

Review

ChatGPT in healthcare education: a double-edged sword of trends, challenges, and opportunities

Michael Agyemang Adarkwah¹  · Samuel Anokye Badu²  · Evans Appiah Osei³  · Enoch Adu-Gyamfi⁴  · Jonathan Odame⁵  · Käthe Schneider¹

Received: 7 October 2024 / Accepted: 19 December 2024

Published online: 17 January 2025

© The Author(s) 2024 

Abstract

The advancement of artificial intelligence (AI) tools has revolutionized teaching and learning, particularly in healthcare education, where they enhance pedagogy, foster immersive learning, and support healthcare provision. However, their use in healthcare education is contentious, warranting careful examination, especially regarding Generative AI (GenAI) tools like ChatGPT. This scoping review aims to explore the impact of ChatGPT on healthcare education and identify future research directions. The scoping review, conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, utilized search terms such as “ChatGPT,” “GPT,” “natural language processing,” “large language models,” and “health education”. The review followed the five-stage framework outlined for organization and analysis. The search encompassed Web of Science (WOS) (n = 100), PubMed (n = 100), CINAHL (n = 21), SCOPUS (n = 4), Science Direct (n = 25), and Google Scholar (n = 150). Initially, 400 papers were retrieved from these search engines, which were then reviewed and narrowed down to 33 papers for final analysis. This review investigated the trends, challenges, and opportunities of ChatGPT in healthcare education. The findings suggest that GenAI tools such as ChatGPT can significantly enhance teaching, learning, and research in healthcare education. Developed countries, particularly the United States and China, which are leaders in AI investment and research, lead research on ChatGPT’s applications in healthcare education, with limited studies conducted in the African region. Additionally, barriers remain that could lead to ethical and legal issues, particularly exacerbating inequalities in developing countries. Further research is needed to promote better GenAI practices in healthcare educational settings, especially for individuals in these regions.

Keywords ChatGPT · Healthcare education · Nursing education · Medical education · Artificial intelligence

1 Introduction

Over time, AI technologies – like virtual reality, augmented reality, virtual health assistants, and conversational agents – have significantly boosted their effectiveness in education through ongoing advancements [1–3]. AI, defined as machines capable of human-like tasks, is reshaping education by revolutionizing learning experiences. In healthcare education, AI tools are swiftly adopted to enhance teaching practices, creating immersive learning environments,

✉ Evans Appiah Osei, oseiappiahevens@gmail.com; Michael Agyemang Adarkwah, michael.agyemang.adarkwah@uni-jena.de; Samuel Anokye Badu, anokye14@gmail.com; Enoch Adu-Gyamfi, e.adu-gyamfi@salford.ac.uk; Jonathan Odame, jonathanodame@ug.edu.gh; Käthe Schneider, k.schneider@uni-jena.de | ¹Institute for Education and Culture, Chair of Adult Education, Friedrich-Schiller-University, Jena, Germany. ²Royal Liverpool University Hospital, Liverpool, UK. ³Purdue University, West Lafayette, IN, USA. ⁴University of Salford, Manchester, UK. ⁵University of Ghana, Accra, Ghana.



and guiding healthcare delivery [4–6]. For example, they facilitate clinical simulation education, medical training, and healthcare literacy, aiding in patient diagnosis, prognosis, and treatment [2, 6, 7]. In special education, AI addresses educational, adaptive, and social skill gaps among students with intellectual disabilities and persistent health issues [3, 5, 7]. Higher education institutions are integrating AI tools to advance healthcare education, aiming to reduce errors, optimize patient care, and ensure data integrity among healthcare professionals [8]. AI in healthcare education also facilitates access for learners in remote areas, promotes interactive learning, and enhances overall accessibility. In 2024, OpenAI introduced GPT-4o, an advanced AI model that supports document uploads for analysis and the creation of images and diagrams, further advancing educational capabilities has been introduced.

