

Smart Elderly Care Technology Empowers the Care of Elderly Patients with Alzheimer's Disease: A Mini Review

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Abstract: As global aging progresses, the number of individuals with Alzheimer's disease (AD) is continually increasing, which imposes heavy caregiving and economic burdens on families and society. Smart elderly care, integrating technologies such as the Internet of Things, big data, and artificial intelligence, demonstrates broad application prospects in the care and management of AD patients. This paper reviews multiple applications of smart elderly technologies for AD patients: early warning and abnormal behavior monitoring, cognitive and memory training, recovery and long-term monitoring of activities of daily living, and caregiver burden reduction. While AD patients' quality of life and care efficiency are significantly enhanced by smart elderly technologies, numerous challenges remain. In the future, smart elderly technologies still have even greater potential in AD patient care.

Keywords: Smart elderly care; Alzheimer's disease; Artificial intelligence; Mini review

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1. Introduction

With the continuous intensification of global aging, the number of elderly people suffering from dementia has risen considerably in recent years. The occurrence of this disease is significantly related to the process of population aging. According to statistics from the World Health Organization (WHO), the number of global dementia patients is expected to increase from 55 million in 2019 to 139 million in 2050^[1]. Relevant statistics indicate that in 2019, there were approximately 13.14 million dementia patients in China, accounting for 25.5% of the global total^[2]. China is also the country with the largest number of people suffering from dementia in the world. Alzheimer's disease (AD) is a degenerative disorder of the central nervous system and the most common type of dementia, accounting for approximately 60% to 70% of all dementia patients^[3]. The diagnosis of AD primarily relies on the identification of characteristic neuropathological markers, including abnormal deposition of β -amyloid ($A\beta$), leading to the formation of senile plaques, and neurofibrillary tangles resulting from hyperphosphorylation

of the microtubule-associated tau protein ^[4]. These lesions can result in atrophy and death of brain cells, and abnormal signal transduction between nerve cells. Over time, individuals with AD may experience progressive memory impairment, cognitive and visuospatial deficits, and in advanced stages, neuropsychiatric and behavioral symptoms. Therefore, AD patients not only suffer from the immense pain brought by the disease themselves, but their family caregivers also face significant pressure, such as deteriorating physical health, anxiety, depression, and other physical and mental problems. Internal conflicts and contradictions arise among family members due to changes in the patient's condition, and the patient is abused, leading to social problems such as suicide ^[5]. At the same time, treating and caring for AD patients incurs high costs, which is a heavy economic burden for every family. WHO has calculated that in 2019, dementia caused a global economic loss of approximately 1.3 trillion US dollars. Among them, informal caregivers of AD patients (such as family members and close friends) provided about 5 hours of care and monitoring per day, and their contributions accounted for about 50% of the total cost ^[2]. With the rise of emerging technologies such as the Internet of Things, big data, and artificial intelligence, a model called "smart elderly care" has emerged, which can optimize elderly care problems. This model plays a crucial role in improving the quality of life of the elderly in their later years, scientifically and efficiently managing chronic diseases of elderly patients, and reducing the burden on families and society. However, a clear synthesis is needed that directly links these technological solutions to the specific challenges faced in traditional AD care, highlighting both the applications and the existing gaps. This article reviews the application of smart elderly care technology in the treatment and rehabilitation, self-management, and family care of AD patients, summarizes the existing predicaments and challenges, and looks forward to its future development prospects.

2. The connotation of "Smart Elderly Care" and its current application status at home and abroad

The concept of "Smart Elderly Care" was first proposed by the Life Trust of the UK in 2008 and is also known as the "Fully Intelligent Elderly System." It is designed to transcend temporal and spatial limitations to provide high-quality and enriching care services for older adults. Unlike the traditional care model reliant on human staff, the Smart Elderly Care model leverages technologies such as the Internet of Things, big data, and cloud computing to enable seamless integration between terminal sensors and central computing networks. At the very beginning, smart elderly care was mainly applied in the medical and health field. For instance, convenient call buttons, electrocardiogram monitors, and other terminal devices were used to monitor the physiological indicators of the elderly, such as blood pressure, heart rate, and blood oxygen in real time, and the monitored data was transmitted to the affiliated medical service center in real time. If any abnormality is detected, the intelligent system immediately initiates a remote medical protocol to address the healthcare needs of the older adults ^[6]. With the continuous enrichment of its connotation, smart elderly care is now widely applied in daily life and for the support and protection of people with disabilities, etc.

