



Chat Generative Pre-Trained Transformer (ChatGPT) usage in healthcare

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ABSTRACT

In recent years, with the rapid development of deep learning, artificial intelligence (AI) has gradually become a powerful assistant for humans in various aspects. The maturity and advancement of natural language models led to the birth of Chat Generative Pre-Trained Transformer (ChatGPT), generating great potential for healthcare applications. This review summarized the possible application prospects of ChatGPT in healthcare, assessed the limitations that still exist, and suggested possible improvements. In conclusion, the current version of ChatGPT can provide accurate and practical information for doctors and patients, help healthcare professionals to diagnose and treat, promote medical education, and improve the accuracy and efficiency of the healthcare system, etc. However, ChatGPT still has some limitations, as issues such as the accuracy of the information, privacy of data, ethical and moral sentiments still need to be solved. In the future, scientists still need to make efforts to achieve more accurate and effective medical applications with ChatGPT or other AI model by enhancing model performance, filling the data gap, and promoting the standardization of ethical and copyright issues.

1. Introduction

Chat Generative Pre-Trained Transformer (ChatGPT) is the recently most popular artificial intelligence (AI) chatbot developed by OpenAI, an artificial intelligence research and deployment company located in California.¹ It is a state-of-the-art AI model premised on transformer neural networks, the core ability of this model is to generate human-like text, leveraging its comprehension of contextual cues in a conversation. Since being launched on November 30, 2022, ChatGPT has quickly gained widespread attention and now has over 100 million users.²

In recent years, the healthcare industry has been constantly developing, however, there are a series of problems that needs to be solved at the same time. Firstly, problems including diagnostic errors, treatment errors, waste of resources, inefficient workflow, and inequity, make healthcare systems around the world be struggling with rising costs.¹¹ Secondly, due to the complexity of medical knowledge and technology and its constant developing characteristics, doctors need to invest a lot of time and effort to acquire, update and maintain their professional

knowledge and skills. However, medical professionals work with high intensity and high learning time costs, hence the period required to train a qualified medical worker is relatively long. Thirdly, the development of medical technology has produced a large amount of data, and it is difficult for researchers to complete the cleaning, mining, and analysis process. Applying AI technology such as ChatGPT to the healthcare industry may be a good solution and a new opportunity to enhance the cost-effectiveness and efficiency of healthcare industry.

ChatGPT is not the first attempt to achieve intelligent medicine. Compared to the past medical care pattern, medical personnels can now rely on some mature AI products to assist in diagnosis and treatment, such as disease risk prediction models,^{12–14} medical imaging-assisted diagnosis,^{15,16} and triage systems.^{17,18} Unlike the existing AI assistants mentioned above, ChatGPT can achieve all the above functions and additionally help the patients with medical knowledge. In addition, ChatGPT exhibits higher accuracy and consistency in answering medical questions compared to other AI chatbots.¹⁹ These may make ChatGPT a promising tool in the healthcare field, with significant implications for

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efficiency improvement in the healthcare industry.

In the past few months, multiple studies have been finished suggesting that ChatGPT has great potential for applications in the healthcare industry, such as providing assistance to doctors in diagnosis and treatment,^{20–23} serving as a psychological counselor,²⁴ providing high-quality medical education,²⁵ promoting medical knowledge to the public,^{26,27} and helping in events of public health emergency²⁸ (see Table 1). However, considering issues such as data privacy and security, fake or false information, and ethics concerns, some researchers believe that ChatGPT, at its current ability, is a great tool to help researchers and clinicians but not yet a substitute for them.²⁹ Thus, AI may still have aspects to improve its performance in medical applications.

Our review aims to summarize the possible application scenarios of ChatGPT in healthcare usage and to assess the remaining limitations and possible directions to its further expansion.

2. ChatGPT in disease treatment

ChatGPT, as a large knowledge retrieval database, has possible clinical application value. By reviewing the available literature, we concluded that ChatGPT has at least the following application prospects.

ChatGPT may improve the accuracy and efficiency of diagnosis. In the diagnosis process, ChatGPT can make diagnostic suggestions based on the patient's medical history and symptoms input. Take triage in the emergency department as an example, in general, doctors assign priority to patients by assessing the severity of their medical situation based on their past medical history and current symptoms, which may result in poor prognosis efficiency by increasing patients' waiting time.³⁰ ChatGPT can provide diagnostic recommendations within seconds after inputting symptoms and medical history, which could significantly increase efficiency. One study³¹ tested ChatGPT's ability to triage and found it accurate in classifying the Emergency Severity Index (ESI) manual scenarios. However, there are already AI triage assistants developed specifically for triage that are being used in hospitals.³² Compared with these AI triage assistants, ChatGPT has two weaknesses: first, the training set of ChatGPT is not derived from real patient data in hospitals, so it may be difficult to ensure the accuracy of triage; second, ChatGPT is based on a question-and-answer interaction format, while existing AI triage assistants are more likely to use a click-based interaction format, which further shortens the time from triage to treatment for patients. Thus, there may not be a great need to continue developing ChatGPT's triage capabilities.

