NARRATIVE REVIEW

Advancements of AI in healthcare: a comprehensive review of ChatGPT's applications and challenges

Sara Ali, Atrubah Aslam, Zarmeen Tahir, Bashair Ashraf, Afifa Tanweer

Abstract

The rapid integration of artificial intelligence into healthcare has introduced transformative possibilities and challenges. The current narrative review was planned to explore diverse applications of Chat Generative Pre-Trained Transformer (ChatGPT) across medical domains, ranging from dietary planning and disease management to medical education and clinical decision support. A comprehensive analysis of ChatGPT's healthcare applications was conducted between July and September 2023, reviewing literature from prominent medical journals and databases, including PubMed, Embase, Cochrane library and the Cumulated Index in Nursing and Allied Health Literature. The studies revealed notable limitations, including inaccuracies, bias and potential safety concerns. Quantitative data highlighted ChatGPT's high accuracy rates in disease detection, nutrient sufficiency in ChatGPT-generated diet plans and various medical scenarios. The predominantly quantitative evaluations might overlook nuanced qualitative aspects, such as users' perceptions, experiences and ethical concerns. Studies often focus on specific domains, potentially limiting generalisability. Evolving artificial intelligence technology warrants long-term impact assessment, including ChatGPT's contextual appropriateness and accommodation of individual preferences. ChatGPT shows promise in healthcare, but needs specialised training for medical use. Ethical concerns, data quality and interpretability require thorough investigation for responsible implementation

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Introduction

Artificial intelligence (AI) is a field of computer science that focuses on mimicking human intelligence to perform tasks, such as critical decision-making, speech recognition, problem-solving, visual perception and many more, by the computer itself. It has been in existence for about 60 years, with its origins dating back to the Second World War.[1] Over time, it has enabled computers to accomplish complex tasks that were once solely the domain of humans. The term AI was coined in 1956.[2]

AI technology has been making significant progress in the field of healthcare over the years, and it has been made possible for it to assist physicians in their practice by aiding in making better clinical decisions, early disease detection and diagnosis, outcome prediction and treatment.[3] The prominent applications of AI in healthcare have been observed in the fields of cancer, neurology and cardiovascular diseases (CVDs).[4] Chatbots are AI programmes created to simulate human-like conversations with users, often using text or voice-based interfaces. They are frequently used for a variety of applications, such as delivering customer service, interacting with users on social media platforms, enhancing gaming experiences, and providing personalised recommendations in the healthcare industry.[5] One such chatbot was released by OpenAI on Nov 30, 2022, named Chat Generative Pre-Trained Transformer (ChatGPT). It is known for its exceptional natural language processing (NLP) capabilities to understand, interpret and generate human-like responses. It uses a neural network architecture, or brain mimicking algorithm, that is trained on massive amounts of text data, allowing it to generate contextually appropriate responses.[6]

Although ChatGPT is not specifically designed for medical purposes, it can be used for healthcare applications by drawing upon information from publicly available medical texts, research papers, official databases and websites.[7] Considerable research has been done on evaluating ChatGPT's performance in the domain of healthcare, particularly in the areas of disease diagnosis and management, such as cancer, radiology and public health.[8,9] The fact that ChatGPT has demonstrated a high level of performance, approaching or even surpassing the passing threshold of the United States Medical Licensing Exam (USMLE), further confirms its potential as a valuable asset in the medical field.[10]

The current narrative review was planned to extensively explore the diverse applications of AI, particularly ChatGPT,

Department of Nutrition & Dietetics, School of Health Sciences, University of Management and Technology, Lahore, Pakistan
Correspondence: Afifa Tanweer. e-mail: afifa.tanweer@umt.edu.pk
ORCID ID: 0000-0002-0174-2941

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in healthcare, drawing insights from a wide range of studies.

Materials and Methods

The narrative review was conducted between July and September 2023, and comprised studies conducted between 2021 and 2023. Literature search comprised prominent medical journals, such as Journal of Medical Internet Research (JMIR) Medical Education, Journal of the National Cancer Institute (JNCI) Cancer Spectrum, American Journal of Obstetrics and Gynaecology, Diabetes Care, BioMed Central (BMC) Medical Informatics and Decision Making, Non-Profit Journalism (NPJ) Digital Medicine, and Journal of Medical Systems, along with reputable healthcare databases, including PubMed, Embase, Cochrane library and Cumulated Index in Nursing and Allied Health Literature (CINAHL).

Studies were included as per their relevance to medical applications, the utilisation of ChatGPT as a central component, and the availability of adequate data for analysis. Those not meeting the inclusion criteria were excluded. Data was reviewed with the aim of providing a comprehensive and insightful overview of ChatGPT's role in revolutionising healthcare practices in 4 broad disciplines.

