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Artificial Intelligence in Medication Management for Alzheimer's Patients in China

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ABSTRACT

This study provides a comprehensive overview of artificial intelligence (AI) in managing Alzheimer's within China's domain through medication management research. The focus is on critical factors influencing medication adherence and significant AI contributions and trends. A systematic analysis examines how artificial intelligence can monitor medication adherence, provide reminders, and identify potential drug interactions by a theoretical review. These applications can potentially enhance patient adherence, therapeutic efficacy, and overall quality of life. However, existing literature reveals notable gaps, underscoring the necessity for further research. In conclusion, future projects should address these gaps to serve patients better, enhance treatment outcomes, and navigate the ethical and policy considerations in advancing Alzheimer's drug management.

Keywords: Alzheimer's, Artificial intelligence, Medication management, Medication adherence

PHARMACOLOGICAL BACKGROUND OF ALZHEIMER'S DISEASE

Alzheimer's Disease

Alzheimer's Disease (AD) is an incurable neurological illness primarily affecting older individuals (Jalbert et al., 2008). As the global population ages, it is estimated that 22% will be over 60 by 2050 (United Nations). China confronts a more pronounced ageing challenge (Zhang et al., 2020). According to the seventh Chinese population census, 18.7% of the total population is aged 60 and above (Central People's Government of the People's Republic of China, 2021). The prevalence of AD is approximately 7.8% among those aged 65 and older (Tian et al., 2009). The escalating ageing population has elevated Alzheimer's disease to a prominent position within medical research and as a significant social concern (Zhang et al., 2020). The incongruity between the growing number of individuals affected by AD and the finite healthcare resources has imposed a considerable burden on patients, their families, the social health system, and the care system (Rajiah et al., 2017).

Current Status of Pharmacological for AD Treatment in China

Alzheimer's disease (AD) induces neuronal death in the pyramidal cells of the second layer of the internal olfactory cortex and the CA1 region of the hippocampus, as reported by Gomezisla et al. (1996). This leads to a deterioration in recent memory, spatial orientation, and attention in severe cases, significantly impacting the daily lives of AD patients. As the disease progresses, there is a decline in both memory and cognitive functions (Ballard et al., 2011).

Various pharmacological interventions, such as cholinesterase inhibitors, N-methyl-D-aspartate receptor antagonists, and newer drugs like GV-971, have shown the potential to slow disease progression and enhance the quality of life for AD patients (Wang et al., 2016). However, despite these advancements, a potent clinical treatment still needs to be developed (Weller, 2018).

In China, a substantial number of AD patients adopt a combined approach involving both traditional Chinese herbal treatments and Western interventions. Chinese herbs, known for boosting energy and promoting blood circulation (Sun et al., 2013; Zhang, 2020; Fu, 2011), have gained attention. Innovative compounds derived from these herbs, as highlighted by Zhang et al. (2020), have demonstrated efficacy in reducing dementia symptoms with fewer adverse effects. Additionally, Wu et al. (2011) research indicates that substances like Huperzine A (HupA), Ginkgo biloba, curcumin, and Rhodiola rosea root show promise in treating AD.

MEDICATION ADHERENCE CHARACTERISTICS, BEHAVIOURS, AND INFLUENCES IN AD PATIENTS

While non-adherence to disease treatment can have detrimental consequences, it is regrettably common. Barriers to medical use, such as complex regimens and unclear directions, contribute to this issue. These challenges, particularly prevalent in Alzheimer's disease (AD) patients, can complicate medication treatment (Lam and Fresco, 2015).

Key obstacles to patient medication adherence include poor doctor-patient communication, insufficient drug understanding, complex long-term prescription regimens, and high treatment expenses (Elmansy and English, 2023). Weingarten et al. (1995) and Haynes et al. (1979) reported that over 60% of patients required assistance in understanding medical advice. Additionally, Svarstad (1976), Meichenbaum, and Turk (1987) found that over 60% of patients misunderstood their prescribed medication following a visit. Complex treatment regimens, primarily responsible for misunderstandings of medical advice (Burnier, 2000), may lead to patients needing to be more accurate with medical recommendations. This misunderstanding, often termed medication-taking bias, can result in dosage omissions or late measurement scheduling (Jimmy and Jose, 2011). Identifying these patient behaviours is crucial for physicians to enhance treatment efficacy (Paes et al., 1997).

