engaged, and emotionally expressive during and after VR sessions. For example, residents who were typically withdrawn began participating in group activities, and others showed increased interactions with peers and staff. These changes were also reported by family members, who noticed positive shifts in their loved ones' mood and sociability. Moreover, caregiver interviews revealed that VR fosters communicative behaviour, emotional expression, and peer interaction, often resulting in noticeable improvements in mood and sociability. Caregivers identified that VR sessions often resulted in emotional benefits such as laughter, joy, the evocation of nostalgic memories, and reductions in behaviours like wandering. These effects led to overall improvements in residents' emotional well-being and relational connections.

The emotional impact of VR was reported to be more profound when the content aligned with residents' cultural contexts, which supports previous literature (Brooks et al., 2024; Dickinson et al., 2023) emphasizing the importance of personalization and familiar stimuli in enhancing engagement. A critical observation from caregivers was that the emotional and therapeutic impact of VR was amplified

when the content was culturally relevant. Familiar environments, music, and imagery tailored to residents' cultural backgrounds produced stronger emotional reactions and higher engagement levels. Caregivers emphasised the need for personalised VR content to optimise its impact and support holistic emotional and social engagement in dementia care.

Behavioural and Cognitive Management

Another key dimension emerging from the dataset is Behavioural and Cognitive Management, which integrates themes such as Managing Resident Behaviours, Memory Recall and Reminiscence, Therapeutic Potential of VR, and Session Duration and Resident Engagement. This dimension reflects the significant impact of VR on both the behavioural and cognitive aspects of care for residents with dementia. Based on interviews with caregivers, the data suggests that VR can play a critical role in supporting residents' behavioural and cognitive health by managing challenging behaviours and enhancing memory recall and reminiscence.

Within Managing Resident Behaviours, caregivers frequently noted that VR therapy helped reduce agitation and behavioural disruptions, which is consistent with the study of Bhargava & Baths (2022), where the authors demonstrated the psychological efficacy of VR in dementia care. Caregivers frequently reported that VR therapy contributed to reductions in verbal repetition, agitation, and restlessness, while offering a calming effect for non-verbal residents. This helped prevent behavioural escalation and improved daily care routines. Regarding Memory Recall and Reminiscence, VR was also recognised as a tool for stimulating memory and reminiscence, with many residents recalling childhood experiences during sessions. Caregivers saw VR as an effective tool to stimulate autobiographical memories, promote social interactions, and help residents reconnect with their past, particularly childhood memories. This, in turn, supported stronger identity and emotional stability.

Additionally, the potential of VR as a non-pharmacological intervention aligns with the study of Matsangidou et al. (2023a, b), and in this context, optimal session lengths for sustained engagement were also recommended. Caregivers recognised the Therapeutic Potential of VR as a non-pharmacological approach for managing behavioural symptoms. VR interventions facilitated emotional engagement and reminiscence in ways that traditional methods or medications could not. Caregivers also noted that shorter VR sessions (around six minutes) were particularly effective in maintaining resident engagement, and longer sessions were tolerated well without significant adverse effects. Collectively, this dimension illustrates VR's broad potential for

supporting behavioural and cognitive health, as highlighted by caregivers' firsthand experiences.

Emotional and Behavioural Barriers

The first dimension within the broader theme of VR implementation challenges is Emotional and Behavioural Barriers. This dimension captures the emotional and psychological factors that hinder the effective adoption of VR interventions in aged care settings. Comprising themes such as Resident Fear and Agitation, Need for Simplified or Interesting VR Experiences, and Physical and Emotional Barriers, this dimension highlights the obstacles that can prevent successful VR engagement among residents, particularly those with dementia.

Caregivers highlighted psychological resistance and sensory overload as initial barriers to VR use, which are well-documented in the literature (Matsangidou et al., 2023a, b). Resident Fear and Agitation emerged as a prominent issue in caregiver interviews, where many described residents' initial reluctance to engage with VR due to anxiety, fear of new technology, and sensory overload. This often led to non-adoption or decreased participation, particularly during early VR exposure. Caregivers stressed the importance of familiarizing residents with VR equipment gradually and providing reassurance to overcome this barrier.

The Need for Simplified or Interesting VR Experiences, which is supported by Brooks et al. (2024) and Dickinson et al. (2023), emphasised caregivers' concerns about managing VR sessions that were either too complex or failed to capture residents' attention. Many caregivers noted that the technology needed to be intuitive and that engaging, personalised content was essential to encourage adoption. Physical and Emotional Barriers also played a role, for instance, experiencing physical discomfort, such as dizziness or fear of heights, have been described as typical deterrents in dementia populations (Matsangidou et al., 2023a, b). These physical responses could lead to withdrawal from VR therapy, reinforcing the need for careful session planning, including shorter, less intense experiences tailored to individual needs.

Financial and Safety Constraints

Another critical dimension within the implementation challenges is Financial and Safety Constraints. This dimension includes themes such as Cost as a Barrier, Cybersickness and Motion Sickness Experience, and Balancing Safety and Other Aspects. It reflects the operational and safety-related challenges that aged care facilities face when implementing VR therapy, as reported by caregivers.

