Advancing Medical Practice with Artificial Intelligence: ChatGPT in Healthcare

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ABSTRACT **Background:** Advancements in artificial intelligence (AI) and natural language processing (NLP) have led to the development of language models such as ChatGPT. These models have the potential to transform healthcare and medical research. However, understanding their applications and limitations is essential.

Objectives: To present a view of ChatGPT research and to critically assess ChatGPT's role in medical writing and clinical environments.

Methods: We performed a literature review via the PubMed search engine from 20 November 2022, to 23 April 2023. The search terms included *ChatGPT*, *OpenAI*, and *large language models*. We included studies that focused on ChatGPT, explored its use or implications in medicine, and were original research articles. The selected studies were analyzed considering study design, NLP tasks, main findings, and limitations.

Results: Our study included 27 articles that examined ChatGPT's performance in various tasks and medical fields. These studies covered knowledge assessment, writing, and analysis tasks. While ChatGPT was found to be useful in tasks such as generating research ideas, aiding clinical reasoning, and streamlining workflows, limitations were also identified. These limitations included inaccuracies, inconsistencies, fictitious information, and limited knowledge, highlighting the need for further improvements.

Conclusions: The review underscores ChatGPT's potential in various medical applications. Yet, it also points to limitations that require careful human oversight and responsible use to improve patient care, education, and decision-making.

IMAJ 2024; 26: 80–85

KEY WORDS: artificial intelligence (AI), natural language processing, ChatGPT, healthcare, medical research

Recent artificial intelligence (AI) and natural language processing (NLP) advancements have led to the development of large language models like ChatGPT [1]. These models can potentially revolutionize many sectors, including healthcare and medical research. A deeper look into their applications, limitations, and ethics is necessary as they become popular and gain acceptance.

AI models like ChatGPT show promise in automating tasks and increasing efficiency. They can extract information from electronic medical records, summarize data, and support clinical decision-making [2-4]. However, their use in medicine is not without concern. Questions about the accuracy and ethics of AI-generated text arise [5-7]. Mistakes in AI text could taint the scientific record and possibly spread misinformation [5]. Moreover, while AI can benefit medical research, it opens ethical questions about authorship. Legal issues such as copyright and regulations add more complexity. The creativity of the models may be limited due to their dependence on data [1].

In this article, we presented a view of ChatGPT research and critically assessed ChatGPT's role in medical writing and clinical environments.

MATERIALS AND METHODS

SEARCH APPROACH

We performed a literature search using PubMed, focusing on articles written in English from 20 November 2022 to 23 April 2023. Our search terms were: *ChatGPT* or *OpenAI* or *large language models*.

CHOOSING THE STUDIES

We first reviewed the titles and abstracts of the resulting articles. To be included, studies had to focus on ChatGPT,

explore its use or implications in medicine, and be original research articles or reviews. We excluded studies that were not in English or were centered on other large language models. We also excluded conference abstracts, letters, editorials, or commentaries.

SYNTHESIZING AND ANALYZING THE DATA

For each study, we collected data on the study design, the NLP task, the main findings, and any limitations found. We conducted a narrative synthesis of our findings considering the methodological quality, relevance, and consistency of the studies. We described the main findings, applications, limitations, and overall implications of ChatGPT in medicine. Given the diversity in the study designs, populations, and outcomes, meta-analysis was not suitable.

RESULTS

In total, we included 27 studies that evaluated ChatGPT's performance in various medical fields and tasks [Table 1, Table 2]. These studies showed how ChatGPT could be used in knowledge assessment (12 studies, 44.4%), writing (2 studies, 7.4%), analysis (8 studies, 29.6%), education (2 studies, 7.4%), and a mix of knowledge assessment and analysis tasks (3 studies, 11.1%). The medical field most frequently reviewed was radiology (3 studies, 11.1%).

The studies displayed a varied picture of the possible benefits and limitations of using ChatGPT in healthcare. Some researchers found ChatGPT useful for generating new research ideas (3 studies, 11%), aiding in clinical reasoning (5 studies, 18%), and streamlining clinical workflows (2 studies, 7%). For example, ChatGPT has proven effective in determining research priorities in gastroenterology [8], discovering novel systematic review ideas in plastic surgery [9], and providing accurate information about cancer myths and misconceptions in oncology [10].