Virtual agents, powered by conversational and generative AI, are among the AI applications utilized for healthcare education and services [9]. AI-driven chatbots assist students in overcoming learning obstacles and provide learning opportunities outside the classroom [10]. In many educational institutions worldwide, didactic teaching methods prevail in health courses. AI-driven chatbots enhance medical and nursing education by fostering interactive learning environments. Amidst the COVID-19 pandemic, chatbots saw widespread adoption in education and continue to be utilized in post-pandemic learning settings [11]. Past studies have highlighted the use of AI chatbots by instructors in healthcare education, with the potential to personalize learning experiences [9, 12]. Additionally, voiced-enabled and text-based chatbots are deployed for nutrition education [13].

Chat Generative Pre-trained Transformer (ChatGPT), an advanced chatbot from OpenAI released in November 2022, is reshaping education. Within its first week, ChatGPT attracted a million users due to its robust features. It was further reported that ChatGPT can create novel content and mimic human behavior convincingly [14]. With extensive training data and refined capabilities, ChatGPT-4 provide accurate medical information compared to other contemporary chatbots [15]. Its efficient design enables it to produce human-like responses [16]. ChatGPT has undergone testing in educational contexts, sparking discussions on its transformative potential. Dwivedi et al. explored its implications for educational assessment, Lund and Wang envision changes in library services and academia, Thorp discusses its impact on scientific research, Biswas demonstrates its role in public health education, Bettayeb et al. and Saleem et al. agree ChatGPT can transform student engagement and enrich the learning experience [16–20]. Thus, the educational possibilities of ChatGPT are vast and groundbreaking.

Despite advancements, the utilization of AI tools in healthcare education remains contentious. Some authors have underscored that medical chatbots are susceptible to providing inaccurate information and compromising user privacy [9]. Ethical dilemmas arise as AI tools, like chatbots, often necessitate extensive learner data, some of which may be sensitive, for model training [21]. Given the potential implications of ChatGPT, there is a critical need to evaluate its impact on healthcare education. ChatGPT may occasionally generate incorrect responses, error messages, and exhibit biased language [14, 22, 23], posing considerations for its deployment in healthcare education. Additionally, concerns regarding ChatGPT's effect on academic integrity have been raised [14, 17, 18], and the potential to create over reliance and impact critical thinking – a key element in healthcare education [4]. Research on ChatGPT, particularly its implications for health education, is still growing. Thus, this scoping review aims to delineate the evidence regarding ChatGPT's potential impact on healthcare education.

2 Method

The methodology for this scoping review was based on the five-stage framework outlined [24] which are; (1) identifying the research question, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting the results. This framework enhances the reliability of the findings of the study through a rigorous and transparent methodology.

2.1 Identifying the research question

The chapter sought to provide a comprehensive overview of the potential impact of ChatGPT on healthcare education by looking at the trends, challenges, and opportunities of the conversational agent.

The following questions are what is guiding the scoping review;

- RQ1. What accounts for the trends of ChatGPT in healthcare education?

- RQ2. What are the potential challenges of ChatGPT in healthcare education?
- RQ3. What are the opportunities of ChatGPT in healthcare education?
- *Identifying relevant studies*

To include diverse relevant studies involving ChatGPT's role in health education, we developed keywords following Arksey and O'Malley's (2005) guidelines [24]. The search terms on Web of Science (WoS) and SCOPUS were "ChatGPT" and "Health". Aside from that, a search was conducted involving other databases such as Google Scholar and ScienceDirect, Psychinfo and CINAHL using search terms involving "ChatGPT," "GPT," "natural language processing," "large language models," and "health education." Employing Boolean operators aided in refining our search scope. We confined our search to publications between 2023 and 2024, aligning with ChatGPT's release in November 2022 and subsequent research.