Another significant factor contributing to poor adherence is the failure of patients and their families to comprehend prescription instructions, leading to improper dosing (Jimmy and Jose, 2011). Given that most Alzheimer's patients are cared for by elderly family members (Zhan, 2004), low literacy rates may play a role. Low-literacy patients may require assistance understanding certain medications, leading to suboptimal medication management and adherence (Praska et al., 2005).

Chronic illnesses like hypertension and Alzheimer's often contributed to drug nonadherence (Jimmy and Jose, 2011). Meichenbaum and Turk (1987) noted that weak or asymptomatic patients exhibit the highest medication nonadherence rates. Even if they deviate from their prescribed regimen, they may not experience immediate adverse effects. Sackett and Snow (1979) found that 63% of patients adhered to medication for curative purposes. However, when prescribed long-term medications for treatment or prevention, patient adherence drops below 50% (Sackett and Snow, 1979). Finally, more studies on the influencing factors affecting medication adherence in AD patients are detailed in Table 1.

Table 1. Summary of some factors influencing adherence. This table was created by the authors to collect and summarise some of the influencing factors affecting medication adherence in AD patients in the relevant literature.

Article	Factors
Orange et al., 1994;Werner et al., 2022;Brodaty and Green, 2002	Family and social support
Brodaty and Green, 2002;Brodaty and Green, 2002; Gallagher Thompson et al., 2006; Meng et al., 2020	Emotional support
Cummings et al., 2002;Richter et al., 1993;Ndume, 2020;Cox and Pardasani, 2013	Family Education
Sona et al., 2013;Mayhew, 2005;Omar et al., 2019; Holroyd and Shepherd, 2001; Ilha et al., 2016	Patient self-management
Lalic et al., 2016;Sun et al., 2013;Yang et al., 2021	Complexity of medication regimes
Briggs et al., 2016;Weller, 2018;Small and Dubois, 2007;Nili-Ahmadabadi,2017	Clinical Progression and Therapeutic Effects

ARTIFICIAL INTELLIGENCES IN HEALTHCARE

Artificial Intelligence

In 1950, Alan Turing introduced the Turing test to distinguish between humans and machines, based on his belief that machines could simulate human behaviour and thought (Mintz and Brodie, 2019). In contrast, the term "Artificial Intelligence" (AI) was first proposed in 1956 by John McCarthy. In the current information age, AI is often called "The new electricity" (Hoppe et al., 2023, p. 225). Obschonka and Audretsch (2020) defined AI as "Intelligence demonstrated by machines" on page 3 of their study (2020, p. 530).

Machine Learning, Deep Learning and Artificial Neural Networks

Machine Learning (ML) is an algorithm-based AI learning paradigm (Janiesch et al., 2021). Defined by Hamet and Tremblay (2017) as a machine's ability to budget and learn from previous examples, machine learning holds significant potential in advancing medical discoveries facilitated by algorithms and learning expertise (Holzinger et al., 2019).

Deep Learning (DL) utilizes multi-layered neural networks resembling the human brain for processing and analyzing complex data (Razzak et al., 2018; Shen et al., 2017). One application of deep learning in healthcare is tailored drug management, as highlighted by Oyebode et al. (2023). To enhance adherence, deep learning can use physiological and disease progression data to formulate optimal drug management strategies (Oyebode et al., 2023).

Artificial Neural Networks (ANNs), described by Agatonovic-Kustrin and Beresford (2000) as computational models of biological nerve systems, are anticipated to contribute significantly to future developments in personalized medicine, precision therapy, disease prediction, and medication management (Wang et al., 2020; McCarthy, 2020).

Medical AI

Medical AI, characterized by the application of artificial intelligence in healthcare, primarily involves using computer technology for clinical diagnosis and treatment recommendations (Szolovits et al., 1988). Machine Learning (ML) is one of AI's crucial sub-domains in the disease detection process (Kumar et al., 2022; Ghaffar et al., 2023). Furthermore, neural networks and Deep Learning (DL) constitute the fundamental sub-domains of ML (Fig. 1) (Ghaffar et al., 2023).

According to Bohr and Memarzadeh (2020), AI uses computers to simulate intelligent human behaviour, endowing them with human-like thought processes and programming them to replicate human behaviour. Consequently, AI can effectively mimic and augment human cognitive capabilities. This widespread implementation of artificial intelligence in healthcare has facilitated improved availability of healthcare data and the rapid development of data analytics (Jiang et al., 2017).