However, the studies also pointed to significant limitations, including inaccuracies (9 studies, 33%), inconsistencies (4 studies, 15%), and improvements needed in the model's performance (6 studies, 22%). In laboratory medicine and oral and maxillofacial surgery radiology, ChatGPT showed limited abilities [11-13]. It was found to be unfit for interpreting the overall diagnostic picture in laboratory medicine and needed careful handling when used for radiological information or training in oral and maxillofacial surgery.

Other common limitations included a lack of specific training on medical data, inconsistent performance across different topics, and knowledge only up to the year 2021 [11,14,15]. These issues impacted the model's performance and reliability in various medical fields.

The studies by Ariyaratne et al. [16], Sallam et al. [17], and Dergaa et al. [18] described concerns about the authenticity and reliability of ChatGPT. The model occasionally created inaccurate or fictitious information that may have seemed real to those not trained to spot it. Studies also stressed the need to address the ethical, legal, and cybersecurity challenges tied to using ChatGPT in healthcare. From an ethics standpoint, providing misleading information can harm patient care and may reinforce biases in the training data, worsening healthcare disparities. Privacy and confidentiality concerns arise when dealing with sensitive medical information. From a legal perspective, questions of liability and accountability develop when AI-generated advice leads to poor patient outcomes. The researchers emphasized the importance of using ChatGPT responsibly, and with awareness of its risks and challenges.

DISCUSSION

In this review, we evaluated ChatGPT's role in healthcare, focusing on its applications in various medical tasks and fields. Based on 27 studies, our analysis highlighted the utility and challenges of ChatGPT in medical contexts. The model under review, GPT-3.5, demonstrates promise in areas like clinical decision support, general practice, and medical education.

These studies revealed ChatGPT's potential to generate research ideas, aid in clinical reasoning, and streamline workflow. Its effectiveness is noted in gastroenterology research [8], systematic review development in plastic surgery [9], and dissemination of accurate oncology information [10]. Such applications suggest its capacity to support diverse medical activities.

However, the results also underline significant limitations of the model. Inaccuracies in outputs were reported in a significant portion of studies (33%), as well as inconsistencies (15%) and a general need for performance improvement (22%). Specific areas such as laboratory medicine and oral and maxillofacial surgery radiology showed the model's limitations, where it was unsuitable for interpreting diagnostic information [11-13]. These findings highlight the need for cautious and context-aware application of ChatGPT in specialized medical fields.

Moreover, the studies bring attention to concerns about ChatGPT's authenticity and reliability [16-19].