The Cost as a Barrier theme captured the financial limitations that prevent widespread adoption of VR systems, echoing the cost-effectiveness concerns noted by Chung-Chih et al. (2024). Caregivers noted that while shared use across multiple facilities could mitigate costs, the high initial investment and ongoing maintenance expenses were significant obstacles. The Cybersickness and Motion Sickness Experience theme showed that while some residents experienced mild discomfort, such as eye strain or disorientation, there were minimal reports of severe cybersickness, aligning with Matsangidou et al. (2023a, b; Dickinson et al. (2023), who found AR/VR side effects in older adults to be tolerable. The VR system used by caregivers was generally considered comfortable, and most caregivers reported no significant adverse effects.

Lastly, Balancing Safety and Other Aspects underscored the need for staff training to ensure safe VR use. Caregivers emphasised that clear safety protocols were essential to mitigate risks such as falls, confusion, or other safety concerns, particularly when working with residents who had mobility or cognitive impairments. This is in consensus with the work of Baudin et al. (2024), who advocate for structured training to ensure safe practice. These financial and safety constraints are interconnected with emotional and behavioural barriers, with inadequate training or resources exacerbating resistance to VR adoption.

Therapeutic Impact

Therapeutic Impact emerged as a crucial dimension in understanding how VR interventions affect the well-being of residents in aged care. This dimension includes the themes of Effectiveness of VR on Dementia Stage, Personalization and Adaptation of VR Therapy, and Seamless Integration into Aged Care Plans. Based on caregivers' input, the effectiveness of VR was found to vary based on the stage of dementia, the need for personalised content, and the integration of VR into care plans.

Effectiveness of VR on Dementia Stage was noted as particularly relevant, as residents with mild to moderate dementia often responded well to VR therapy, supporting the findings by Pietro (2019), while those with severe dementia showed limited engagement. Caregivers emphasised that more tailored strategies were needed for residents with advanced dementia. Personalization and Adaptation of VR Therapy was highlighted as a critical factor for ensuring that VR content aligned with each resident's history, interests, and cognitive abilities, a view reinforced by Baudin et al. (2024) and Brooks et al. (2024). Caregivers noted that personalised VR experiences, such as familiar environments or culturally relevant content, fostered stronger emotional engagement.

Lastly, Seamless Integration into Aged Care Plans emphasised the necessity of embedding VR within structured care routines. This aligned with the findings by Baudin et al. (2024) regarding the importance of embedding VR in

structured care delivery. Caregivers stressed the importance of detailed documentation of residents' preferences and the coordination of VR therapy with care schedules to ensure its effectiveness.

Adoption Factors

The Adoption Factors dimension, consisting of Drivers of Adoption and Barriers to Adoption, reflects the facilitators and challenges associated with implementing VR in dementia care. According to caregivers, the adoption of VR therapy was influenced by factors such as the stage of implementation, emotional engagement, and staff involvement.

Caregivers noted that early introduction and familiarity boosted adoption rates, echoing the study of Fixl et al. (2021), while emotional engagement from both staff and residents further facilitated uptake (Aysan Mahmoudi et al., 2022). Drivers of Adoption included introducing VR therapy in the early stages of dementia, which helped residents become familiar with the technology. Additionally, this dimension reflects the complex interplay of facilitators and inhibitors that influence the successful implementation of virtual reality (VR) therapy in aged care contexts. Drawing from interviews with caregivers, the findings highlight how organizational readiness, resident characteristics, and staff engagement shape the trajectory of VR adoption in dementia care.

In contrast, the theme Barriers of Adoption highlights significant challenges that hinder uptake. Barriers such as staff time, lack of training, generational gaps, and physical discomfort were frequently cited. These challenges are well-supported by Windle et al. (2022), who identified systemic, generational, and resource-based obstacles to digital technology adoption. In addition, financial constraints at the organizational level, coupled with limited access to resources, posed systemic barriers. The generational gap and physical limitations of older residents - such as difficulty understanding technology or physical discomfort, were also mentioned as important obstacles that influenced the likelihood of adoption.

Overall, the Adoption Factors dimension demonstrates that while emotional engagement and early exposure can facilitate VR use in dementia care, implementation is heavily dependent on overcoming operational, financial, and cultural barriers. Caregivers' insights underscore the need for tailored training, ongoing support, and infrastructure investment to ensure sustained and equitable access to VR therapies across aged care settings.

Content Preference and Cultural Relevance

The Content Preference and Cultural Relevance dimension underscores the need for VR content to be both contextually relevant and personalised to each resident's cultural

and experiential background. Themes such as Preference for Seasonal and Familiar Activities, Preference for Nature and Travel-Based VR Content, Avoidance of Fast-Paced or Motion-Heavy Content, and Desire for Cultural and Personalised Content emerged as crucial for maximizing VR's therapeutic and emotional impact. The findings are drawn from interviews with caregivers, whose observations provide rich insight into how VR content is received by older adults in care settings.