We exclusively considered full-text journal articles in English and, only peer-reviewed publications.. Excluded were research blogs, newspaper articles, website publications, and institutional documents. We focused on only health education research and no other aspect of health. That is, all studies focusing solely on healthcare without a connection to educational contexts were excluded. While not restricted to any educational level, most acquired studies focused on higher education. All articles that were non-full text and inaccessible were excluded. Articles that do not provide clear insights into the trends, challenges or opportunities of ChatGPT in healthcare education were also excluded. Table 1 provides a summary of the inclusion/exclusion criteria.

We sourced research articles from two primary scientific databases: Web of Science (WOS) (n = 100), PubMed (n = 100), CINAHL (n = 21) and SCOPUS (n = 4). Additionally, we utilized the ScienceDirect database (n = 25) to expand our article pool. To enhance coverage, we employed the Google Scholar database and a snowballing approach, resulting in the identification of further research articles (n = 150) in all totaling 400 papers. The literature search spanned two months. Details of the search process are depicted in Fig. 1.

2.2 Study selection

Initially, 400 articles were obtained through keyword searches, with authors independently conducting searches aligned with research questions. Each article's title and abstract were reviewed to determine eligibility for further analysis. Authors then collaborated to review and finalize selections, achieving consensus on inclusion criteria. Articles investigating ChatGPT use in various health education domains, such as nursing, medicine, radiology, and public health, were considered suitable. Those not directly related to health education or research were excluded. Studies focusing on LLMS, conversational agents, chatbots, or AI tools generally, without mention of ChatGPT, were also excluded. Duplicate articles were removed during screening. Three study authors confirmed the suitability of all selected articles.

2.3 Charting the data

The final selected studies, based on the established inclusion and exclusion criteria, were compiled into an Excel sheet following [24] guidelines. These records were categorized by author, year, methods, country, findings, and recommendations. Each author independently and collaboratively reviewed the Excel sheet to rectify any errors. See details in Table 1

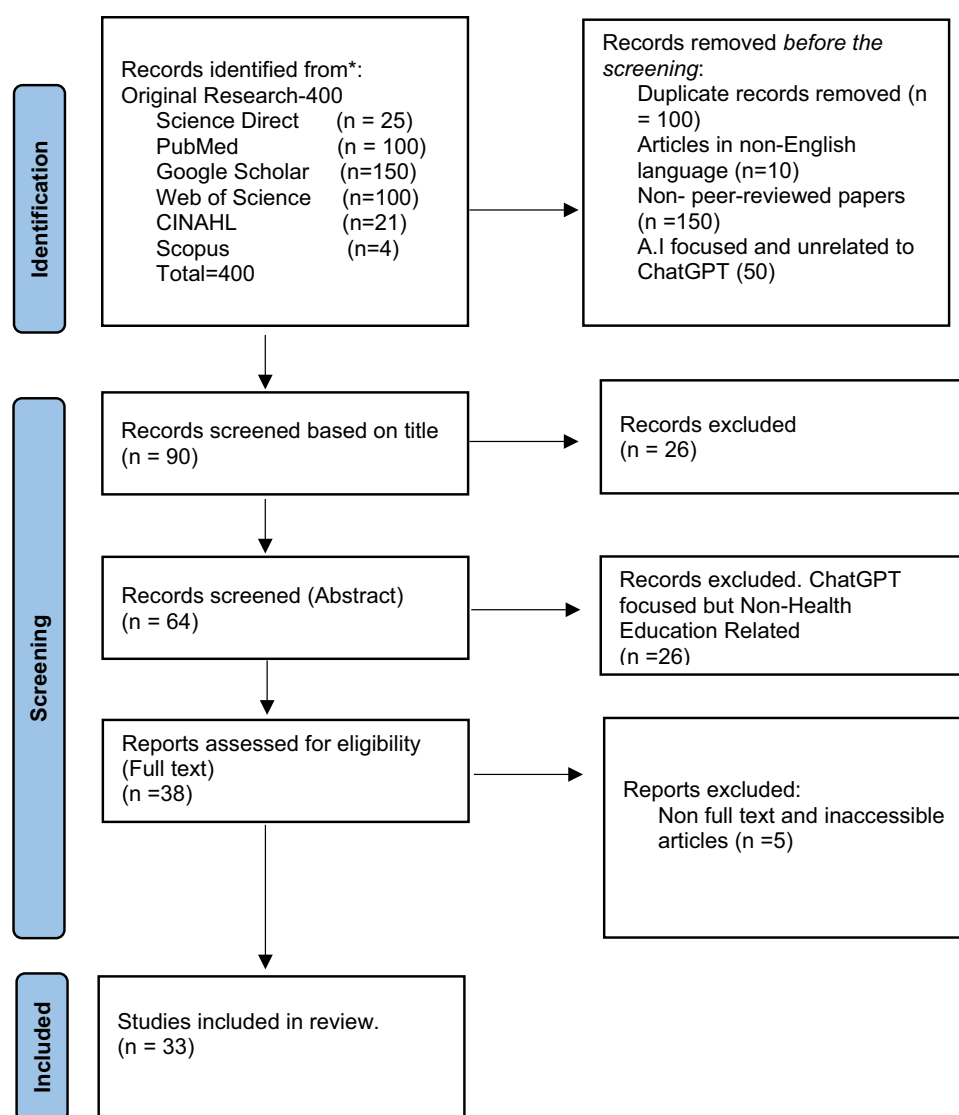
2.4 Collating, summarizing, and reporting the results

