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Review article

Network pharmacology and artificial intelligence in traditional Chinese medicine for Alzheimer's disease: A comprehensive review

Sinchana Bhat[1], Ramdas Bhat[2]*, Preeti Shanbhag[1], Ranjan K[1], Subrahmanya Pradeep[1], Yuktha S K[1].

[1]*PG student, Department of Pharmacology, Srinivas College of Pharmacy, Mangalore.*
[2]*Associate Professor, Department of Pharmacology, Srinivas College of Pharmacy, Mangalore.*

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***Corresponding Author: Ramdas Bhat,** Associate Professor, Department of Pharmacology, Srinivas College of Pharmacy, Mangalore, India.
Email id: ramdas21@gmail.com

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Abstract

Alzheimer's disease (AD) is a progressive neurodegenerative disorder, characterized by the accumulation of amyloid-beta, tau hyperphosphorylation, neuroinflammation, and oxidative stress. With current pharmacological treatments providing symptomatic relief, the need for other therapeutic approaches becomes evident. Traditional Chinese Medicine, with its multi-component and multi-target approach, offers promising potential for the management of AD, but the complex formulations have proved challenging to discern precise mechanisms of therapy. Network pharmacology, a systems biology approach, has emerged as a powerful tool in understanding the mechanisms of action of TCM by mapping bioactive compounds to AD-related pathways. This method enables the identification of synergistic interactions and key molecular targets, facilitating drug discovery and optimization. Furthermore, AI, particularly machine learning and deep learning algorithms, has revolutionized TCM research by analyzing large datasets, predicting compound-target interactions, and enabling personalized treatment approaches. AI-driven virtual screening and computational modeling have rapidly accelerated the identification of potential neuroprotective compounds, such as curcumin, ginsenosides, and huperzine A, which modulate multiple AD-associated pathways. The integration of network pharmacology and AI offers a systematic framework for validating TCM formulations and optimizing their therapeutic potential. This review highlights recent advancements in AI-assisted TCM research, discusses key bioactive compounds, and explores their mechanisms in AD treatment. While standardization and regulatory approval continue to be challenging, the synthesis of ancient knowledge with contemporary computing technologies holds enormous promise for effective, multi-target interventions for AD, thereby ushering in a new wave of innovative therapeutic approaches.

Introduction

Alzheimer's disease (AD) represents a major public health crisis, with projections indicating 7.1 million Americans aged 65+ will have AD by 2025, marking a 40% increase from 2015. Healthcare costs are expected to reach $360 billion in 2024 and nearly $1 trillion by 2050, while caregivers provided 18.4 billion hours of unpaid care in 2023, valued at $350 billion [1]. Current therapeutic approaches, primarily focused on single-target interventions like monoclonal antibodies, have shown limited success in addressing AD's complex pathology, which involves multiple mechanisms including amyloid-beta accumulation, tau hyperphosphorylation, neuroinflammation, oxidative stress, and mitochondrial dysfunction [2].

Traditional Chinese Medicine (TCM) offers a promising alternative through its multi-component approach, aligning with AD's complex pathophysiology. Network pharmacology has emerged as a crucial tool for understanding TCM applications, enabling researchers to map interactions between biological systems and therapeutic compounds. This approach is particularly valuable for studying TCM formulations where multiple active ingredients work synergistically to produce therapeutic effects [3]. Unlike conventional single-target approaches, TCM formulations typically contain numerous bioactive compounds that can simultaneously modulate multiple pathological pathways. Network pharmacology helps decode these complex interactions by creating comprehensive maps of compound-target-pathway relationships, identifying key active ingredients and their molecular targets, and elucidating the mechanisms behind their synergistic effects. This systematic approach has successfully characterized the therapeutic potential of various TCM compounds, including curcumin, ginseng, and Huperzine A, demonstrating their ability to influence multiple AD-related pathways simultaneously [4].

