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Artificial Intelligence in the Management of Chronic Diseases: Opportunities, Challenges, and Future Directions

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Abstract

Chronic diseases represent one of the foremost global health burdens, requiring long-term, coordinated strategies for management. Traditional chronic disease management models, primarily reliant on periodic follow-ups and acute medical interventions, often struggle to address the persistent and complex nature of chronic conditions. In recent years, artificial intelligence (AI) has been introduced as an emerging technology within chronic disease management, playing a significant role in continuous data monitoring, risk prediction, and clinical decision support methodologies. This paper systematically reviews the application of AI in chronic disease management, analysing the potential advantages, functional positioning, and current landscape. By synthesising existing research, it aims to investigate AI's functional role within chronic disease management. AI applications primarily concentrate on continuous monitoring and risk prediction, while also supporting clinician-assisted decision-making and remote health management. Overall, AI offers novel technological support for chronic disease management, yet AI development remains in a transitional phase from technical exploration to systemic integration. Further refinement is required in model interpretability, data security, and fairness. The key to transforming these auxiliary tools into integral components of long-term management systems lies in advancing the development of safe, reliable, and trustworthy AI.

Keywords

artificial intelligence, chronic disease management, clinical decision support, remote patient monitoring, digital therapeutics

1. Introduction

Chronic diseases represent the most significant global health burden. Among them, cardiovascular diseases, cancer, chronic respiratory diseases, and diabetes are the leading causes of death and long-term disease burden worldwide. Research indicates that although chronic diseases have substantial epidemiological and economic impacts, the overall global response to prevention and management remain insufficient [1].

In recent years, Artificial Intelligence (AI) has gradually received widespread attention in the medical field. Bohr and Memarzadeh (2020) argue that this trend is closely related to the rapid digitisation in the medical field [2]. With the massive generation of digital medical records, imaging, and monitoring data of physiological and physical health, medical data has significantly increased in scale and complexity, and traditional methods relying on manual analysis are gradually becoming difficult to cope with. In this context, AI, as a technology tool capable of processing complex data and supporting pattern recognition and prediction, has been introduced into healthcare systems to assist in medical decision-making and system operation. Therefore, AI is gradually developing and receiving attention in areas such as medical image analysis, health status monitoring, and disease risk prediction. This paper aims to systematically review the applications of AI in chronic disease management, analyse AI's benefits and limitations, and identify future research directions.

2. Medical Application Background

Chronic disease management generally refers to a sustained and systematic care process for long-term conditions. Unlike acute disease treatment, which focuses on short-term interventions, chronic disease management emphasises continuous attention to patients' health status over time. Through long-term monitoring, coordination of medical services, and support for patients in coping with disease progression, chronic disease management aims to control disease development and reduce the risk of deterioration and complications. One of the defining characteristics is the long-term nature. Wagner (2019) argues that chronic disease management is not a single treatment intervention but a form of systems engineering [3]. Because chronic diseases involve recurrent or persistent health risks that may alter patients' conditions over time, continuous follow-up and decision support are essential.

Traditional chronic disease management faces many practical challenges in the long-term follow-up process. Existing chronic disease management models generally focus on phased diagnosis and treatment, with an emphasis on acute disease care. However, such models struggle to meet long-term, persistent, and complex management needs of chronic diseases. Previous studies have shown that the widespread coexistence of multiple chronic conditions further increases the complexity of disease management. Standardised management pathways often fail to adequately reflect individual differences among patients, revealing clear limitations in current approaches [1]. Furthermore, the current practice of chronic disease management mainly relies on periodic medical assessments and regular follow-up, which has significant limitations in the context of chronic diseases. Due to the long-term, persistent, and significant individual differences of chronic diseases, the health status of patients often changes constantly in daily lives, and these changes are difficult to capture in a timely manner through intermittent medical contact, resulting in fragmented and discontinuous characteristics of chronic disease management in practice.

During long-term follow-up, the assessment of patients' health status usually relies on manual judgment by medical staff based on established follow-up forms and personal experience. However, due to the relatively static follow-up evaluation criteria, there may be differences in the understanding and application of these criteria among different follow-up personnel, which affects the consistency and reproducibility of the evaluation results. At the same time, this highly manual evaluation method, which relies heavily on human experience, further increases the workload of the medical system when facing a large number of chronic disease patients and the need for continuous follow-up, limiting the efficiency and effectiveness of long-term follow-up in chronic disease management.

3. Literature Review with AI-Medical Implementation

AI is commonly defined as a computational system capable of simulating human cognitive activities, such as learning, reasoning, and decision-making. It is a data-driven system designed to assist rather than replace healthcare professionals. Existing research indicates that AI applications in healthcare mainly focus on several areas, including medical imaging and clinical data analysis, continuous monitoring of patient health status, support for clinical decision-making, and assistance with medical processes and administrative management. Together, these applications highlight the role of AI as a supportive technology within healthcare systems [4]. Overall, AI provides a data-driven support framework for healthcare services, laying a conceptual foundation for exploring a potential role in long-term care scenarios such as chronic disease management. The following content would present AI implementation value in three different scenarios.