Caregivers consistently reported that residents responded more positively to VR therapies that featured familiar or seasonal activities, such as cooking, gardening, or Christmas carols, activities that often evoke nostalgic memories and emotional comfort. The preference in gardening or music was more effective than abstract or high-motion experiences, a view supported by Brooks et al. (2024); Matsangidou et al. (2023a, b). Similarly, immersive scenarios involving nature, animals, and travel (e.g., flying over scenic landscapes) were identified as highly engaging, consistent with Dickinson et al. (2023), suggesting that experiential content grounded in real-world experiences enhances emotional engagement.

Conversely, the theme Avoidance of Fast-Paced or Motion-Heavy Content reflects a clear trend among residents to reject overly stimulating or disorienting experiences, such as skydiving or rapid-motion simulations, which often led to disengagement or distress. Caregivers observed that such content was not only less enjoyable but also occasionally distressing or confusing for residents, particularly those with more advanced cognitive decline.

Finally, the theme Desire for Cultural and personalised Content highlights the importance of tailoring VR experiences to individual residents' cultural backgrounds, life histories, and preferences, which is in consensus with the findings from Brooks et al. (2024) and Dickinson et al. (2023). Caregivers emphasised that understanding and integrating these preferences significantly enhanced the effectiveness of therapy, particularly when personalised content aligned with residents' values, language, or memories. They also noted that therapy preferences varied depending on the stage of dementia, reinforcing the need for dynamic and adaptive content strategies.

Together, these insights point to the central role of culturally sensitive and personally relevant content in maximizing the therapeutic and emotional impact of VR in aged care. Caregiver perspectives strongly suggest that VR interventions must go beyond standardised or non-specific VR experiences, instead by prioritizing personalization and relevance to the individual's background and environment, to be truly meaningful and effective. In this way, VR therapies not only provide an immersive experience but also help restore identity, dignity, and social connection for people

living with dementia. The following section outlines how we addressed the research questions of this study.

Mapping Aggregate Dimensions to Research Questions

Table 3 systematically maps the study's core research questions (RQ1 - RQ3) to the corresponding aggregate dimensions derived from the Gioia analysis, offering a structured overview of the empirical insights generated. Each dimension provides relevant insights aligned with the adoption, and therapeutic significance of VR in dementia care.

RQ1 is informed by the dimensions of Social Connection and Emotional Engagement, Behavioural and Cognitive Management, Therapeutic Impact, Financial and Safety Constraints, and Emotional and Behavioural Barriers. These dimensions collectively capture the dual nature of VR's role, its capacity to enhance emotional stimulation, reminiscence, and social interaction, as well as its limitations, including high costs, cybersickness, psychological resistance, and usability concerns.

RQ2 draws on Adoption Factors, Financial and Safety Constraints, Emotional and Behavioural Barriers, and Content Preference and Cultural Relevance. These dimensions elucidate both the enablers and inhibitors of VR adoption in aged care contexts. Key facilitators include early-stage adoption, caregiver involvement, and content personalization, while barriers relate to staff training deficits, generational technology gaps, and resident emotional discomfort.

RQ3 is reinforced by the dimensions of Therapeutic Impact, Content Preference and Cultural Relevance, and Social Connection and Emotional Engagement. These findings foreground caregivers' perceptions of VR as an effective therapeutic tool, contingent upon personalization, cultural alignment, and dynamic content adaptation tailored to residents' profiles and cognitive status.

Implications of Integrating Technology into Dementia Care

Theoretical Implications

This study advances theory on technology adoption in dementia care by mobilising the NASSS framework not only as an evaluation checklist but as a generative lens for mixed-methods integration. By combining a PRISMA-guided review with a NASSS-sensitised Gioia analysis of caregiver interviews, we show that NASSS Domains 1

to 4 are deeply intertwined in the context of VR adoption and that socio-emotional and cultural dynamics are central to this interdependence. Successful VR implementation depends not only on technological usability or organisational readiness, but also on emotional engagement, cultural relevance, and individualised cognitive considerations.

Table 3 Aggregate dimension linked with research questions

Research Question	Linked Aggregate Dimensions	Key NASSS Domains	Key Insights
RQ1	Social Connection and Emotional Engagement; Behavioural and Cognitive Management; Therapeutic Impact; Financial and Safety Constraints; Emotional and Behavioural Barriers	D1 (Condition); D2 (Technology); D3 (Value proposition); D4 (Adopter system)	VR is perceived as beneficial for emotional stimulation, reminiscence, and social engagement, and as a non-pharmacological option for managing behavioural and cognitive symptoms. At the same time, cost, safety concerns, cybersickness, fear of unfamiliar equipment, and workload implications highlight tensions between experiential benefits and practical risks.
RQ2	Adoption Factors; Financial and Safety Constraints; Emotional and Behavioural Barriers; Content Preference and Cultural Relevance	D3 (Value proposition); D4 (Adopter system); D5 (Organisations); D7 (Embedding and adaptation over time)	Key drivers include early-stage introduction, visible resident enjoyment, enthusiastic champions, and access to personally meaningful content. Barriers include limited training, generational and digital literacy gaps, resource constraints, risk management concerns, and emotional discomfort among residents, which collectively challenge long-term embedding of VR.
RQ3	Therapeutic Impact; Content Preference and Cultural Relevance; Social Connection and Emotional Engagement	D1 (Condition); D2 (Technology); D3 (Value proposition)	Caregivers view VR as most effective when content is tailored to residents' cognitive stage, cultural background, life history, and current emotional state, and when sessions are facilitated as shared, socially meaningful experiences. Personalisation and socio-emotional fit are therefore central to perceived therapeutic impact.