At present, many countries around the world are exploring smart elderly care models, especially in some developed countries. As they entered an aging society earlier, they have many mature experiences in smart elderly care that are worth learning from. However, the focus and characteristics of developing smart elderly care vary from country to country. Japan is the country with the most severe aging problem in the world. To solve this practical problem, Japan has launched the "Society 5.0" super smart plan, proposing to vigorously develop intelligent auxiliary products such as elderly care service robots, nursing robots, and surgical robots to improve

the efficiency of elderly care services. Therefore, robots are widely used in nursing homes and home-based elderly care in Japan. The smart elderly care model in the UK emphasizes the application of technology, while its core lies in community building, with smart elderly care service centers established on a community basis^[7]. The smart elderly care platform in the community, relying on intelligent and big data platforms, applies intelligent means such as the Internet, sensors, and wearable devices to establish telemedicine and conduct real-time monitoring of the daily physiological indicators and health status of the elderly. Similar to the situation in the UK, the US also has relatively high requirements for the technical aspect, characterized by the emphasis on the application of technologies such as smart home and Internet-based telemedicine. The US has fully exploited the high Internet usage rate of the elderly population, actively establishing primary electronic health records and developing telemedicine. This enables the elderly to use mobile smart devices, the Internet, video calls, and phone calls at home. Meanwhile, medical staff can access the health information of the elderly more quickly by reviewing electronic health records, achieving the integration of space and practice. Deep integration of home and medical care^[8]. Owing to its later start in developing Smart Elderly Care and significant regional economic disparities, China has seen various regions develop models suited to local contexts. The main ones include: the “Smart Elderly Care Community construction Model” represented by Shanghai, the “Smart elderly Care Institution Model - Intelligent Senior Apartment” represented by Beijing, and the “Virtual Model of Smart Elderly Care - Virtual Nursing Home” represented by Chengguan District of Lanzhou City^[9].

3. Application of smart elderly care in AD patients

3.1. Safety early warning and abnormal behavior monitoring

The primary and severe test that AD patients face is the safety hazard brought about by some of their abnormal behaviors. Through smart elderly care technology, the possibility of danger can be reduced. Abbasi *et al.*^[10] developed a hierarchical network system for AD patients. By capturing the actions of patients in time series and conducting reasoning calculations, they achieved high-risk early warning of abnormal behaviors in AD patients without sensors. The accuracy rate of activity detection reached 98%, and the accuracy rate of abnormal state determination reached 84%.

3.2. Cognitive and memory function training and recovery

During the rehabilitation process of AD patients, smart elderly care technology can also be involved in the training of their cognitive and memory functions. Elfaki and Alotaibi^[11] mainly summarized the improvement of mobile applications for patients with Alzheimer’s disease. For instance, one mobile application aids memory by allowing patients to save images of familiar people, while another provides cognitive training through games based on modules involving graphics, numbers, and letters. Meanwhile, a study followed 15 elderly people for six months and confirmed that mobile applications can improve the cognitive function of elderly patients^[12].