3.1 AI for Monitoring and Early Detection

Current research on AI in chronic disease management primarily focuses on disease monitoring and early risk identification, particularly through the continuous collection and analysis of patients' physiological data. A substantial body of literature emphasises the use of wearable sensors and biosensing technologies for health monitoring, enabling the long-term collection of physiological signals, such as heart rate, electrocardiogram (ECG) data, and other longitudinal indicators. Continuous monitoring allows for the detection of changes in patients' health states over time. Overall, the literature suggests that AI plays an important role in supporting non-invasive data collection, and identifying abnormal patterns or trends in health status, which are critical for chronic disease management [5].

In addition, other studies summarise advances in AI research related to the early detection and risk assessment of cardiovascular events at a broader, population level. This research illustrates that AI is widely used to analyse medical data in order to identify potential risk patterns associated with disease onset and progression, thereby supporting early warning of adverse

health events. Early detection and risk assessment represent one of the core research areas of AI applications in chronic disease contexts [6].

Overall, the literature indicates that research on AI-based monitoring and early identification in chronic disease management mainly concentrates on long-term data acquisition and risk identification. These studies provide an important foundation for the further development of AI-supported chronic disease management models.

3.2 AI-supported Clinical Decision Support

In the medical field, AI is typically defined as a clinical decision-support tool. Di Nucci (2024) systematically discusses the distinction between decision-making systems and decision-support systems [7]. Specifically, decision-making systems imply that clinical actions are directly determined by algorithmic outputs, whereas decision-support systems provide reference information for human decision-making. This theoretical differentiation offers a crucial analytical framework for understanding the role of AI in healthcare. Di Nucci (2024) notes that in current medical contexts, most AI applications are explicitly defined as clinical decision-support tools [7]. Under this framework, AI systems assist clinicians by offering relevant information, recommendations, or risk assessments, while the ultimate responsibility for clinical decisions remains with medical professionals [8]. This positioning reflects a broad consensus in academia that AI should augment rather than replace clinical judgment.

Moreover, the literature consistently emphasises that clinical understanding and human oversight are essential conditions for AI to serve as a decision-support tool. Gerdes (2024) argues that for AI systems to become reasonable and acceptable clinical decision-support tools, physicians must maintain a supervisory role and be capable of understanding the scope and limitations of AI-supported decision-making [8]. In this sense, relevant research focuses more on whether AI can provide meaningful information support for clinical judgment, rather than demanding complete transparency of the algorithm's internal processes.

In general, the relevant literature generally views AI-supported clinical decision-making as a process of human-machine collaboration, where algorithmic tools and human expertise work together within established clinical workflows. Under continuous physician supervision, AI systems are integrated into clinical decision-making as a supplementary aid rather than an independent decision-maker. This conceptual framework provides a crucial theoretical foundation for further exploring the application of AI in complex, long-term care settings such as chronic disease management [7, 8].

3.3 Remote Health Management and Digital Therapeutics

In the context of chronic disease management, the functionalities of AI do not exist independently as isolated algorithms; rather, AI is typically integrated into more complex remote health management systems. Among these, digital tools represented by remote patient monitoring (RPM) and digital therapeutics have garnered significant attention [9, 10].

Remote patient monitoring primarily relies on wearable devices, home monitoring equipment, and mobile applications to conduct long-term, continuous data collection of patients' physiological indicators and health status. Marier-Tétrault et al. (2024) highlighted in the practice research on heart failure patient management that it enables the sustained monitoring of key health metrics, such as weight, blood pressure, and blood glucose levels, while identifying potential risk changes through algorithmic analysis [9]. The study notes that remote patient monitoring systems are designed as supportive tools continuously supervised by care teams, with clinical intervention decisions made by healthcare professionals based on algorithmic analysis outcomes.

Building on continuous monitoring, digital therapeutics (DTx) further integrate AI into the intervention stage of chronic disease management. Shah and Shah (2023) describe DTx as software-based therapeutic interventions grounded in evidence-based medicine, designed to prevent, manage, or treat specific conditions [10].

In contrast to general health applications, DTx must undergo rigorous clinical validation and regulatory approval to ensure both safety and effectiveness. Existing studies suggest that digital therapeutics typically deliver structured intervention programmes via mobile applications or online platforms, often supporting medication adherence, lifestyle modification, and behavioural management.

Within chronic disease care, DTx is widely regarded as enhancing patients' self-management capabilities through ongoing feedback and personalised support, while also complementing conventional medical treatments in long-term care settings [10].