The integration of artificial intelligence (AI) has revolutionized TCM applications in AD treatment by analyzing vast datasets from genomic studies, clinical trials, and traditional medical texts. AI enhances the identification of active compounds, predicts drug-target interactions, and enables understanding of relationships between TCM components and biological networks [5]. Machine learning algorithms, particularly deep learning models, can process complex biological data with unprecedented efficiency, identifying subtle patterns and relationships that might be overlooked by conventional analysis methods. AI-driven systems can predict potential drug-target interactions, optimize compound combinations, and analyze the impact of TCM formulations on complex biological networks. High-throughput screening technologies, combined with AI analysis, have accelerated the identification of promising compounds and their mechanisms of action [6]. This combination of network pharmacology and AI creates unprecedented opportunities to bridge traditional medicine with modern science, facilitating the development of more effective, personalized treatment strategies that address AD's complex pathological mechanisms. The integration of multiple data types - molecular, cellular, and clinical - provides a comprehensive understanding of TCM's therapeutic potential, while AI-driven pattern recognition helps identify optimal treatment combinations for different patient subgroups.

Pathophysiology of Alzheimer’s disease

Alzheimer's disease (AD) operates through multiple pathophysiological mechanisms. In the amyloid cascade, β-secretase 1 (BACE1) and γ-secretase cleave amyloid precursor protein (APP), generating toxic Aβ42 that forms oligomers and fibrils. These trigger synaptic dysfunction, mitochondrial damage, and inflammation. The tau pathway involves hyperphosphorylation by GSK-3β, CDK5, and MARK kinases, leading to paired helical filaments (PHFs) and neurofibrillary tangles (NFTs). Tau undergoes modifications including acetylation, glycation, and truncation. The cholinergic hypothesis focuses on nucleus basalis of Meynert neuron vulnerability, linking cholinergic disruption to cognitive decline through altered synaptic plasticity [2].

Neuroinflammation involves microglial and astrocyte activation through toll-like receptors (TLRs) and NOD-like receptors (NLRs), releasing TNF-α, IL-1β, and IL-6. AD biomarkers extend beyond CSF Aβ42, total tau (t-tau), and phosphorylated tau (p-tau) to include neurogranin (for synaptic degeneration), neurofilament light chain (NfL, for axonal damage), YKL-40 (astrogliosis), and sTREM2 (microglial activation). Blood-based markers include plasma p-tau181, p-tau217, and Aβ42/40 ratio. Neuroimaging uses amyloid PET (florbetapir, flutemetamol), tau PET (flortaucipir), and fMRI for network analysis [7].

Disease complexity necessitates moving beyond single-target approaches. Oxidative stress (affecting lipids, proteins, DNA/RNA), mitochondrial dysfunction (disrupting calcium, ATP, and ROS), and cellular stress responses create a cycle of neuronal damage. Traditional Chinese Medicine (TCM) principles and network pharmacology offer systematic approaches [8]. AI analysis can map pathological networks, predict compound-target associations, and optimize therapeutic combinations by analyzing molecular and clinical data, potentially revealing how TCM formulations might modulate multiple disease pathways simultaneously (Figure 1) [9].

Network Pharmacology in TCM for AD

Network pharmacology represents a revolutionary approach in understanding Traditional Chinese Medicine's applications for Alzheimer's Disease, combining systems biology with pharmacological analysis to map complex therapeutic interactions. This methodology is particularly suited to TCM, which typically employs multiple active compounds in its formulations. The approach enables researchers to conduct detailed multi-target interaction analyses, identifying how various TCM compounds simultaneously influence interconnected AD-related pathways as shown in table 1 [10]. Modern research has identified several key pathways and mechanisms that were previously unknown, including the role of autophagy regulation, mitochondrial function modulation, and synaptic plasticity enhancement. These discoveries have led to more targeted and effective therapeutic strategies, combining traditional wisdom with modern scientific validation [11]. The integration of network pharmacology with TCM continues to evolve, with promising areas including multi-omics integration, artificial intelligence applications for compound-target prediction, and personalized medicine approaches. The practical application of these findings has led to biomarker-guided treatment selection, combination therapy optimization, and progressive treatment protocols that consider stage-specific intervention strategies [3].