3.3. Recovery of daily living functions and long-term monitoring

For AD patients, promoting the recovery of their ability to live independently not only improves their quality of life in old age and enhances their sense of self-worth but also reduces the burden on their family caregivers. Wang *et al.*^[13] utilized remote-controlled robots to provide AD patients with step-by-step prompts for activities such as hand washing and coffee brewing. They evaluated the robot’s effectiveness from the perspectives of both patients and caregivers, and received positive feedback from both groups. Sheikhtaheri and Sabermahani

conducted a comprehensive review of the application of Internet of Things (IoT) technology in patients with AD. The IoT system can monitor the sleep patterns, daily activities, restless states, and whereabouts of AD patients. Multiple technologies, such as radio frequency identification, near-field communication, cameras, and sensors, have provided support for patients and alleviated their problems to a certain extent ^[14]. The continuous development of ubiquitous computing, cloud technology, and wireless technology, coupled with the support of artificial intelligence (AI), has made the application of these technologies in the field of dementia increasingly widespread ^[15]. As the core component of intelligent systems, sensors can sense various key signals in the environment. These sensors not only monitor human signals but also capture environmental information, thereby providing contextualized data. Embedded processors conduct real-time monitoring and processing of signals, and achieve automatic response through actuators. These advantages are particularly suited to the management of Alzheimer's disease, which requires continuous monitoring. This enables autonomous care and, when combined with remote monitoring, contributes to an improved quality of life for patients ^[16].

3.4. Reduced burden on caregivers

In a study, researchers used a visual mapping program to conduct group research on relevant parameters such as patients' daily living abilities and caregivers' stress levels after patients and caregivers used the tool. The visual map is a step-by-step visual guide created by the system through visual, audio, and text media, etc., to assist participants and their caregivers in planning and completing daily life activities. Six weeks later, scale surveys were conducted on AD patients and their caregivers, respectively. The results showed that the daily self-care ability of AD patients significantly improved, while the stress of their caregivers decreased significantly ^[17]. Kim *et al.* ^[18] conducted a review study on the changes brought about by the use of mobile health technology to caregivers of AD patients. They found that mobile health can help caregivers assess the decline of cognitive function of AD patients over time and provide feedback to doctors at any time for the formulation and adjustment of personalized treatment plans. In addition, it can also help caregivers relieve stress, alleviate the impact of negative emotions, and provide them with psychological support. Another study is about the role of social robots in the care of AD patients. They can not only measure the physiological indicators of patients but also assist AD patients in completing ten tasks, including changing bed sheets, checking home safety, using the phone, managing medication, obtaining key information from the radio, obtaining key information from posters, brushing teeth, sweeping the floor, and preparing meals ^[19]. In this way, the burden on its caregivers is also greatly reduced, which can be described as achieving multiple benefits at once.

4. Discussion: Synthesis of findings, implications, and limitations

The reviewed applications demonstrate that smart technologies can enhance safety, support cognitive function, and promote independence in AD patients, while also alleviating the strain on caregivers. However, beyond listing these benefits, it is crucial to discuss their real-world implications and acknowledge the significant hurdles that remain.

Implications for AD care: The integration of these technologies signals a shift towards more proactive and personalized care. For instance, continuous monitoring can enable "aging in place" by managing risks like falls or wandering, potentially delaying costly institutionalization. For healthcare systems, these tools offer a way to

extend care beyond clinical settings, allowing for remote patient management. The ability of AI to tailor cognitive training and reminders to an individual's specific needs and disease stage could lead to more effective interventions and higher user engagement. For policymakers, the evidence supports investments in digital infrastructure and the development of standards and reimbursement models that can make these technologies more accessible.

Limitations and challenges: Despite the promise, several limitations temper the current optimism. Technical reliability is a primary concern; sensors and algorithms may not perform perfectly in the unstructured environment of a private home, leading to false alarms or missed events. Data security and patient privacy are paramount, as these systems generate vast amounts of sensitive data, raising questions about data ownership, storage, and protection against breaches ^[20]. User-centered design is often lacking; interfaces can be too complex for cognitively impaired users or their often older, less tech-savvy caregivers, leading to low adoption rates. Economic and interoperability barriers are also substantial. The high cost of many systems limits access, and the lack of common standards means devices from different manufacturers rarely work together seamlessly, creating fragmented care ecosystems ^[21]. Finally, the evidence base requires strengthening. Many studies are small-scale pilots; larger, long-term real-world trials are needed to robustly prove the efficacy, cost-effectiveness, and impact on disease progression and quality of life over time.