Remote patient monitoring and digital therapeutics typically operate synergistically under the telemedicine framework, forming a remote chronic disease management model. Marier-Tétrault et al. (2024) noted that the research's coordinated efforts facilitate data transmission between telemedicine platforms and care teams, as well as ongoing clinical supervision [9]. Similarly, Shah and Shah (2023) argued that telemedicine provides the essential technical and institutional foundation for digital therapeutics and monitoring systems, enabling the implementation and expansion within existing healthcare systems while supporting large-scale chronic disease management [10].

3.4 Key Findings

Although existing research indicates that AI demonstrates broad application potential in chronic disease-related fields, the relevant literature still exhibits certain limitations in research focus and perspective. Current studies predominantly concentrate on continuous physiological data monitoring and early risk identification [5]. While such research provides crucial data support for understanding changes in patient health, management is not synonymous with the continuous monitoring of health indicators. Chronic conditions are characterised by long-term nature, dynamic progression, and the prevalence of coexisting conditions. The management necessitates decision adjustments across time, coordination of healthcare resources, and sustained behavioural support [3]. Consequently, reducing management challenges to mere risk identification and status assessment remains inadequate for addressing the complex demands of chronic disease long-term management.

From the perspective of AI's functional positioning within healthcare systems, existing literature generally defines AI as a decision support tool. Primarily serving to provide clinicians with information, recommendations, and risk assessments, the ultimate responsibility for decision-making remains with the physician [7, 8]. Wasilewski et al. (2024) note that despite the technical feasibility of sensor-based continuous real-time monitoring, AI's role within decision-making frameworks remains confined to that of an auxiliary tool [5]. This implies AI's primary application lies in supporting clinical judgements at specific points in time or during particular phases, with limited involvement in the sustained, cross-temporal collaborative decision-making processes inherent to chronic disease management.

4. Discussion

4.1 Ethical Challenge

Although AI has shown considerable potential in chronic disease management, the practical implementation still faces a range of challenges that constrain the effectiveness in real-world healthcare contexts. A key concern relates to data privacy and security. In this field, AI-driven systems depend extensively on patient-generated health data, including physiological measurements, lifestyle-related information, and electronic health records. Given the highly sensitive nature of such data, any breach may not only compromise patient confidentiality, but also erode public trust in AI-based healthcare systems [11].

4.2 Functional Bias

Furthermore, issues related to algorithmic bias and limited interpretability continue to affect the application of AI in chronic disease management. Many AI models are trained on historical data, and when such data lack representativeness, such models may generate systematic biases, resulting in uneven predictive performance across different populations. For instance, these models may demonstrate lower accuracy when predicting outcomes for certain age groups or socioeconomic populations, which may in turn lead to misdiagnoses or inappropriate treatment recommendations. Such biases not only undermine the reliability of individual clinical decisions, but may also exacerbate existing health inequalities at a broader level [12].

4.3 Sample Limitation

At the sample level, existing research predominantly comprises single-centre feasibility studies or small-scale pilots, while large-scale, long-term follow-up and validation in real-world settings remain relatively limited [11]. The efficacy of chronic disease management often requires prolonged observation to manifest, and short-term studies struggle to assess the sustained impact of AI in long-term care. Kelly et al. (2019) also noted that AI models frequently perform well in research settings but encounter difficulties when integrated into routine clinical practice [13]. Consequently, despite demonstrating technical potential.

Current evidence remains insufficient to fully determine the long-term efficacy and practical application outcomes of AI within complex chronic disease management systems.

4.4 Discussion Summary

Overall, AI in chronic disease management remains in a transitional phase, gradually evolving from technological exploration towards more mature management tools. While progress has been made in data monitoring and risk prediction, existing research still shows limitations in long-term management logic, sustained coordination in decision-making, and validation within real clinical settings.

Consequently, greater attention needs to be given to how AI can be more effectively integrated into the long-term management processes of chronic diseases when considering future development.

5. Conclusion

Overall, AI is progressively transforming the technological foundations and practical approaches to chronic disease management. Through continuous data monitoring, risk prediction, and decision support mechanisms, AI offers new possibilities for early intervention and dynamic management of chronic conditions. Particularly within the frameworks of remote health management and digital therapeutics, AI technologies are expanding applications in chronic disease care.

However, several notable limitations remain in existing research. Current AI applications are largely confined to monitoring and risk detection, with limited capacity to support the long-term, collaborative decision-making processes required in chronic disease management. In addition, much of the existing literature focuses on small-scale validation studies and therefore provides insufficient evidence for large-scale and sustained implementation.

As a result, advancing AI in chronic disease management requires not only more robust research designs in long-term, real-world settings, but also closer integration with existing healthcare systems, along with stronger safeguards for data security, fairness, and transparency. Only when both technological capabilities and institutional frameworks are sufficiently developed can AI move beyond a supportive role to become an essential component of long-term chronic disease management.

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