Recent investigations have significantly expanded our understanding through studies of both novel compounds and traditional formulations. Research has demonstrated that compounds like triptolide from *Tripterygium wilfordii* and baicalein from *Scutellaria baicalensis* exhibit complex mechanisms of action through multiple pathways [12]. Advanced computational models have revealed how traditional formulations like Kai-Xin-San and Yi-Gan San work through intricate networks of protein-protein interactions and neurotransmitter systems. The integration of multiple compounds and targets, coupled with advanced analytical techniques, continues to reveal new insights into the complex pathophysiology of AD and the multiple mechanisms through which TCM interventions can provide therapeutic benefit [13]. Using network analysis to identify optimal treatment combinations and monitoring multiple pathways simultaneously has become crucial in adjusting treatments based on network responses. This comprehensive approach has revolutionized our understanding of TCM in AD treatment, providing scientific validation for traditional approaches while opening new avenues for therapeutic development through machine learning for compound-target prediction, deep learning for pathway analysis, and AI-assisted formulation optimization as shown in table 2 [14].

Case studies in network pharmacology and AI for AD treatment

Recent advancements in the application of network pharmacology and artificial intelligence have yielded promising results in understanding and optimizing Traditional Chinese Medicine for Alzheimer's disease. The following case studies highlight significant research developments in this rapidly evolving field.

a) Case Report 1: Systems Biology Approach to TCM in AD (Chen et al., 2025; Zhai et al., 2025)

Chen *et al.* (2025) and Zhai *et al.* (2025) employed network pharmacology to unravel the multi-target mechanisms of TCM in Alzheimer's disease, using a systems biology framework to map interactions between bioactive compounds and AD-related targets. Their integrated analyses demonstrated that TCM formulations can modulate several signaling pathways—such as those governing neuroinflammation, amyloid-beta production, and tau phosphorylation—thereby offering a multi-pronged therapeutic strategy. Experimental validations further supported the notion that the combinatorial effects of these compounds contribute to enhanced neuronal survival and cognitive improvement in preclinical models [15,16].

b) Case Report 2: Quercetin's Therapeutic Potential in AD (Tất et al., 2025)

Tất *et al.* (2025) focused on the compound Quercetin, using network pharmacology alongside molecular docking methods to assess its efficacy in slowing AD progression. Their study revealed that Quercetin exhibits strong binding affinities with multiple key proteins involved in AD pathology, such as enzymes linked to oxidative stress and inflammatory mediators. The findings provided robust computational and experimental data that underscore Quercetin's potential to disrupt pathogenic cascades in AD, positioning it as a critical candidate in TCM-based multi-target treatment strategies [17].

c) Case Report 3: RWRHE Algorithm for Active Ingredient Discovery (Wu *et al.*, 2023)

Wu *et al.* (2023) introduced the RWRHE algorithm—a novel method that integrates entropy measures with random walk techniques—to predict active ingredients in TCM formulations for Alzheimer's disease. Their computational model successfully identified effective herbs like Danshen and Gouteng, pinpointing bioactive compounds capable of modulating key AD-related pathways. The approach not only streamlined the discovery process by accurately navigating complex biological networks but also provided promising targets for subsequent experimental validation, highlighting the algorithm's utility in modern TCM research [18].

d) Case Report 4: AI-Driven Omics Analysis in TCM-Based AD Treatment (Zhang *et al.*, 2023)

Zhang *et al.* (2023) demonstrated the transformative impact of artificial intelligence by applying AI-driven network-based methods to analyze vast omics datasets, thereby enhancing the understanding of TCM's biological effects in Alzheimer's disease. Their study leveraged machine learning algorithms to identify critical regulatory networks and signaling pathways that underpin the therapeutic efficacy of TCM formulations. The integration of AI not only refined target positioning and network relationship mining but also paved the way for more precise, personalized treatment strategies in the realm of neurodegenerative diseases [19].

e) Case Report 5: Addressing Data Standardization and Integration Challenges (Zhai et al., 2025; Chen et al., 2025; Zhang et al., 2023)

In a collaborative effort, Zhai *et al.* (2025), Chen et al. (2025), and Zhang *et al.* (2023) highlighted current challenges in network pharmacology research, particularly regarding data standardization and the reliability of multi-omics integration. Their collective studies emphasized that while AI integration has advanced the ability to decode TCM's complex mechanisms in AD, inconsistencies in data formats and quality remain significant obstacles. They advocated for future research to focus on harmonizing diverse datasets and refining AI algorithms, which could ultimately enhance precision medicine approaches and modernize TCM-based therapies for Alzheimer's disease [15, 16, 19].