Our findings both support and extend NASSS. Consistent with Greenhalgh et al. (2017), we observe that non-adoption and abandonment arise when condition complexity, technology characteristics, value propositions, and adopter capacities are misaligned. For example, VR is particularly beneficial for residents with mild to moderate dementia (Domain 1), but its high sensory load and hardware requirements can overwhelm those with advanced disease or comorbidities. At the same time, our results point to several refinements of the framework in the context of VR and dementia care:

Personalisation capacity emerges as a critical technological attribute within Domain 2 (Technology), emphasising the need for flexible content, adjustable intensity, and individual tailoring rather than one-size-fits-all VR scenarios.

Socio-emotional and cultural value appears as a distinct sub-dimension of the demand-side value proposition in Domain 3, beyond generic notions of “benefit” or usability, highlighting the importance of identity, reminiscence, and culturally meaningful content.

Caregiver mediation work is foregrounded as a core component of the adopter system in Domain 4, where staff actively screen residents, pace and adapt sessions, manage fears and behavioural responses, and translate VR into relational and therapeutic practices rather than simply “using” a tool.

Communication and integration in care plans emerges as an important sub-domain of Domain 5 (Organisations), capturing how VR is (or is not) embedded in formal care planning, documentation, team communication, and alignment with funded care minutes and organisational priorities. This sub-domain helps explain whether VR remains a discretionary activity or becomes part of core care.

Building on the aggregate dimensions derived through Gioia analysis - Social Connection and Emotional Engagement, Behavioural and Cognitive Management, Content Preference and Cultural Relevance, Adoption Factors, Financial and Safety Constraints, and Emotional and Behavioural Barriers, this study proposes a conceptual foundation for theorising VR adoption as a dynamic and context-sensitive process. Taken together, these dimensions suggest a functional pathway in which VR adoption in dementia care is shaped by ongoing interactions between: (a) technological design, safety characteristics, and personalisation capacity (Domains 2 and 3); (b) emotional impact, socio-cultural fit, and content personalisation (Domains 1 and 3); (c) caregiver facilitation, mediation work, and organisational communication (Domains 4 and 5); and (d) residents’ cognitive stage, comorbidities, and behavioural responses (Domain 1).

This emerging functional pathway points toward the development of a more holistic theoretical model that integrates selected NASSS domains with socio-emotional, cultural, and personalisation constructs, as well as organisational sub-domains such as communication and integration in care plans. It invites future research to systematically refine, validate, and extend this pathway, ensuring that technology adoption models in dementia care more effectively capture the emotional, cultural, organisational, and socially connected dimensions of user experience.

Practical and Social Implications

The findings offer multi-level implications for implementing VR in dementia care. At a system and organisational level, the results underscore the importance of treating VR as part of the core care infrastructure rather than a discretionary “activity.” Facilities and policymakers should: (1) align VR sessions with funded care minutes and documentation requirements so that therapeutic outcomes (e.g., reduced agitation, improved participation) are recognised within care quality metrics; and (2) establish procurement and maintenance models that spread hardware and content costs across sites or provider networks, thereby maximising return on investment.

At the caregiver and team level, our findings highlight the need for structured training and support. Staff require not only technical skills (e.g., headset operation, basic troubleshooting) but also clinical and relational competencies: selecting appropriate content for different dementia stages, pacing sessions to minimise distress, monitoring for subtle signs of discomfort, and using VR experiences as prompts for reminiscence and social conversation. Co-designed training modules that incorporate caregiver feedback and lived examples from practice can help embed VR into routines in ways that feel safe, meaningful, and sustainable.

Socially, VR emerged as a powerful medium for enhancing quality of life by enabling residents to reconnect with meaningful places, activities, and identities. When content is culturally relevant and personalised, VR sessions can reduce social isolation, stimulate positive emotions, and strengthen relationships between residents, families, and staff. Over time, this may reduce caregiver burden and support more person-centred models of dementia care, both in residential facilities and home-care settings. Policymakers and aged-care leaders are therefore encouraged to support initiatives that make culturally sensitive, personally relevant VR content more accessible and affordable within dementia care ecosystems.

Limitations

While this study provides a comprehensive evaluation of dementia care technologies through a systematic literature review and caregiver interviews, several limitations must be acknowledged.