Table 1. General characteristic of the included studies

Date of publication (DD/MM/YYYY)	Title	Authors	Journal/Book	Medical field
24/04/2023	Potentials and pitfalls of ChatGPT and natural-language artificial intelligence models for the understanding of laboratory medicine test results. An assessment by the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) Working Group on Artificial Intelligence (WG-AI)	Cadamuro J, et al.	*Clin Chem Lab Med*	Clinical chemistry and laboratory medicine
22/04/2023	Using AI-generated suggestions from ChatGPT to optimize clinical decision support	Liu S, et al.	*J Am Med Inform Assoc*	Clinical reasoning
21/04/2023	Trialling a large language model (ChatGPT) in general practice with the applied knowledge test: observational study demonstrating opportunities and limitations in primary care	Thirunavukarasu AJ, et al.	*JMIR Med Educ*	General practice
20/04/2023	Accuracy of information and references using ChatGPT-3 for retrieval of clinical radiological information	Wagner MW, Ertl-Wagner BB	*Can Assoc Radiol J*	Radiology
14/04/2023	A comparison of ChatGPT-generated articles with human-written articles	Ariyaratne S, et al.	*Skeletal Radiol*	Radiology
13/04/2023	Can ChatGPT be used in oral and maxillofacial surgery?	Balel Y	*J Stomatol Oral Maxillofac Surg*	Oral and maxillofacial surgery
09/04/2023	Using a Google web search analysis to assess the utility of ChatGPT in total joint arthroplasty	Dubin JA, et al.	*J Arthroplasty*	Orthopedics
05/04/2023	Implications of large language models such as ChatGPT for dental medicine	Eggmann F, et al.	*J Esthet Restor Dent*	Dental medicine
03/04/2023	An exploratory survey about using ChatGPT in education, healthcare, and research	Hosseini M, et al.	*medRxiv*	Digital health
29/03/2023	Performance of ChatGPT on free-response, clinical reasoning exams	Strong E, et al.	*medRxiv*	Clinical reasoning
22/03/2023	Assessing the performance of ChatGPT in answering questions regarding cirrhosis and hepatocellular carcinoma	Yeo YH, et al.	*Clin Mol Hepatol*	Hepatology
21/03/2023	Expanding cosmetic plastic surgery research using ChatGPT	Gupta R, et al.	*Aesthet Surg J*	Plastic surgery
19/03/2023	ChatGPT utility in healthcare education, research, and practice: systematic review on the promising perspectives and valid concerns	Sallam M	*Healthcare (Basel)*	Digital health
17/03/2023	The capability of ChatGPT in predicting and explaining common drug-drug interactions	Juhi A, et al.	*Cureus*	Pharmacology
17/03/2023	Using ChatGPT to evaluate cancer myths and misconceptions: artificial intelligence and cancer information	Johnson SB, et al.	*JNCI Cancer Spectr*	Oncology
15/03/2023	From human writing to artificial intelligence generated text: examining the prospects and potential threats of ChatGPT in academic writing	Dergaa I, et al.	*Biol Sport*	Sports medicine
15/03/2023	ChatGPT: as this version good for healthcare and research?	Vaishya R, et al.	*Diabetes Metab Syndr*	General practice
13/03/2023	Evaluating the use of large language model in identifying top research questions in gastroenterology	Lahat A, et al.	*Sci Rep*	Gastroenterology
12/03/2023	Assessing the capability of ChatGPT in answering first- and second-order knowledge questions on microbiology as per competency-based medical education curriculum	Das D, et al.	*Cureus*	Microbiology
28/02/2023	Assessing the accuracy and reliability of AI-generated medical responses: an evaluation of the Chat-GPT model	Johnson D, et al.	*Res Sq*	General practice
26/02/2023	Assessing the utility of ChatGPT throughout the entire clinical workflow	Rao A, et al.	*medRxiv*	Clinical Reasoning
23/02/2023	Assessing the value of ChatGPT for clinical decision support optimization	Liu S, et al.	*medRxiv*	Clinical Reasonin
20/02/2023	Applicability of ChatGPT in assisting to solve higher order problems in pathology	Sinha RK, et al.	*Cureus*	Pathology
15/02/2023	ChatGPT output regarding compulsory vaccination and COVID-19 vaccine conspiracy: a descriptive study at the outset of a paradigm shift in online search for information	Sallam M, et al.	*Cureus*	Public Health
08/02/2023	How does ChatGPT perform on the United States medical licensing examination? the implications of large language models for medical education and knowledge assessment	Gilson A, et al.	*JMIR Med Educ*	Medical Education
07/02/2023	Evaluating ChatGPT as an adjunct for radiologic decision-making	Rao A, et al.	*medRxiv*	Radiology
26/01/2023	Assessment of chemistry knowledge in large language models that generate code	White AD, et al.	*Digit Discov*	Medicinal chemistry

AI = artificial intelligence

Table 2. Evaluation of ChatGPT performance in current literature: data from 27 included studies