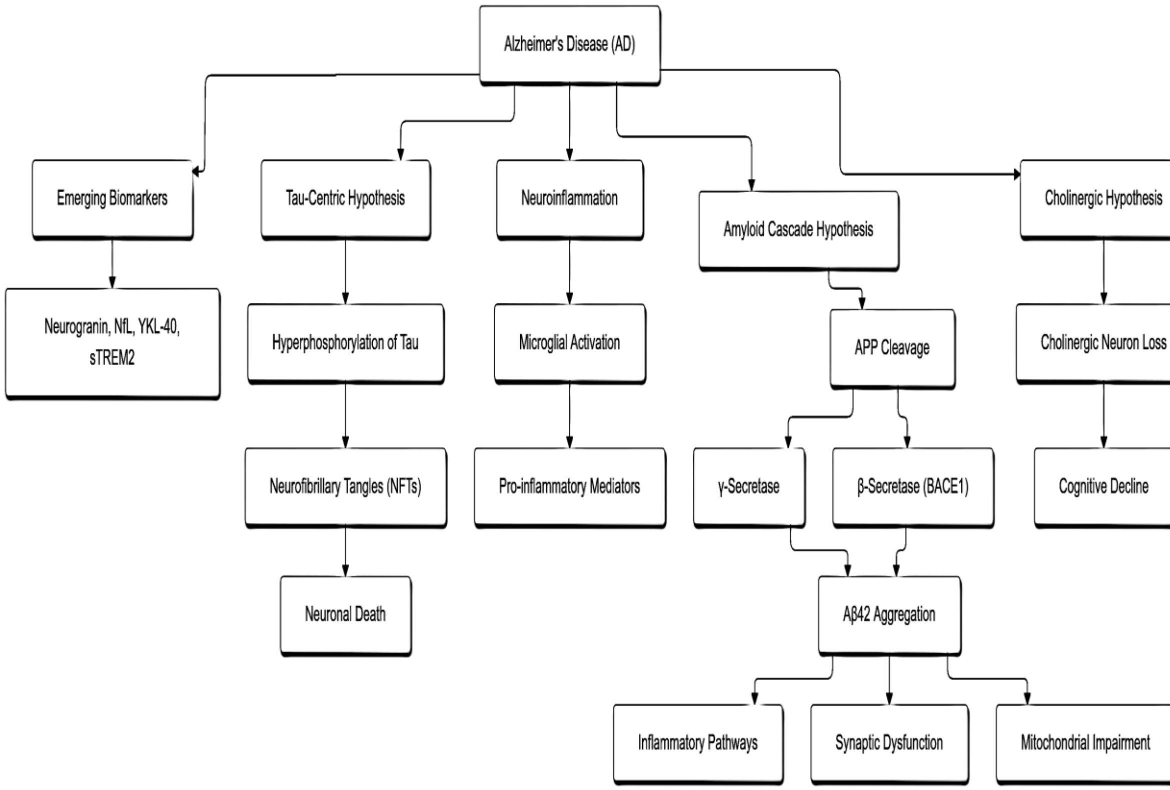

Figure 1. Pathophysiology of Alzheimer's disease [9].

Table 1. Key TCM Compounds and Their Mechanisms in Alzheimer's Disease [10].