AI in meal planning and dietary recommendations

ChatGPT's widespread adoption in healthcare stems from its human-like text-generation, user-friendly interface, and vast knowledge base. Moreover, it excels in nutrition calculations by replicating underlying formulas used in specialised tools. For instance, it can calculate Total Daily Energy Expenditure and suggest calorie intake for weight-loss based on user-provided details. It is also able to replicate and perform various elements of the Nutrition Care Process (NCP). Specifically, ChatGPT can assist by answering questions about specific nutrients, providing general dietary guidelines, estimating individual nutrition needs, offering dietary assessment tools, explaining body composition assessment, and discussing common nutrition-related health conditions. Furthermore, it can help by providing evidence-based nutrition diagnoses, identifying nutrition-related problems, explaining the significance of nutrition diagnoses, identifying potential comorbidities, and assisting in documenting the diagnoses. Additionally, ChatGPT can assist by offering dietary recommendations, suggesting personalised meal plans, providing recipe modification tips, recommending behaviour change techniques, giving guidance on portion control and meal frequency, and suggesting resources for finding balanced recipes.[11]

While ChatGPT is promising for sharing nutrition knowledge, it cannot replace registered dietitians' expertise, especially in complex cases where expert judgment and validation are essential to ensure accuracy and appropriateness. Additionally, it may lack a dedicated nutrition database, relying on external sources, potentially impacting data accuracy. Unlike dedicated nutrition applications, ChatGPT lacks the capacity for real-time monitoring and feedback, limiting its ability to provide immediate support comparable to human interactions or dedicated monitoring devices. Furthermore, in complex cases involving multiple medical conditions or specialised dietary requirements, ChatGPT may not offer comprehensive and tailored guidance. Its inability to interpret conversational cues or address emotional factors in real-time necessitates the need for human involvement in counselling. Additionally, unlike nutrition apps, it cannot integrate with wearable devices or offer visual data, limiting real-time feedback .[12]

A study evaluated ChatGPT's dietary advice for individuals with food allergies, comparing it against established nutritional guidance. It found a mix of accurate advice and errors, including inaccuracies in food quantities, energy values, and the presence of allergens in some diets.[13] Another study evaluated the adequacy of nutrients in dietary meal plans generated by ChatGPT across various dietary patterns. The findings revealed areas for optimisation, as protein levels exceeded recommendations, while carbohydrates and fats fell short. Essential micronutrients like fibre, saturated fats, and most vitamins were within recommended limits, but deficiencies were noted for vitamin D, selenium, fluoride and iodine, particularly in vegan meal plans.[14]

AI in medical education and learning

ChatGPT has demonstrated promising strengths in various domains, particularly in academic assessments and educational settings. Its responses are generally well-articulated, showcasing its ability to generate coherent and understandable content. Despite inherent randomness in its responses, ChatGPT has shown evolving capabilities over time, with later responses displaying improvements, including providing detailed information, such as chemical structures.[15] Moreover, it has the potential to enrich course materials and support active learning approaches in education by offering systematic lists of recommended diets and explanations about glycaemic changes with different forms of exercise.[16] Additionally, in the context of cancer-related questions, ChatGPT's outputs have been found to offer accurate information about common myths and misconceptions, contributing positively to knowledge dissemination without introducing harmful content.[17]

However, alongside its strengths, ChatGPT also presents several limitations and challenges. In academic assessments, it has shown variability in the quality of responses, particularly in handling questions requiring understanding or manipulation of specific subject matter, such as chemical structures or medical knowledge.[15] Moreover, ChatGPT's reliance on general databases rather than domain-specific ones can lead to factual inaccuracies and oversimplified responses. Safety concerns arise as ChatGPT does not verify the reliability of its answers, potentially resulting in the presentation of inaccurate information, which could be persuasive to users. Furthermore, there are concerns about its ability to facilitate plagiarism, undermining academic integrity and assessment fairness[19] Additionally, its limitations in addressing lacrimal drainage disorders for patient education and medical training purposes highlight the need for further refinement and training in specific medical subspecialties.[19]

Studies evaluating ChatGPT's performance in various domains provide insights into its accuracy and reliability. In the context of diabetes self-management education, ChatGPT demonstrated some inaccuracies, such as not recognising the proper storage conditions for insulin analogues and being rigid in suggesting dietary plans.[16] Similarly, in cancer-related questions, ChatGPT generally provided accurate information, but discrepancies were observed for specific questions. However, despite minor differences in sentence structure, ChatGPT consistently provided accurate responses when questioned repeatedly. Both Non-Controlling Interest (NCI) and ChatGPT responses had similar word counts and readability levels, although some ChatGPT messages exhibited terms associated with hedging and uncertainty.[17]