First, the scope of the literature review was limited to studies published between 2020 and mid-2024, which may have excluded relevant earlier work, or the most recent innovations not yet indexed in selected databases. Additionally, while the review applied the NASSS framework to structure and interpret findings, some domains, particularly Domains 5 to 7 (organizational context, wider system, and adaptation over time), were underrepresented in the literature and could not be deeply explored due to limited empirical data.

Second, the qualitative findings were derived from a relatively small sample of nine caregiver interviews, which, while rich in insight, may not fully capture the diverse perspectives and experiences across different care settings, geographic regions, or cultural contexts. As such, the themes identified through Gioia analysis, while robust, should be interpreted as exploratory and indicative rather than conclusive.

Third, the focus on a single VR platform limits the generalisability of the findings to other VR solutions with different design features, content types, or hardware configurations. Variations in implementation models, costs, and levels of immersion across platforms may produce different user experiences and outcomes.

Lastly, this study did not include direct input from people living with dementia, whose first-hand perspectives are critical in evaluating the therapeutic and emotional impact of VR interventions. Ethical and practical constraints limited direct involvement of people living with dementia; however, future studies should incorporate their voices to gain a more holistic understanding of user needs and preferences.

Conclusion

In conclusion, this study identified essential themes in dementia care technologies, emphasizing significant advancements as well as persistent challenges in this sector. The focus on monitoring systems, interactive robots, and immersive technologies such as augmented and virtual reality underscores their potential to improve patient outcomes and engagement. However, the study reveals critical research gaps, particularly in long-term adoption, comparative effectiveness, and seamless integration into existing care models. Effective implementation in dementia care requires technologies that seamlessly integrate into

healthcare systems, meet practical needs, and respect the privacy and autonomy of patients.

The value proposition domain within the NASSS framework plays a crucial role in guiding dementia care technology development by emphasizing user-centred design, safety, efficacy, and economic feasibility. By addressing these aspects, stakeholders can ensure that innovations are not only advanced but also aligned with real-world demands. Technologies that focus on measurable clinical benefits, comprehensive safety, and cost-effective scalability are more likely to integrate successfully into dementia care practices. This alignment between technological capabilities and practical needs helps bridge the gap between innovation and utility, pushing dementia care towards more effective, accessible, and sustainable solutions.

This study also highlights the importance of emotional, behavioural, and organizational factors in VR adoption. Caregivers' perspectives revealed that social engagement, emotional benefits, memory recall and reminiscence are key outcomes of well-designed VR therapy, particularly when content is personalized and culturally relevant. However, challenges such as resident fear, physical discomfort, staff training gaps, and financial constraints underscore the need for careful planning and support. Adoption is not solely dependent on the technology itself but is shaped by emotional readiness, institutional support, and the therapeutic alignment of VR content with resident needs.

While current evaluations provide valuable insights drawn from an analysis of caregiver interviews, the NASSS framework analysis indicate that further successful implementation of VR in dementia care must be holistic, adaptable, and person-centred. Observational studies and cross-sectional surveys could provide a more in-depth understanding of these dimensions. The NASSS framework suggest a strategic, multifaceted approach to technology adoption, focusing on aligning with stakeholder needs, providing technical and clinical training, and supporting new staff roles and routines. Furthermore, the NASSS framework, especially its emphasis on technology characteristics and demand-side value, offers a structured method for evaluating healthcare technologies. Addressing the identified gaps could enhance the effectiveness of dementia care technologies, improve patients' quality of life, and reduce the strain on caregivers. Future research in this field is essential for developing effective, sustainable dementia care solutions.

VR technologies offer unique potential for immersive, engaging therapeutic experiences that can support cognitive health and provide enjoyable interactions for patients. Research should explore how VR can be effectively integrated into existing care practices, examining factors such as usability for patients with varying cognitive abilities and staff training for safe and effective use. Importantly,

different stages of dementia may benefit from tailored VR experiences, for instance, more calming and interactive experiences such as reminiscence therapy, virtual travel, or cognitive games may be more suitable for those in the early to moderate stages to stimulate memory and engagement. On the other hand, personalised therapies could be implemented to help prevent sundowning episodes in patients with severe dementia. In his context, VR therapies offer more than just an immersive experience, they also contribute to restoring identity, preserving dignity, and fostering social connection for individuals living with dementia.

Future research should extend this work across all NASSS domains, particularly Domains 5 to 7 (organisation, wider system, embedding over time), through longitudinal and implementation-focused studies that track how funding, staffing, governance, and communication and integration in care plans shape the sustainability of VR interventions. Building on our therapy analysis, further studies should refine and validate VR therapy categories (e.g., reminiscence, social connection, behavioural regulation) across different dementia stages and cultural contexts. A key avenue is the design and evaluation of a personalised VR recommendation system that links resident profiles (cognitive stage, comorbidities, emotional patterns, life history) with a structured therapy taxonomy and organisational constraints. Such a system could operationalise our NASSS-informed pathway, supporting caregivers to select, adapt, and document VR sessions as part of routine dementia care.