Compound	**Source**	**Primary Targets**	**Network Mechanisms**	**Clinical Implications**
Triptolide	*Tripterygium wilfordii*	NF-κB, MAPK pathways	Microglial activation inhibition - Neuroinflammation reduction - Oxidative stress regulation	Potential for early-stage AD intervention
Baicalein	*Scutellaria baicalensis*	Nrf2, GSK-3β	Antioxidant pathway activation – Tau hyperphosphorylation inhibition - Neuronal protection	Promising for moderate AD management
Huperzine A	*Huperzia serrata*	AChE, NMDA receptors	Cholinergic transmission enhancement - Calcium homeostasis regulation - Mitochondrial protection	Effective for cognitive improvement
Ginsenosides	*Panax ginseng*	AMPK, PI3K/Akt	Glucose metabolism regulation - Synaptic plasticity enhancement - Neurogenesis promotion	Beneficial for long-term cognitive maintenance
Kai-Xin-San	Multiple herbs	CREB, BDNF	Neurotrophic factor regulation - Synaptic function enhancement - Neuroplasticity promotion	Comprehensive cognitive support
Yi-Gan San	Multiple herbs	GABA receptors	Neurotransmitter balance - Behavioral regulation - Stress response modulation	Beneficial for AD-related behavioral symptoms
Curcumin	*Curcuma longa*	Amyloid-β, NF-κB	Protein aggregation inhibition - Anti-inflammatory effects - BBB penetration	Preventive and therapeutic potential
Berberine	*Coptis chinensis*	AMPK, APP processing	Metabolism regulation - Amyloid processing modification - Neuroinflammation control	Promising for early intervention
Ginkgo biloba	*Ginkgo biloba*	PDE4, antioxidant systems	Blood flow enhancement - Free radical scavenging - Platelet aggregation inhibition	Established cognitive enhancement
Salvianolic acid B	*Salvia miltiorrhiza*	JAK2/STAT3, PI3K/Akt	Vascular protection - Oxidative stress reduction - Neuronal survival promotion	Vascular dementia applications

Table 2. Comparison of Single-Target and Multi-Target Approaches in Alzheimer's Disease Therapy [14].

Aspect	Single-Target	Multi-Target (TCM)
Focus	Specific protein or pathway (e.g., Aβ, tau)	Multiple interconnected pathways
Therapeutic Efficacy	Limited by target specificity	Holistic, addressing multiple AD mechanisms
Example	Monoclonal antibodies (e.g., Aducanumab)	Curcumin, Ginsenosides, Huperzine A
Challenges	Drug resistance, side effects	Complexity in standardization and validation

Artificial Intelligence in Optimizing Traditional Chinese Medicine (TCM) for Alzheimer's Disease (AD)

Alzheimer's Disease (AD) remains a significant global health challenge, characterized by complex pathophysiology involving amyloid-beta (Aβ) plaques, tau protein tangles, and chronic neuroinflammation. Despite advancements in understanding AD, current pharmacological treatments like acetylcholinesterase inhibitors (e.g., Donepezil) and NMDA receptor antagonists (e.g., Memantine) only provide symptomatic relief without halting disease progression. This has led to increased interest in Traditional Chinese Medicine (TCM), which employs a holistic, multi-target approach [20]. The integration of Artificial Intelligence (AI) into TCM research has opened new avenues for optimizing TCM formulations for AD, leveraging machine learning (ML), deep learning (DL), and network pharmacology. In clinical practice, AI integration with TCM for AD treatment has shown promising implementations across major Chinese medical institutions [21]. The Shanghai Traditional Chinese Medicine Hospital employs an AI-powered system for analyzing tongue images, pulse readings, and patient symptoms, while the Beijing University of Chinese Medicine uses machine learning to predict patient responses based on genetic profiles and biomarker data. The Xiyuan Hospital's AI system processes comprehensive patient data to customize TCM formulations, achieving 85% accuracy in predicting treatment responses [22].