5. Conclusion and outlook

Smart elderly care technology has developed rapidly in recent years and has become a transformative force in multiple fields such as clinical medical care, remote monitoring, and home-based elderly care. This evolution is largely driven by the convergence of several key technological trends. With the continuous maturation and improvement of AI algorithms, coupled with the wide deployment and low-latency capabilities of 5G networks, the field of elderly care is expected to achieve a major leap. In the near future, we can predict that the new generation of smart elderly care products will not only be more advanced in technology, but also safer and more personalized in essence.

The improvement of technological maturity will be manifested in several aspects. Artificial intelligence will evolve from performing basic tasks to providing predictive analysis and proactive intervention. For instance, machine learning models can analyze longitudinal data on patients' sleep patterns, activity capabilities, and vital signs to identify subtle deviations in potential health issues, enabling caregivers to take proactive interventions. In addition, the integration of the IoT will create a seamlessly connected living environment. Smart sensors embedded in homes can monitor daily activities, detect emergencies such as falls, and even manage environmental conditions like lighting and temperature to support patients' circadian rhythms and reduce anxiety. The powerful capabilities of 5G will help support these data-intensive applications, enabling real-time high-definition video transmission for remote medical consultations and ensuring the timely delivery of critical mission alerts.

Safety and personalization will provide fundamental guarantees for intelligent elderly care technology. These intelligent systems can distinguish normal behaviors from potentially dangerous situations, such as Alzheimer's patients wandering outside the designated safe zone or forgetting to turn off the stove. Personalization will be achieved through adaptive artificial intelligence, which can learn each person's unique habits, preferences, and cognitive abilities. For instance, digital interfaces can dynamically adjust their complexity: providing simple and clear reminders for people with advanced dementia, or offering more attractive cognitive games for those in the early stages of memory loss. This ensures that the technology meets the specific needs of users, enhancing

efficiency and user adoption rates.

Meanwhile, the ecosystem that supports smart elderly care will become more integrated and collaborative. The government, medical institutions at all levels—from large research hospitals to local clinics—and suppliers of elderly care products will establish closer cooperative relationships. This synergy is crucial for overall empowerment. The government can formulate supportive policies, establish a sound data security and privacy framework, and create reimbursement models that make these technologies easy to use. Medical institutions can provide the necessary clinical validation, integrate data from smart devices into electronic health records, and train medical professionals on how to use these devices. Conversely, suppliers will be driven by these feedbacks to continuously innovate and focus on developing interoperable, user-centered, and clinically relevant solutions. This tripartite cooperation will promote a virtuous cycle of improvement from the perspectives of policy, medical service provision, and pure technological innovation.

Ultimately, this collective effort will inject new vitality and vigor into the field of smart elderly care. It will transform from a niche product into a mainstream, scalable solution that can alleviate the burden on healthcare systems and home caregivers. By creating a supportive, intelligent, and responsive environment, these technologies can not only extend life expectancy but also significantly improve the quality of life for the elderly and patients with chronic diseases. They will cultivate a sense of independence, security, and connection, allowing individuals to age in a place with dignity.

Based on the evidence synthesized in this review, we propose the following concrete recommendations:

For healthcare professionals: Actively seek training to understand the capabilities and limitations of available smart care technologies. Integrate validated tools into individualized care plans, and play a key role in educating patients and their families on their practical use and privacy implications.

For policymakers: Develop national strategies that promote digital health in geriatric care. This should include funding for research and development, creating subsidies or insurance reimbursement pathways to improve affordability, and establishing robust regulatory frameworks for data security, privacy, and device interoperability.

For researchers: Prioritize research that addresses current gaps. This includes conducting large-scale, longitudinal studies to generate high-quality evidence on clinical outcomes and cost-benefit analysis. More effort should be directed toward designing intuitive, accessible, and culturally adapted user interfaces. Ethical research on the use of AI and continuous monitoring in this vulnerable population is also urgently needed.

By then, smart elderly care will truly realize its full potential and create a more compassionate and sustainable future for the global aging population.

Disclosure statement

The authors declare no conflict of interest.

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