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Author Contribution Mr. Zhengyang Feng – Conducted interviews with caregivers, developed initial themes and aggregate dimensions, and mapped second-order themes to existing literature. Prepared the draft article. Dr. Jayan Chirayath Kurian – Conducted interviews with caregivers, reviewed themes and aggregate dimensions, and contributed to the development of theoretical and practical implications. Revised and modified the draft article. Dr. Mukesh Prasad – Conducted analysis of first-order, second order, and aggregate dimensions to ensure research rigour and validity. Revised and modified the draft article. Dr. Nimish Bitoria – Reviewed the application of the NASSS framework and contributed insights from the literature review. Revised and modified the draft article. Dr. Priya Saravanakumar – Revised the manuscript and provided critical feedback on the formulation of aggregate dimensions. Revised and modified the draft article.

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Declarations

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Consent to publish This study does not contain any individual person's data in any form (including individual details, images, or videos), and consent to publish is not applicable.

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Authors area of interest Mr Zhengyang Feng – Technologies in Dementia care, Qualitative research. Dr Jayan Chirayath Kurian - Qualitative research, Technologies in Dementia care. Dr Mukesh Prasad – Artificial Intelligence. Dr Nimish Bitoria – Designing empathetic environment. Dr Priya Saravanakumar – Gerontology.

Competing interests The authors declare that they have no competing interests.

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References

- Abbas Saad, A., Khan, W., Hussain, A., Al-Jumeily, D., & for the Alzheimer's Disease Neuroimaging, I. (2023). Wide and deep learning-based approaches for classification of Alzheimer's disease using genome-wide association studies. *PLoS One*, 18(5). <https://doi.org/10.1371/journal.pone.0283712>
- Aged Care Research & Industry Innovation Australia (2024). Types of technology in aged care. <https://www.ariia.org.au/knowledge-implementation-hub/technology-in-aged-care/types-technology-aged-care>
- 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*, 17(5), 928–940.
- Asl, A. M., Toribio-Guzmán, J. M., Van Der Roest, H., Castro-González, Á., Malfaz, M., Salichs, M. A., & Martin, M. F. (2022). The usability and feasibility validation of the social robot MINI in people with dementia and mild cognitive impairment; a study protocol. *Bmc Psychiatry*, 22(1), 760.
- Aysan Mahmoudi, A., Miguel, J., van der Henriëtte, T. G., Castro-González, R., Malfaz, Á., Salichs, M., M. A., & Franco, M., M (2022). The usability and feasibility validation of the social robot MINI in people with dementia and mild cognitive impairment; a study protocol. *Bmc Psychiatry*, 22, 1–8. <https://doi.org/10.1186/s12888-022-04418-9>
- Baudin, K., Sundström, A., & Lindner, H. (2024). Informal carers' experiences in everyday life and the use of digital assistive