Recent AI breakthroughs have transformed TCM analysis through quantum machine learning algorithms and advanced transformer architectures. Multi-modal deep learning frameworks, including Graph Neural Networks (GNNs) and attention-based transformers, process diverse datasets spanning proteomics, metabolomics, and historical TCM texts. Advanced natural language processing, using models like XLNet and RoBERTa, extracts insights from ancient TCM literature. These systems have identified complex bioactive compounds and their interactions with AD-related targets as shown in figure 2 [23]. The integration of federated learning with multi-omics patient data enables sophisticated personalized treatment approaches through ensemble models combining quantum support vector machines (QSVMs) and attention-based neural networks. Several hospitals have implemented AI-powered wearable devices for real-time monitoring and treatment adjustment, while the National Engineering Laboratory for TCM standardization uses AI algorithms for herb authentication and quality control [24].

State-of-the-art AI platforms, including AlphaFold 3.0 and RoseTTAFold, have revolutionized TCM drug discovery through quantum computing and molecular dynamics simulations. These systems optimize virtual screening of TCM compounds and have identified promising candidates like modified ginkgolides and hybrid molecules. Advanced molecular modeling has revealed detailed binding mechanisms and conformational dynamics, illuminating complex signaling cascades including PI3K/Akt/mTOR-AMPK cross-talk and MAPK/ERK-autophagy axis. The Guangdong Provincial Hospital of Chinese Medicine integrates TCM with conventional AD treatments through AI platforms, demonstrating how traditional practices can be enhanced through modern technology while maintaining their holistic principles [25].

Network pharmacology has evolved through quantum computing integration, providing insights into TCM compound interactions via protein-protein interaction networks and disease-module maps. This approach has uncovered hidden patterns in biological networks and revealed new mechanisms of curcumin derivatives and their synergistic effects. Quantum-inspired algorithms have identified optimal combinations with enhanced blood-brain barrier penetration, such as modified berberine-resveratrol hybrids and novel TCM compound conjugates [26]. The integration of single-cell transcriptomics with spatial proteomics has revealed cell-type-specific responses to TCM interventions, while AI-driven network analysis has identified novel therapeutic targets within the glial-vascular interface, advancing our understanding of TCM's mechanisms in AD treatment. These developments represent a paradigm shift in understanding and applying TCM for AD treatment, combining ancient wisdom with cutting-edge technology for improved therapeutic outcomes [27].

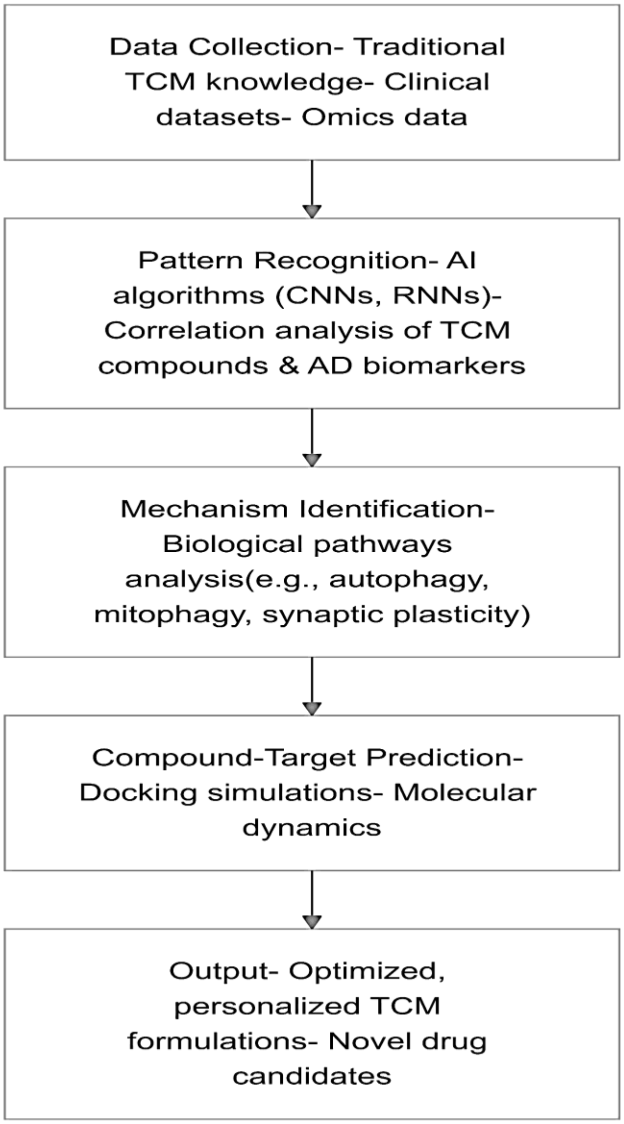

Figure 2. AI-Driven Workflow for TCM-Based Alzheimer's Disease Drug Discovery [23].