ChatGPT can accurately and effectively answer questions from physicians and patients. For instance, before the surgery, it can provide patients with information about the surgery and advice on pre-operative preparations, which may have a positive impact on the outcome of the treatment by reducing their fears.^{33,34} Lee et al.³ selected eight frequently asked questions about colonoscopy to ChatGPT and submitted their answers to four gastroenterologists for scoring. It was found that ChatGPT-generated answers had low similarity (0–16%) in text and high similarity in ease of understanding (AI 5.0 – 6.4 vs non-AI 4.8 – 5.8), scientific adequacy (AI 5.4 – 6.5 vs non-AI 5.1 – 6.3), and satisfaction compared to non-AI answers (AI 4.9 – 6.3 vs non-AI 4.8 – 5.8). John et al.⁸ evaluated the results of ChatGPT responses with selected 195 conversations between patients and certified physicians in online forums, then reported 78.6% (95% CI (Confidence Interval): 75.0%, 81.8%) of evaluators preferred ChatGPT responses than doctors, including higher response quality and empathy. Besides, ChatGPT may provide patients with quick, safe, and easy-to-understand medical advice that can be used as an aid in querying and understanding complex medical situations as well as providing some basic preventive knowledge, especially in epidemic situations where medical professionals are understaffed.³³

ChatGPT can also serve as a virtual assistant to doctors during treatment. For instance, it can generate a list of possible surgical risks based on patient history and inform patients of risks and expected outcomes.³³ In the intraoperative phase, ChatGPT can provide real-time surgical

Table 1

Available evidence on ChatGPT performance.

Author	Year	Scenario	Result
Lee, et al. ³	2023	Answer questions about Colonoscopy	Ease of understanding: AI 5.0 – 6.4 vs non-AI 4.8 – 5.8 Scientific adequacy: AI 5.4 – 6.5 vs non-AI 5.1 – 6.3 Satisfaction: AI 4.9 – 6.3 vs non-AI 4.8 – 5.8
Zhu, et al. ⁴	2023	Answer questions of patient with prostate cancer	ChatGPT Free: Accuracy: "correct" = 100% Comprehensiveness: "very comprehensive" = 95.45% Readability: "very easy to understand" = 100% Stability: consistency = 100% ChatGPT Plus: Accuracy: "correct" = 93.94% Comprehensiveness: "very comprehensive" = 91.94% Readability: "very easy to understand" = 100% Stability: consistency = 90.91%
Yeo, et al. ⁵	2023	Answer questions about cirrhosis and hepatocellular carcinoma	Correct: cirrhosis (79.1%), HCC (74.0%) Comprehensive: cirrhosis (47.3%), HCC (41.1%)
Wagner, et al. ⁶	2023	Retrieve information and references of clinical radiology	Answers: 67% correct, 33% had errors References: 36.2% available on internet, 63.8% generated by ChatGPT
Ali, et al. ⁷	2023	Answer questions about lacrimal drainage disorder	40% correct, 35% partially correct (60% factual inaccuracy existed), 25% factually incorrect
John et al. ⁸	2023	Public conversation in online doctor consultant	Response content length: Mean (IQR): physician: 52 [17–62] words; ChatGPT: 211 [168–245] words; t = 25.4; P < .001. Response quality: Proportion: physician: 22.1%, 95% CI: 16.4%–28.2%; ChatGPT: 78.5%, 95% CI: 72.3%–84.1%. Responses rated empathetic: Proportion: physicians: 4.6%, 95% CI, 2.1%–7.7%; ChatGPT: 45.1%, 95% CI, 38.5%–51.8%.
Aidan, et al. ⁹	2023	United States Medical Licensing Examination	ChatGPT achieved accuracies of 44% (44/100), 42% (42/100), 64.4% (56/87), and 57.8% (59/102) in the 4 data sets (AMBOSS-Step1, AMBOSS-Step2, NBME-Free-Step1, and NBME-Free-Step2), respectively.
Adi, et al. ¹⁰	2023	Identifying top research questions in gastroenterology including inflammatory bowel disease, microbiome, Artificial Intelligence in GI, and advanced endoscopy in GI	The questions were rated 3.6 ± 1.4 (a scale of 1–5, with 5 being the most important and relevant to current research), with inter-rater reliability ranging from 0.80 to 0.98. The mean grades for relevance, clarity, specificity, and originality were 4.9 ± 0.1, 4.6 ± 0.4, 3.1 ± 0.2, 1.5 ± 0.4, respectively.