- technology for time management in persons with dementia or mild cognitive impairment. *BMC Geriatrics*, 24(1), 365.
- Bhargava, Y., & Baths, V. (2022). Technology for dementia care: benefits, opportunities and concerns. *Journal of Global Health Reports*, 6, e2022056. <https://doi.org/10.29392/001c.39606>
- Braun, V., & Clarke, V. (2025). Reporting guidelines for qualitative research: A values-based approach. *Qualitative Research in Psychology*, 22(2), 399–438.
- Brooks, D., Wyles, K., Pachana, N. A., Beattie, E., & Gaugler, J. E. (2024). Tailored videoconferencing counselling program to support family carers of people living with dementia during the transition to permanent residential care: A pilot and feasibility randomised trial. *BMC Geriatrics*, 24(1), 375.
- Campani, D., De Luca, E., Bassi, E., Busca, E., Airoidi, C., Barisone, M., Canonico, M., Contaldi, E., Capello, D., & De Marchi, F. (2022). The prevention of falls in patients with parkinson's disease with in-home monitoring using a wearable system: A pilot study protocol. *Aging Clinical and Experimental Research*, 34(12), 3017–3024.
- Chary, A., Hernandez, N., Rivera, A. P., Ramont, V., Obi, T., Santangelo, I., Ritchie, C., Singh, H., Hayden, E., & Naik, A. D. (2024). Perceptions of acute care telemedicine among caregivers for persons living with dementia: A qualitative study. *Journal of Applied Gerontology*, 43(1), 69–77.
- Chung, J., Boyle, J., Pretzer-Aboff, I., Knoefel, J., Young, H. M., & Wheeler, D. C. (2021). Using A GPS watch to characterise life-space mobility in dementia: A dyadic case study. *Journal of Gerontological Nursing*, 47(10), 15–22.
- Chung-Chih, L., Yang, C. T., Pei-Ling, S., Jung-Ling, H., Shyu, Y. I. L., & Hsu, W. C. (2024). Implementation difficulties and solutions for a smart-clothes assisted home nursing care program for older adults with dementia or recovering from hip fracture. *BMC Medical Informatics and Decision Making*, 24, 1–10. <https://doi.org/10.1186/s12911-024-02468-5>
- Day, J. O., Smith, S., Noyce, A. J., Alty, J., Jeffery, A., Chapman, R., & Carroll, C. (2022). Challenges of incorporating digital health technology outcomes in a clinical trial: Experiences from PD STAT. *Journal of Parkinson's Disease*, 12(5), 1605–1609. <https://doi.org/10.3233/JPD-223162>
- 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 health-care monitoring. Companion Proceedings of the Web Conference 2020.
- Fan, Q., Hoang, M. N., DuBose, L., Ory, M. G., Vennatt, J., Salha, D., Lee, S., & Falohun, T. (2024). The Olera. Care digital caregiving assistance platform for dementia caregivers: Preliminary evaluation study. *JMIR Aging*, 7, e55132.
- 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.
- Greenhalgh, T., Wherton, J., Papoutsi, C., Lynch, J., Hughes, G., A'Court, C., Hinder, S., Fahy, N., Procter, R., & 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). Han, S., White, K., & Cisek, E. (2022). A Feasibility Study of Individuals Living at Home with Alzheimer's Disease and Related Dementias: Utilization of Visual Mapping Assistive Technology to Enhance Quality of Life and Reduce Caregiver Burden. *Clinical Interventions in Aging*, 17, 1885–1892. <https://doi.org/10.2196/jmir.8775>
- Han, S. S., White, K., & Cisek, E. (2022). A Feasibility Study of Individuals Living at Home with Alzheimer's Disease and Related Dementias: Utilization of Visual Mapping Assistive Technology to Enhance Quality of Life and Reduce Caregiver Burden. *Clinical Interventions in Aging*, 17, 1885–1892. <https://doi.org/10.2196/CIA.S387255>
- Kumar, A., & Shirish, A. (2023). What triggers digital employee advocacy behavior? In *ICIS 2023: International Conference on Information Systems*.
- Lauraitis, A., Maskeliūnas, R., Damaševičius, R., & Krilavičius, T. (2020). A mobile application for smart computer-aided self-administered testing of cognition, speech, and motor impairment. *Sensors (Basel, Switzerland)*, 20(11), 3236.
- 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. <https://doi.org/10.1016/j.ajp.2022.103135>
- Lipsmeier, F., Simillion, C., Bamdadian, A., Tortelli, R., Byrne, L. M., Yan-Ping, Z., Wolf, D., Smith, A. V., Czech, C., Gossens, C., Weydt, P., Schobel, S. A., Rodrigues, F. B., Wild, E. J., & Lindemann, M. (2022). A remote digital monitoring platform to assess cognitive and motor symptoms in huntington disease: Cross-sectional validation study. *Journal of Medical Internet Research*. <https://doi.org/10.2196/32997>
- Magnani, G., & Gioia, D. (2023). Using the Gioia methodology in international business and entrepreneurship research. *International Business Review*, 32(2), 102097.
- Matsangidou, M., Solomou, T., Frangoudes, F., Ioannou, K., Theofanous, P., Papayianni, E., & Pattichis, C. S. (2023a). Affective Out-World experience via virtual reality for older adults living with mild cognitive impairments or mild dementia. *International Journal of Environmental Research and Public Health*, 20(4), 2919. <https://doi.org/10.3390/ijerph20042919>
- Meiland, F., Innes, A., Mountain, G., Robinson, L., van der Roest, H., García-Casal, J. A., Gove, D., Thyrian, J. R., Evans, S., & Dröes, R.-M. (2017). Technologies to support community-dwelling persons with dementia: a position paper on issues regarding development, usability, effectiveness and costeffectiveness, deployment, and ethics. *JMIR rehabilitation and assistive technologies*, 4(1), e6376.
- Pietro, M. D. (2019). *How does dementia progress over time?* Retrieved 2024-10-20 from <https://www.medicalnewstoday.com/articles/314209?form=MG0AV3>
- Matsangidou, M., Solomou, T., Frangoudes, F., Papayianni, E., & Pattichis, C. S. (2023b). Offering outworld experiences to in-patients with dementia through virtual reality: Mixed methods study. *JMIR Aging*, 6(1), e45799. Meiland, F., Innes, A., Mountain, G., Robinson, L., van der Roest, H., García-Casal, J. A., Gove, D., Thyrian, J. R., Evans, S., & Dröes, R.-M. (2017). Technologies to support community-dwelling persons with dementia: a position paper on issues regarding development, usability, effectiveness and cost-effectiveness, deployment, and ethics. *JMIR rehabilitation and assistive technologies*, 4(1), e6376.
- Rawtaer, I., Mahendran, R., Kua, E. H., Tan, H. P., Tan, H. X., Lee, T. S., & Ng, T. P. (2020). Early detection of mild cognitive impairment with in-home sensors to monitor behavior patterns in community-dwelling senior citizens in singapore: Cross-sectional feasibility study. *Journal of Medical Internet Research*, 22(5), e16854.