Network pharmacology model

A network pharmacology model provides a schematic representation of the interactions between TCM compounds and AD-related pathways. This model integrates data from transcriptomics, proteomics, and metabolomics to construct a multi-layered network that captures the complexity of TCM's effects on AD. For instance, curcumin reduces Aβ plaques, inhibits tau phosphorylation, and suppresses neuroinflammation via NF-κB and STAT3 pathways. Similarly, ginsenosides modulate PI3K/Akt signaling, enhance synaptic plasticity, and reduce oxidative stress via Nrf2/ARE activation, while Huperzine A inhibits acetylcholinesterase and enhances BDNF expression. These models enable researchers to identify disease modules and drug-disease networks, facilitating the discovery of novel therapeutic candidates [28].

Challenges in AI-Driven TCM optimization

The implementation of AI-driven optimization in Traditional Chinese Medicine faces several interconnected challenges that require comprehensive solutions. The fundamental complexity of TCM formulations presents a significant hurdle, as these preparations often contain multiple bioactive compounds working in intricate synergy, necessitating sophisticated AI models and substantial computational resources to fully understand their interactions. This complexity is further compounded by the critical need for standardization across TCM preparations, as ensuring consistent quality, precise dosage measurements, and reproducible results is essential for these treatments to gain widespread acceptance in the global medical community. The path to international adoption, particularly in Western nations, is further complicated by ethical considerations and regulatory requirements, which demand rigorous clinical validation and compliance with established pharmaceutical standards [29]. These challenges are amplified by the technical and methodological difficulties inherent in data integration, where researchers must effectively combine and analyze information from vastly different sources, including modern omics data, clinical trial results, and traditional TCM texts, each with its own format, terminology, and validation requirements. This multifaceted challenge requires a coordinated approach that combines technological innovation, standardization efforts, regulatory compliance, and sophisticated data management strategies to advance the field of AI-driven TCM optimization while maintaining both scientific rigor and traditional wisdom [30].

Limitations

The limitations of AI-driven TCM research for Alzheimer's disease treatment span multiple domains. Technical limitations include AI model constraints such as the limited ability to capture the extreme complexity of TCM synergistic effects, computational bottlenecks in quantum chemical calculations, insufficient training data for rare compounds, challenges in model interpretability, and difficulties in validating AI predictions [31]. Data-related issues include incomplete historical documentation, inconsistent data quality, limited standardized clinical data, gaps in molecular interaction databases, and bias in clinical trials. Methodological limitations arise from research design challenges such as difficulty in conducting double-blind trials, placebo control issues, limited long-term follow-ups, and a lack of standardized AI-TCM integration protocols [32]. The validation barriers include lack of proper cross-validation, inability to replicate the traditional preparation methods, inadequacy in bioavailability data, inability to measure synergistic effects, and incomplete safety profiles. Clinical implementation barriers involve expensive infrastructure for AI, lack of trained personnel, inability to standardize the traditional practices, problem in integrating traditional medicine with the healthcare systems, resistance from conventional medicine, and variable responses, compliance issues, genetic influences, and cultural barriers [33]. Challenges in regulatory and standardization are variability in the quality of herbs, lack of standardization in processing, not enough quality control, limited stability data, batch-to-batch inconsistencies, along with different requirements in various global regulatory bodies, intellectual property concerns, not enough safety documentation, and complex approval processes. Theoretical knowledge gaps include incomplete integration with modern medical theory, gaps in mechanism studies, unclear relationships between biomarkers, and less knowledge about long-term effects. Some research methodology issues identified are the non-standardized protocol, lack of adequate controls, poor reproducibility, partial adverse effect profile, and scarce data on interaction between drugs and herbs [34]. Further research requirements also include long-term safety studies, enhancement of bioavailability, research on drug-herb interaction, population variability in response, and cost-effectiveness, which go hand-in-hand with better methodological work in AI model validation, designs of clinical trials, quality control, safety evaluations, and reporting as shown in table 3 [35]. To overcome such limitations, ongoing technological development is needed, higher standards of research, better amalgamation of the traditional and modern medicine system, extensive clinical trials, international regulation, investment in infrastructure and training, personalized approaches to medicine, and quality control, all will guide future research on AI-based TCM [36].