Abbreviations: HCC, hepatocellular carcinoma.

AMBOSS: a commonly used question bank for medical students.

NBME: the National Board of Medical Examiners.

guidance, case studies, and reference materials to physicians.²⁰ ChatGPT can also provide drug advice to physicians and patients⁴ and even discover drug targets to facilitate new drug discovery.³⁵ Moreover,

ChatGPT may be a good psychotherapist, providing free and convenient services to patients who need counseling, expanding the accessibility of counseling and providing services to more patients. Commonly, the diagnosis and treatment of mental illnesses usually take the form of questionnaires and interviews, so the doctor's attitude, emotion, and surrounding environment may have an impact on the results.³⁶ The emergence of ChatGPT may optimize this process, leading to a more accurate diagnostic result and better treatment outcomes.

3. ChatGPT in disease prognosis

ChatGPT can help healthcare workers monitor the prognostic status of patients, such as the presence of recurrence or postoperative complications. Usually, patients should have regular checkups for a period of time after receiving treatment, during which doctors will record the patient's test data, recovery status, etc. ChatGPT can help doctors to do these by recording and analyzing follow-up data, predicting the risk of poor prognosis and giving warnings, so as to identify and intervene at an early stage to improve the prognosis.³⁷ Even in the case of no doctor, patients can use ChatGPT to be informed of their prognosis status and make their own interventions in time, which greatly improves the efficiency of the healthcare system. Post-treatment care had a significant impact on the prognostic outcome of the patients. Especially after treatment such as orthopedic surgery, patients still need a long period of rehabilitation to allow them to fully recover. ChatGPT can also provide patients with general information on postoperative care, including instructions on wound care, diet, and medications.³⁸ Zhu et al.³⁹ evaluated the ability of ChatGPT to answer common questions including rehabilitation-related questions from patients with prostate cancer and found that the answers from the free version were excellently accurate (100%), comprehensive ("very comprehensive" = 95.45%), easy to understand ("very easy to understand" = 100%), and consistent (100%). In addition, ChatGPT can enhance patient self-management and improve disease prognosis by providing personalized medical services.⁴⁰

4. ChatGPT in medical education and scientific research

ChatGPT, which combines medical knowledge with dialogic interaction, has been investigated as a tool for medical education and scientific research.

Within the medical education domain, ChatGPT could help medical students improve their communication, problem-solving, and logical thinking abilities in clinical work.⁴¹ With this tool, medical students can create medical records. It can also give some feedback to users from non-English-speaking backgrounds in terms of writing style and language usage.⁴² All these facts taken together prove ChatGPT is a potential interactive medical education tool to assist learning. An interview conducted by Gunther⁴³ briefly introduced its current function and potential ability in medical education, scientific research, and clinical work. The advancement of ChatGPT is the ability to understand the context and be consistent and relevant to the current topic. The nature of this dialogue makes it different from previous models and could be useful as an effective educational tool. ChatGPT interface produces unique narrative responses, which allows users to take advantage of novel use cases such as simulating patients, providing brainstorming feedback, or simulating group discussion. Thus, for those practical applications, ChatGPT still needs to reach a level similar to people when evaluating medical knowledge and logical information, so that users can fully adopt its responses. Recently, a study reported the potential of ChatGPT in medical education. ChatGPT is shown as the level expected of a third-year medical student on the assessment of the primary competency of medical knowledge.⁹

ChatGPT has also shown effectiveness in scientific research. Lahat et al.¹⁰ queried ChatGPT on four key topics in gastroenterology, including inflammatory bowel disease, the microbiome, AI in gastroenterology, and advanced endoscopy in gastroenterology. Several

experienced gastroenterologists separately compared and evaluated the exported research issue by ChatGPT and current research in gastroenterology. The results showed that ChatGPT can provide a set of relevant, clear, and specific research questions for gastroenterologists in all four key topics. Although the novelty of the exported research issue by ChatGPT still needs improvement, ChatGPT has shown its effectiveness in identifying research priorities in the field of gastroenterologists. Otherwise, ChatGPT has shown an astounding ability to write specialized texts.⁴⁴ According to Dr. Biswas,⁴⁵ ChatGPT can revolutionize medical writing by extracting information, assisting in literature retrieval, and providing a rough draft for medical writers to work further upon. However, ChatGPT lacks the necessary knowledge and expertise to accurately and adequately convey complex scientific concepts and information. Thus, ChatGPT needs strong human intervention to write reliable scientific texts.