The potential impact of ChatGPT in education is significant, offering opportunities for enhancing teaching and learning processes. It can serve as a valuable tool for instructors in creating course materials and supporting active learning approaches. However, challenges, such as accuracy and reliability issues, need to be addressed through updated assessment methods and institutional policies. Strategies may involve integrating multimedia elements into assessments and introducing digital-free components to mitigate the impact of AI-generated content. Moreover, instructor training on detecting and addressing ChatGPT usage in student assignments is essential. Educating students about the limitations of ChatGPT and emphasising academic integrity is crucial to ensuring responsible use of the technology.[18]

In medical contexts, ChatGPT's performance has been evaluated in addressing lacrimal drainage disorders, revealing generally unsatisfactory results for patient education and medical training purposes. Its drawbacks include reliance on training libraries, potential for providing inaccurate information, and verbosity in responses. Responses may lack specificity and evidence-based content, especially on contentious issues or specific inquiries. However, ChatGPT's ability to learn from human interactions and challenge incorrect assumptions suggests potential for improvement. Despite its limitations, rapidly learning language models like ChatGPT hold promise for revolutionising the field of medicine. Future endeavours should concentrate on refining and training ChatGPT for distinct medical subspecialties and applications, involving stakeholders to maximise its contributions to science and healthcare.[19]

AI in enhancing clinical decision support

Several studies have highlighted ChatGPT's potential strengths in providing healthcare information across various domains. For instance, in a study evaluating ChatGPT's performance in responding to clinical queries (CQs) related to hypertension management based on the Japanese Society of Hypertension (JSH) 2019 guidelines, it exhibited an overall accuracy rate of 64.5%. While this accuracy level may not be deemed exceptionally high, ChatGPT demonstrated language independence, with consistent accuracy observed between questions originally written in Japanese and those translated from English. This suggests its potential as a valuable resource for clinicians seeking rapid access to dependable information on hypertension management. However, effective risk mitigation and regulation are deemed imperative to ensure safety and efficacy in healthcare practices, given potential risks, such as responses lacking adequate evidence support.[20]

In another study, ChatGPT showcased its capacity to respond accurately to patient inquiries concerning cirrhosis and hepatocellular carcinoma (HCC). It provided practical advice on basic knowledge, lifestyle modifications, and treatment options, aligning with cirrhosis quality measures recommended by the American Association for the Study of Liver Diseases (AASLD). Additionally, ChatGPT demonstrated the potential to streamline provider workflows by generating tailored questions and empowering patients with better information for shared decision-making processes.[21]

Despite its strengths, ChatGPT exhibits several limitations that need to be considered. For instance, while it generally offers accurate advice for managing high blood pressure, there is a bias towards certain guidelines over others, possibly due to its training data predominantly sourced

from the United States. Furthermore, ChatGPT may provide occasional incomplete responses and the risk of outdated information, suggesting that it should be viewed as a supplementary resource rather than a substitute for healthcare providers. Continuous optimisation efforts are necessary to overcome these limitations and ensure the accuracy of its responses.[22]

Studies evaluating ChatGPT's performance in addressing specific medical conditions have provided valuable insights. For example, in composing medical notes for intensive care unit (ICU) patients, ChatGPT accurately categorised most parameters into relevant sections, albeit with some struggles in identifying causal relationships among conditions. Nonetheless, it excelled in summarising information, catering to both clinical and lay audiences, thus showcasing its potential utility in healthcare settings.[23]

Overall, ChatGPT shows promise in aiding patient education, communication and healthcare management. With an accuracy rate of 88% in providing recommendations for hypertension management, it can play a significant role in facilitating patient care. However, further research is needed to address its limitations and explore its potential in bolstering clinical decision support and promoting adherence to guidelines across various medical domains.[22]

AI in disease detection and prevention

The integration of AI in disease detection and prevention has become a pivotal area of research, offering innovative approaches to identifying medical conditions and promoting better health outcomes. The examination of ChatGPT's self-diagnostic abilities unveiled a range of accuracies and precisions across different health conditions. While it accurately identified carpal tunnel syndrome and lumbar spinal stenosis with high rates of 100% and 96%, respectively, it struggled with knee osteoarthritis and hip osteoarthritis, achieving rates of 64% and 68%, respectively. Chronic migraine posed the most significant challenge, with an accuracy rate of only 4%. Around 6% of responses failed to recommend medical attention, while 80% advised consultation, albeit only 12% provided explicit recommendations. Adjustments in question formulation, such as presenting both the primary diagnosis and potential differential diagnoses, yielded improved accuracy for certain ailments.[24]