Title	Types of task	Evaluation methods	Specific training?	Performance statistics	Conclusions	Limitations
Potentials and pitfalls of ChatGPT and natural-language artificial intelligence models for the understanding of laboratory medicine test results. An assessment by the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) Working Group on Artificial Intelligence (WG-AI)	Analyzing	Independent evaluation by EFLM working group on Artificial Intelligence (WG-AI)	No	N/A	Not suitable for interpreting overall diagnostic picture	Not specifically trained on medical or laboratory data
Using AI-generated suggestions from ChatGPT to optimize clinical decision support	Analyzing	Human clinician reviewers	No	9/20 top suggestions were suggested by chatGPT	Useful complementary part of optimizing clinical decision support alerts	Low acceptance, bias, inversion, redundancy
Trialling a large language model (ChatGPT) in general practice with the applied knowledge test: observational study demonstrating opportunities and limitations in primary care	Knowledge	Royal College of General Practitioners Applied Knowledge Test (RCGP AKT) questions and comparison to correct answers	No	60.17% accuracy	Approaching human expert-level performance	Below the mean passing mark for the AKT
Accuracy of information and references using ChatGPT-3 for retrieval of clinical radiological information	Knowledge	Cross-checking with peer-reviewed, PubMed-listed references	No	67% correct responses to questions from the daily routine of radiologists	Caution advised when using for radiological information	Majority of provided references not found or incorrect
A comparison of ChatGPT-generated articles with human-written articles	Writing	Independent analysis by two fellowship-trained radiologists	No	4 of the 5 articles written by ChatGPT were significantly inaccurate	May appear authentic to an untrained reader	Factually inaccurate and fictitious references
Can ChatGPT be used in oral and maxillofacial surgery?	Education	Evaluated by oral and maxillofacial surgeons	No	Mean score for answers to Patient Questions 4.62 ± 0.78	Useful for patient information, caution in training	Incorrect answers, not completely safe for training
Using a Google web search analysis to assess the utility of chatgpt in total joint arthroplasty	Knowledge	Comparison of most frequently asked questions (FAQs)	No	11 of 20 (55%) different responses between a Google web search and ChatGPT	Heterogeneous questions and responses, trending use	Credibility, reliability of information
Implications of large language models such as ChatGPT for dental medicine	Overview/ Knowledge	N/A (Overview)	No	N/A	Useful applications, but risks of misinformation	Malicious use, misinformation
An exploratory survey about using ChatGPT in education, healthcare, and research	Education	Survey, audience interaction, qualitative methods	No	Only 40% of the respondents had tried ChatGPT	Uncertainty around acceptability and optimal uses	N/A
Performance of ChatGPT on free-response, clinical reasoning exams	Analyzing	Clinical reasoning exams	No	43% passing rate	ChatGPT can pass clinical reasoning exams, but revisions needed	Inconsistency in performance across multiple runs
Assessing the performance of ChatGPT in answering questions regarding cirrhosis and hepatocellular carcinoma	Knowledge	Graded by hepatologists	No	79.1% accuracy in cirrhosis, 74.0% accuracy in HCC	ChatGPT can provide accurate information, but not comprehensive	Lacks knowledge of regional guidelines
Expanding cosmetic plastic surgery research using ChatGPT	Writing	Literature review	No	55% accuracy in generating ideas for systematic reviews	ChatGPT can generate novel systematic review ideas, better for specific ideas	Less accurate for general ideas
ChatGPT utility in healthcare education, research, and practice: systematic review on the promising perspectives and valid concerns	Analyzing	Systematic review	No	N/A	ChatGPT offers promising applications but needs responsible use	Ethical, legal, accuracy, and cybersecurity issues
The capability of ChatGPT in predicting and explaining common drug-drug interactions	Knowledge	Drug-drug interactions (DDIs)	No	Among 40 DDI pairs, one answer was incorrect	Partially effective for predicting/ explaining DDIs, needs improvement	Incomplete guidance on occasions
Using ChatGPT to evaluate cancer myths and misconceptions: artificial intelligence and cancer information	Knowledge	Cancer myths	No	96.9% accuracy for questions on the Common Cancer Myths and Misconceptions web page	Provides accurate information about common cancer myths and misconceptions	Limited data on AI system's quality
From human writing to artificial intelligence generated text: examining the prospects and potential threats of ChatGPT in academic writing	Writing/ Knowledge	Literature review	No	N/A	ChatGPT can enhance academic writing and research efficiency	Impact on authenticity and credibility of work
ChatGPT: is this version good for healthcare and research?	Knowledge	Medical research	No	N/A	Limited use in medical field, requires fact-checking and awareness of limitations	Errors in responses, limited knowledge up to 2021