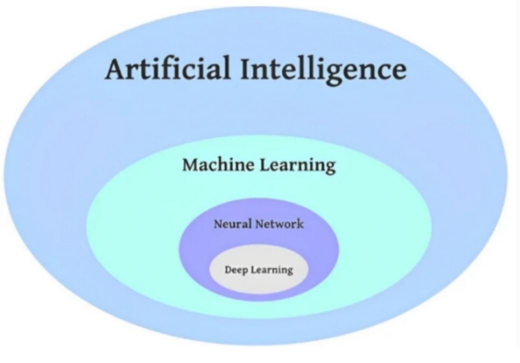

Figure 1: Relationship among AI, ML, NN, and DL techniques (Ghaffar et al., 2023).

Artificial intelligence is commonly employed to tackle diverse healthcare challenges. The benefits of AI in healthcare include drug cross-checking, disease prediction and diagnosis, medical consultation, drug information education, health data monitoring, and personalized services (Damiano, 2021).

ARTIFICIAL INTELLIGENCES IN MEDICATION MANAGEMENT

Medication Management

Drug management and medical management are synonymous terms for medication management, a crucial process ensuring that patients receive proper treatment and minimizing drug-related hazards (Croatti et al., 2019; Ancker, 2015). In a broader sense, medication management encompasses formulation, prescription, purchase, storage, administration, and monitoring. This comprehensive approach necessitates robust collaboration within the healthcare team to optimize patient medication outcomes (Shah et al., 2015; Wang, 2004).

According to He (2020), medication management encompasses all patient and organizational actions related to medications, a perspective supported by Ancker, Shah, Wang, and Majeed-Ariss (2015). In the context of Alzheimer's disease, medication management involves aspects such as adherence, developing a thorough treatment plan, and individualized treatment approaches to enhance patient outcomes (Bassil and Grossberg, 2009).

Drug Development and Therapy

Machine Learning (ML) plays a pivotal role in medication management. ML models trained on high-throughput screening data, which observe patient reactions to new drugs or therapeutic combinations, significantly contribute to achieving better treatment goals. Additionally, ML can expedite drug development by designing and constructing reverse synthetic compound routes (Nascimento et al., 2019; Sharma & Rani, 2020; Watson, 2019). In the context of Alzheimer's, machine learning can predict patient progression and drug responses, aiding healthcare professionals in selecting and adjusting drug regimens to enhance therapeutic efficacy and patient care (Fabrizio et al., 2021; Vatansever et al., 2021).

Deep Learning (DL), a novel machine learning algorithm, is extensively employed in the drug discovery industry. Recent studies highlight its application in computerized picture data extraction, among other uses (Liang et al., 2020). DL algorithms, often based on extensive datasets, have also opened up new possibilities in drug repurposing. Venugopalan et al. (2021) demonstrated that deep learning can analyze brain imaging data, such as MRI scans, for early Alzheimer's diagnosis and disease progression monitoring. This capability allows for the development of individualized treatment plans.

Precision Medicine

Precision medicine employs individual patient characteristics and molecular data to inform disease diagnosis, prevention, and treatment. Artificial Intelligence (AI) focuses on genetic inheritance and environmental and lifestyle factors to identify practical approaches and tailor treatments (Subramanian et al., 2020). In the medical field, precision therapy is frequently applied in anti-cancer drug development, tumour detection, and immunotherapy (Liang et al., 2020). The application of precision therapy in the pharmacological management of Alzheimer's Disease (AD) patients holds significant potential.

EVALUATION OF THE CURRENT STATUS OF AI APPLICATION IN AD DISEASE TREATMENT

Currently, the use of Artificial Intelligence (AI) in the AD treatment is expanding rapidly technology plays a crucial role in the process of early diagnosis and prediction of AD by analysing large-scale patient data, such as neuroimaging, biomarkers, and genetic information, to assist physicians in detecting early signs of AD (Fabrizio et al., 2021; El-Sappagh et al., 2023; Farooq et al., 2017). AI also has the potential to develop personalised treatment plans, based on the patient's condition, genotype, and lifestyle, which can improve treatment outcomes (Fabrizio et al., 2021; El Sappagh et al., 2023; Farooq et al., 2017). Moreover, AI provides innovative solutions for monitoring the condition, supplying medical knowledge, and facilitating patient self-management. Although AI extensively treats adolescent diseases, it is currently less prevalent in patient-centred medication management. Table 2 brings together more specific uses of AI in AD disease treatment.

Table 2. Application of AI in AD. A summary of relevant literature.