- Robinson, L., Tang, E., & Taylor, J. P. (2015). Dementia: timely diagnosis and early intervention. *Bmj*, 350.
- Ruggiero, F., Zirone, E., Molisso, M. T., Carandini, T., Fumagalli, G., Pietroboni, A., Ferrucci, R., Aiello, E. N., Poletti, B., & Silani, V. (2023). Telemedicine for cognitive impairment: A telephone survey of patients' experiences with neurological video consultation. *Neurological Sciences*, 44(11), 3885–3894.
- Saredakis, D., Keage, H. A. D., Corlis, M., Ghezzi, E. S., Loffler, H., & Loetscher, T. (2021). The effect of reminiscence therapy using virtual reality on apathy in residential aged care: Multi-site nonrandomized controlled trial. *Journal of Medical Internet Research*, 23(9), e29210.
- Siette, J., Campbell, C., Adam, P. J., & Harris, C. B. (2024a). Exploring the usability of the virtual reality module LEAF CAFÉ: A qualitative think-aloud study. *BMC Geriatrics*, 24(1), 162.
- Siette, J., Guion, J., Ijaz, K., Strutt, P., Porte, M., Savage, G., & Richards, D. (2024b). Development of a new computer simulated environment to screen cognition: Assessing the feasibility and acceptability of leaf Café in younger and older adults. *BMC Medical Informatics and Decision Making*, 24, 1–16. <https://doi.org/10.1186/s12911-024-02478-3>
- Sriram, V., Jenkinson, C., & Peters, M. (2021). Carers' experiences of assistive technology use in dementia care: A cross sectional survey. *BMC Geriatrics*, 21, 1–12.
- 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.
- Villamil-Cabello, E., Meneses-Domínguez, M., Fernández-Rodríguez, Á., Ontoria-Álvarez, P., Jiménez-Gutiérrez, A., & Fernández-del-Olmo, M. (2023). A pilot study of the effects of individualised home dual task training by mobile health technology in people with dementia. *International Journal of Environmental Research and Public Health*, 20(8), 5464.
- Watanabe, Y., Miyazaki, Y., Hata, M., Fukuma, R., Aoki, Y., Kazui, H., Araki, T., Taomoto, D., Satake, Y., Suehiro, T., Sato, S., Kanemoto, H., Yoshiyama, K., Ishii, R., Harada, T., Kishima, H., Ikeda, M., & Yanagisawa, T. (2024). A deep learning model for the detection of various dementia and MCI pathologies based on resting-state electroencephalography data: A retrospective multi-centre study. *Neural Networks: the Official Journal of the International Neural Network Society*, 171, 242–250. <https://doi.org/10.1016/j.neunet.2023.12.009>
- Windle, G., Flynn, G., Hoare, Z., Masterson-Algar, P., Egan, K., Edwards, R. T., Jones, C., Spector, A., Algar-Skaife, K., & Hughes, G. (2022). Effects of an e-health intervention 'iSupport' for reducing distress of dementia carers: Protocol for a randomised controlled trial and feasibility study. *BMJ Open*, 12(9), e064314.
- Windle, A., Marshall, A., de la Perrelle, L., Champion, S., Ross, P. D. S., Harvey, G., & Davy, C. (2023). Factors that influence the implementation of innovation in aged care: A scoping review. *JBI Evidence Implementation*, 22(1), 61–80. <https://doi.org/10.1097/XEB.0000000000000407>
- World Health Organization. (2021). Global status report on the public health response to dementia. <https://www.who.int/publications/item/9789240033245>
- World Health Organization. (2025). Dementia. Retrieved 2025-06-19 from <https://www.who.int/news-room/fact-sheets/detail/dementia>
- World Health Organization. (2023). Dementia. Retrieved 2024-08-21 from <https://www.who.int/news-room/fact-sheets/detail/dementia>
- Yondjo, J., & Siette, J. (2024). VR is the future: Perspectives of healthcare professionals on virtual reality as a diagnostic tool for dementia status in primary care. *BMC Medical Informatics and Decision Making*, 24, 1–10. <https://doi.org/10.1186/s12911-023-02413-y>
- Zhang, J., Eggink, E., Zhang, X., Li, X., Jiang, B., Liu, H., Ge, S., Zhang, W., Lyu, J., & Niu, Y. (2022). Needs and views on healthy lifestyles for the prevention of dementia and the potential role for mobile health (mHealth) interventions in china: A qualitative study. *BMJ Open*, 12(11), e061111.
- Zhang, Y., Xu, J., Zhang, C., Zhang, X., Yuan, X., Ni, W., Zhang, H., Zheng, Y., & Zhao, Z. (2024). Community screening for dementia among older adults in china: A machine learning-based strategy. *Bmc Public Health*, 24, 1–10. <https://doi.org/10.1186/s12889-024-18692-7>
- Zolfaghari, S., Kristoffersson, A., Folke, M., Lindén, M., & Riboni, D. (2024). Unobtrusive cognitive assessment in Smart-Homes: Leveraging visual encoding and synthetic movement traces data mining. *Sensors (Basel, Switzerland)*, 24(5), 1381. <https://doi.org/10.3390/s24051381>

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