5. ChatGPT in public health

Researchers have reported the potential effect of ChatGPT on public health and checked its ability and accuracy. As an advanced natural language processing tool, ChatGPT could quickly generate scientific writing content related to epidemiology.⁴⁶ Although the accuracy of the generated content may need to be checked and without references⁴⁷, it will increase the efficiency of the public health staff's daily work. ChatGPT could also help in the policymaking process through its data analysis and data prediction abilities, which could help policymakers analyze unstructured data and provide results and advice.⁴⁸

ChatGPT could also increase public awareness about the knowledge of disease prevention and promotion through personal usage, which has an important popularization role for public health. A study applied ChatGPT to the epidemic of monkeypox infection in Pakistan²⁸ and reported that it can help the questioner determine the key information about monkeypox infection, including symptoms, route of infection, consequences, and the current prevalence situation.

However, since the training data of GPT-4 (the newest released ChatGPT model) is not up-to-date, this may lead to timeliness errors, especially in new public health situations or in fast-growing industries, and it may not provide the inquirer with the most up-to-date information and knowledge.³³ Thus, the quantity, quality, and representativeness of training data are all limitations of AI-provided information. A study tested ChatGPT performance in antimicrobial advice based on hypothetical infection scenarios, although most responses provided reasonable advice, some were inappropriate and could even jeopardize patients, also pointing to ChatGPT's shortcomings in context awareness, reasoning, and consistency.⁴⁹ Therefore, while ChatGPT can be useful in the public health field, it still requires caution in the results it provides.

6. Limitations

The development of AI technology had a great impact on the medical field. Therefore, it is necessary to consider the consequences of AI technology before its application, which may lead to wrong information. For example, due to the limitation in training data usage, ChatGPT is unable to integrate data and information after 2021, which restricts its ability to offer timely information to users.^{50,51} In addition, the credibility of ChatGPT also faces big challenges. In some cases, it will provide some false and unfounded information and even make up the wrong references, which may lead to unacceptable consequences for doctors and patients.⁵¹ For example, according to the New York Times, NewsGuard, a US news credibility assessment and research agency, has tested ChatGPT. The researchers asked questions about ChatGPT, which is rife with conspiracy theories and misleading narratives, and found that it was able to adapt information in seconds to produce a large amount of convincing but unsourced content.⁵² Meanwhile, the opacity of information sources makes it difficult to identify plagiarism or creation, which poses a challenge to intellectual property risks.

Facing the complex big data security environment has always been a topic of concern for AI experts. Currently, there are already a number of incidents caused by data security issues.⁵³ Thus, it is worth noticing whether ChatGPT has the potential for data breaches, especially for patient data, because it can save and access user data.⁵⁴ Another point to consider is that ChatGPT has also raised ethical and privacy concerns. For example, data analysis systems can record past conversations between users and themselves, involving the privacy data of users, which also faces the challenge of data protection.

It is also worth noting that ChatGPT, as an artificial intelligence model, has a lot to do with the training dataset. It cannot be proven to provide completely accurate and professional results, so the model bias currently cannot be avoided.

7. Future directions

ChatGPT is a milestone in the development of AI science. With this opportunity, it will make great contributions, inspiration, and changes in the future. However, the current version has a number of limitations in terms of security, privacy, and performance. In the upcoming future, by gradually solving, optimizing, and improving its limitations, AI could continue to make breakthroughs. For example, extending the training dataset would increase the diversity and randomness of the data, updating the training dataset in time would meet timely data availability, and improving the performance of the algorithm would increase the accuracy and reduce bias. Based on the number of its users, ChatGPT should consider higher data security to prevent data leakage. For example, corporations should actively engage with governments to explore the best form of regulation. Current research is dedicated to privacy encryption through special codes and removing personal information from training datasets where feasible, fine-tuning models to reject requests for personal information queries, and responding to requests from individuals to remove their personal information from our systems. In addition, since many questions may be used by the questioner as a practical reference, such as medication or treatment, ChatGPT should consider adding warning messages when providing answers to related questions, suggesting that their information may be incorrect or lack emotional support, to avoid misbehavior or a negative emotional effect on the questioner. One of the most exciting aspects of medicine is that GPT will be able to provide diagnostic support for the treatment of complex diseases, such as multiple underlying diseases and drug allergies, in order to determine the optimal treatment and prognosis.

Recently, the release of the newest updated GPT-4 model has solved some of the limitations and shown its great potential in collaboration with other digital tools. The capabilities of natural language processing and AI technology are being developed in depth to pave the way for automation and intelligence.

8. Conclusion

ChatGPT has great potential in medical application. It can help clinicians diagnose and treat patients in clinical care, as well as serve as a useful tool in the medical education process and provide professional advice in public health usage. However, there are still some limitations to ChatGPT that need to be addressed in order to achieve widespread clinical application.

CrediT author statement

Yanhui Zhang: write manuscript, data collection. **Haolong Pei:** write manuscript, analysis. **Shihan Zhen:** write manuscript, analysis. **Qian Li:** write manuscript, design study. **Fengchao Liang:** design study, write manuscript.

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Declaration of competing interest

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