Article	Study/Information	Healthcare Area
Li et al., 2023	Natural Language Processing (NLP) techniques are used to predict or diagnose disease information	Diagnosis and effect study
Aggarwal, 2018	Utilising DL concentrate on the extraction of valid information from images and a variety of algorithmic models utilising DL will be helped for the treatment.	
Vamathevan et al., 2019, Qian et al., 2019	Combining high-throughput techniques and deep learning with AI in drug development has led to more accurate drug development	Drug Formulation and Treatment
Feil-seifer and Matari, 2005	Socially Assistive Robot (SAR) to assist human users through social interaction and help patients and their families with drug management	Patient Assistance(Nursing Robots in AD Caring and Drug Management)
Esteva et al., 2017; Bejnordi et al., 2017; Bello et al., 2019	ML and AI-based platforms have enabled more precise disease prediction structures.	Precision medicine

CHALLENGES AND FUTURE DIRECTIONS FOR AI IN AD MEDICATION MANAGEMENT

The Role of AI in Improving Doctor-Patient Communication in the AD Treatment

AI has emerged as a significant driving force in the healthcare industry, progressively integrating into healthcare advancements and medical diagnostic innovations (Kubassova et al., 2021; Kermany et al., 2018). The doctor-patient relationship has transcended traditional interactions between physicians and patients due to the application of AI tools (Ichkiti et al., 2023). While incorporating artificial intelligence in medicine has propelled modern healthcare, it has also prompted concerns related to medical ethics, particularly the trust within the doctor-patient relationship (Kaptchuk and Miller, 2015; Reddy, 2018). Kumar and Chattu (2018) emphasize the need to prioritize the "human" aspect of the doctor-patient relationship in this transformative process—the essence of the "human" condition.

For accurate disease diagnosis and effective patient advocacy, maximizing patient participation in healthcare is essential (Kubassova et al., 2021). The research by Kumar and Chattu (2018) highlights the significance of considering an individual's reasoning, desires, feelings, and needs in treating their illnesses, encapsulated in patient-centred care (Hickmann et al., 2022; Robinson et al., 2008). Patient-centeredness involves a range of attitudes towards patients and self-reflection on the part of physicians regarding their medical competence (Hickmann et al., 2022). Robinson et al. (2008) noted that patient-centred interactions could effectively promote treatment adherence and assist patients with medication management.

Challenges

Artificial intelligence has become a dominant force in healthcare, propelled by rapid advancements in information technology (Reddy et al., 2019). While AI holds enormous potential for enhancing patient care and healthcare processes, the future of AI in healthcare is still evolving, shaped by ethical and moral considerations such as privacy, doctor's rights and obligations, and issues related to data bias.

Data bias emerges as a significant challenge for AI in healthcare (Reddy, 2018). Training AI models require extensive health data, making them susceptible to privacy concerns and challenges in data management and sharing (Safavi and Kalis, 2020; Rigby, 2019). Patient healthcare data, encompassing personal information, needs to be improved in distribution and management across databases (Das et al., 2012). As a result, development companies must adhere to stringent privacy regulations, potentially hindering AI development (Singh et al., 2020).

In traditional healthcare, patients trust doctors (Kaptchuk and Miller, 2015). This doctor-patient trust is crucial as it enhances the effectiveness of therapeutic care (Kaptchuk and Miller, 2015). Reddy (2018) argues that trust in the doctor-patient relationship may be compromised if AI excessively interferes with therapeutic care or if it starts replacing doctors partially.

Hence, trust becomes paramount in this evolving interaction between AI technologies, healthcare systems, and patients (Lupton, 2018). Establishing new ethical boundaries for AI is imperative.

CONCLUSION

This study examined drug adherence and Alzheimer's disease therapy. Research findings indicate that multiple therapy characteristics significantly influence drug adherence in Alzheimer's patients. Notably, the existing literature on Alzheimer's drug adherence often lacks the identification of fundamental causes and patient requirements. Further research is essential to address medication adherence issues among Chinese Alzheimer's patients.

In the second aspect, the literature was analyzed to understand the potential and limitations of Artificial Intelligence (AI) in Alzheimer's drug management. AI in drug management can enhance doctor-patient communication, assisting patients in understanding treatment alternatives and adverse effects. However, the study revealed that the potential of AI in Alzheimer's medication management is still under exploration.

This study aims to assist family member management in exploring factors affecting medication adherence in AD patients through the literature review. It also explores the current status of AI-based research and promotion of patient-centred medication management. Future studies will combine mix research method to explore the most critical medication adherence factors in Chinese Alzheimer's disease patients and propose medication adherence strategies based on the key parameters and artificial intelligence.

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