A study found that 32% of the primary diagnoses provided by ChatGPT aligned with the neuropathological diagnoses made by the neuropathologist. This means that in about one-third of cases, ChatGPT accurately predicted the underlying neuropathological condition based on the clinical information provided. Additionally, the correct diagnosis was included in the responses generated by ChatGPT in 76% of cases. This indicates that while ChatGPT did not always provide the exact correct diagnosis, it included the correct diagnosis or one that closely matched it in a significant majority of cases. In another case, ChatGPT identified progressive supranuclear palsy (PSP) as the most likely diagnosis, followed by multiple system atrophy and corticobasal degeneration. Interestingly, the final clinical diagnosis made by the physician differed slightly, indicating PSP versus Lewy body dementia (LBD). This suggests that while ChatGPT provided a reasonable differential diagnosis based on the clinical information, the ultimate diagnosis by the physician may have included additional factors or considerations not captured by the AI model.[25]

When assessing ChatGPT's diagnostic abilities in identifying different corneal eye diseases, it exhibited a diagnostic accuracy of 60%.[26] A study highlighted the varying performance of ChatGPT across tasks, showing differences in its effectiveness between neuro-ophthalmology diagnosis and responding to practice questions. Despite this variability, advancements in language models like ChatGPT offer promising prospects for neuro-ophthalmology by providing rapid and objective diagnoses, with the capacity for continual improvement through reinforcement learning.

However, concerns arise regarding ChatGPT's exposure to the online database used for case investigation and the limited scope of cases evaluated. Additionally, the incapacity of language models to interpret images restricts their utility in complex cases requiring data from diverse imaging modalities. Nonetheless, ChatGPT holds potential in diverse healthcare contexts, including primary care, emergency services, and tertiary ophthalmology care, where they could facilitate initial assessments and assist in patient triaging.[27]

Overall, while ChatGPT displays potential in generating differential diagnoses, refinements involving the integration of medical terminology, clearer guidance, and optimised question structures are imperative to enhance its utility in self-diagnostic scenarios.[24]

Limitations and negative impact of ChatGPT in healthcare

ChatGPT, despite its promising potential, faces significant limitations that warrant careful consideration. Ethical concerns, particularly regarding the dissemination of false healthcare information or fake news, pose risks to societal wellbeing. Moreover, the potential breach of patient confidentiality raises questions about AI's trustworthiness in sensitive healthcare domains, compounded by ethical dilemmas surrounding privacy, consent and equality.

Additionally, the automation enabled by ChatGPT could threaten employment, especially in labour-reliant sectors, like healthcare. On a technical level, its inability to provide personalised advice or comprehend emotional nuances presents significant challenges, especially in coding applications where complexity and contextual understanding are crucial.[28]

Concerns also arise from ChatGPT's propensity to fabricate references, highlighting the issue of hallucination in AI systems. This unsettling revelation surfaced when ChatGPT cited a non-existent paper titled "Mobile Apps for Medical Education: A Review of Digital Medical Education Resources" from JMIR Medical Education. Despite not existing in any JMIR journal or PubMed, ChatGPT confidently referenced this paper, along with two unrelated digital object identifiers (DOIs). This incident highlights the need for thorough verification of outputs, especially in critical domains like medical education.[29]

Furthermore, a study addressed concerns about the potential de-skilling of healthcare professionals due to over-reliance on technology, highlighting the ethical implications of technology's role in decision-making processes.[30] These findings suggest the need for a balanced approach to AI deployment, considering both its benefits and limitations, to ensure the responsible and effective use of AI technologies in healthcare and other domains.

Future implications

Looking ahead, the implications of this review are substantial for the future of healthcare and the role of AI. ChatGPT's potential to refine dietary planning, disease management, medical education, and clinical decision support points towards more efficient and personalised healthcare delivery. However, the identified limitations and challenges emphasise the need for cautious integration. Ensuring accuracy, reliability and ethical soundness in AI-driven solutions is essential to maintain patient trust. Additionally, a balanced approach between AI and human expertise, reinforced by multidisciplinary collaboration, is crucial for shaping a healthcare ecosystem that benefits from both domains' strengths. As AI continues to shape the healthcare landscape, responsible integration and collaborative efforts will be pivotal in realising its transformative potential while upholding the integrity of healthcare practices.

Conclusion

Despite the evident strides in AI's capabilities, it is essential to acknowledge its inherent limitations, including inaccuracies and the potential for biased responses. As healthcare professionals and researchers navigate this evolving field, a balanced approach is crucial, with the utilisation of AI's advantages accompanied by a focus on ethical considerations, data quality, and interpretability. ChatGPT holds significant promise for revolutionising the medical field, but this potential requires targeted training and retraining to specific medical specialties.

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BA: Concept, design, drafting, writing, review, editing, revision, final approval and agreement to be accountable for all aspects of the work.

AT: Concept, design, drafting, revision, supervision, project administration, final approval and agreement to be accountable for all aspects of the work.