Table 3. Key Traditional Chinese Medicine (TCM) Compounds and Their Evidence in Alzheimer's Disease [35].

Compound	Mechanism	Preclinical Evidence	Clinical Evidence
Curcumin	Anti-inflammatory, antioxidant	Reduced Aβ plaques and tau tangles in mouse models	Limited trials showing modest cognitive improvement
Ginsenosides	Neuroprotection, anti-apoptotic	Modulated tau hyperphosphorylation and reduced oxidative stress in rat models	Ongoing clinical evaluations for cognitive benefits
Huperzine A	Acetylcholinesterase inhibition	Enhanced memory and synaptic plasticity in rodent models	Approved in China for memory loss in AD patients
Berberine	Anti-inflammatory, AMPK activation	Reduced neuroinflammation and improved mitochondrial function in cellular models	Early-stage clinical trials for cognitive enhancement
Ginkgo Biloba	Antioxidant, neurovascular protection	Improved cerebral blood flow and reduced oxidative damage in animal models	Mixed results in clinical trials for AD symptom management

Future directions

The future of AI-driven TCM research for Alzheimer's disease is poised for transformative advancement through several interconnected technological and collaborative initiatives. Quantum computing represents a revolutionary leap forward in our ability to model and understand the complex interactions within TCM formulations, offering unprecedented computational power to simulate molecular behaviours and predict therapeutic outcomes with greater accuracy. This computational advancement is complemented by the emergence of single-cell sequencing technology, which provides researchers with microscopic-level insights into how TCM compounds interact with individual cells, revealing previously unknown mechanisms of action and potential therapeutic targets. The integration of blockchain technology introduces a crucial element of supply chain security and transparency, ensuring the authenticity and quality of TCM ingredients while building trust among practitioners and patients worldwide. These technological advances are most effective when supported by robust interdisciplinary collaboration, bringing together diverse expertise from AI specialists, pharmacologists, traditional TCM practitioners, and neuroscientists to create a comprehensive approach to drug discovery and treatment optimization. The ultimate validation of these combined efforts will come through large-scale clinical trials, which are essential for demonstrating the safety and efficacy of TCM formulations in treating Alzheimer's disease, thereby building the evidence base needed for wider acceptance in modern medical practice. This multifaceted approach to future development ensures that traditional wisdom can be effectively integrated with cutting-edge technology to create more effective treatments for Alzheimer's disease.

Conclusion

The integration of AI and network pharmacology has revolutionized our understanding of TCM's therapeutic potential for Alzheimer's Disease. By bridging traditional wisdom with modern scientific approaches, AI enables the identification of multi-target TCM formulations that address the complex pathophysiology of AD. Continued research, collaboration, and innovation are essential to unlocking the full potential of TCM in AD treatment, paving the way for personalized, holistic, and effective therapeutic strategies. The future of AD treatment lies in the synergy between ancient traditions and cutting-edge technologies, offering hope for millions of patients worldwide.

Ethics Approval and Consent to Participate

Since this manuscript is a review article, formal ethical approval and consent to participate are not applicable.

Conflicts of Interest
None.

Author Contribution
Sinchana Bhat, Yuktha S K, Ranjan K, Subrahmanya Pradeep, Preeti Shanbhag has done Literature review, manuscript drafting, and data collection. Ramdas Bhat has done Conceptualization, supervision, and final approval of the manuscript.

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Data Availability
Since this is a review article, no primary datasets were generated or analyzed. All data supporting this review are available in the referenced literature.

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