Title	Types of task	Evaluation methods	Specific training?	Performance statistics	Conclusions	Limitations
Evaluating the use of large language model in identifying top research questions in gastroenterology	Analyzing	Gastroenterology	No	Generated questions were rated 3.6 ± 1.4 (1-5) on average	Useful for identifying research priorities, needs improvement in novelty	Generated questions lack originality
Assessing the capability of ChatGPT in answering first- and second-order knowledge questions on microbiology as per competency-based medical education curriculum	Knowledge	Microbiology	No	80% accuracy	Effective for answering first- and second-order knowledge questions	Inconsistent performance in different topics
Assessing the accuracy and reliability of AI-generated medical responses: an evaluation of the Chat-GPT model	Knowledge	Physician scoring	No	284 physicians' generated medical questions - median accuracy: 5.5 (1-6)	Largely accurate, but with limitations. Needs further research and model development	Validation needed
Assessing the utility of ChatGPT throughout the entire clinical workflow	Knowledge/ Analyzing	Clinical vignette comparison	No	71.7% accuracy across 36 clinical vignettes	Impressive accuracy, with strengths emerging as more clinical information is available	Inferior performance on certain tasks
Assessing the value of ChatGPT for clinical decision support optimization	Analyzing	Clinician review	No	9/20 top suggestions were suggested by chatGPT	Potential for AI-generated suggestions to improve CDS alerts, complementing expert suggestions	Limited sample size
Applicability of ChatGPT in assisting to solve higher order problems in pathology	Analyzing	Pathologist scoring	No	Solving higher-order reasoning questions in the subject of pathology, median score: 4.08 (1–5)	Capable of solving higher-order reasoning questions in pathology with relational level of accuracy (~80%)	Limited to pathology subject
ChatGPT output regarding compulsory vaccination and COVID-19 vaccine conspiracy: a descriptive study at the outset of a paradigm shift in online search for information	Knowledge	Author evaluation	No	N/A	Dismisses COVID-19 vaccine conspiracies, presents pros/cons of compulsory vaccination with a neutral stance	Not an alternative to official sources
How does ChatGPT perform on the united states medical licensing examination? the implications of large language models for medical education and knowledge assessment	Knowledge	Comparison to GPT-3, InstructGPT	No	AMBOSS-Step1, AMBOSS-Step2, NBME-Free-Step1, and NBME-Free-Step2, ChatGPT achieved accuracies of 44% (44/100), 42% (42/100), 64.4% (56/87), and 57.8% (59/102), respectively	Significant improvement on medical question answering, potential as a medical education tool	Decreased performance as question difficulty increased
Evaluating ChatGPT as an adjunct for radiologic decision-making	Analyzing	American College of Radiology (ACR) Appropriateness Criteria	No	Open-ended (OE) score: 1.83/2, select all that apply (SATA): 88.9%; OE score: 1.125/2, SATA: 58.3%	Feasible for radiologic decision making, potential to improve clinical workflow	Limited to radiology scenarios and ACR guidelines
Assessment of chemistry knowledge in large language models that generate code	Knowledge	Correctness of code, evaluation by experts	No	N/A	Impact on chemistry teaching and research is poised to be enormous	N/A

AI = artificial intelligence

Examples of fabricated information underscored the necessity of evaluation by healthcare professionals. Ethical, legal, and cybersecurity concerns are paramount, especially considering the potential harm from misleading information, the reinforcement of biases, and the handling of sensitive medical data.

The focus on GPT-3.5 in these studies leaves a gap in understanding the capabilities of the more advanced GPT-4 model. As AI technology evolves, continuous assessment of its impact on medical practice, patient care, and education is vital. This ongoing evaluation should also address ethical, legal, and cybersecurity implications associated with AI advancements [16-19].

This review has several limitations. First, the diverse range of applications evaluated in the studies included in this review precluded us from conducting a meta-analysis. In addition, the field of generative AI is evolving rapidly. Numerous relevant studies have been published since the completion of this review. These models are under constant refinement, which leads to ongoing improvements in their performance.

CONCLUSIONS

ChatGPT has demonstrated varied performance in healthcare. It shows promise in research tasks and clinical support but faces challenges in accuracy and ethical concerns. Future research should focus on newer versions like GPT-4 and their implications in medical fields. Responsible use of AI is essential for its positive contribution to healthcare.

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Human kindness has never weakened the stamina or softened the fiber of a free people.
A nation does not have to be cruel to be tough.
Franklin D. Roosevelt (1882-1945), American statesman and political leader who served as the 32nd President of the United States