The last stage of the [24] framework involves collating, summarizing, and reporting the results. Accordingly, summaries of the findings from the final records were provided to address each research question. These summaries aim to enhance reader comprehension of the included studies by presenting their key findings concisely.

Table 1 Inclusion and exclusion criteria for included articles

Criteria	Inclusion	Exclusion
Publication date	Publications from 2022 to 2024, aligning with ChatGPT's release	Publications outside the 2022–2024 range
Language	Full-text journal articles published in English	Non-English publications
Publication type	Peer-reviewed journal articles only	Research blogs, newspaper articles, website publications, and institutional documents
Research focus	Studies related to healthcare education, specifically exploring ChatGPT's role	Studies focusing solely on healthcare without educational contexts
Educational level	No restriction, but most studies focus on higher education	Articles not related to educational settings
Accessibility	Only full-text and accessible articles will be included	Non-full text and inaccessible articles
Content relevance	Articles must provide clear insights into the trends, challenges or opportunities of ChatGPT in healthcare education	Articles lacking relevant insights on the specified themes

Fig. 1 A PRISMA flowchart of included articles in the scoping review



3 Findings

Figure 2 provides a summary of the findings of the literature search regarding the trends, challenges, and opportunities of ChatGPT in healthcare education. A detailed discussion of the findings is presented below.

3.1 Assessing the Growing Impact of ChatGPT on Healthcare Education

Integrating advanced AI technologies like ChatGPT into health education shows great potential for addressing challenges in traditional educational systems. This section explores ChatGPT's functionalities that attract learners in healthcare education and how these features align with opportunities to overcome identified challenges.

ChatGPT's functionality is based on natural language processing that enhances learning with real-time interactions, aiding in understanding complex medical concepts [25]. Moreover, its adaptability addresses the scarcity of healthcare educators, offering personalized learning tailored to individual needs [27]. This personalized approach boosts comprehension and retention of medical knowledge. ChatGPT's interactivity extends to simulating patient interactions, providing

Fig. 2 A map of the trends, challenges, and opportunities of ChatGPT in healthcare education



hands-on training, particularly beneficial where clinical access is limited [28]. Virtual patient consultations enhance diagnostic and communication skills, better preparing healthcare professionals.

ChatGPT's multimedia integration is pivotal in healthcare education, aiding comprehension of medical concepts, especially for diverse learners [26]. Additionally, its multilingual capabilities address language barriers prevalent in many countries, where medical instruction is hindered by linguistic challenges [28]. By offering instruction in learners' native languages, ChatGPT enhances accessibility and extends education to underserved communities.

ChatGPT presents a compelling solution to healthcare education challenges in both developed and developing nations. Its role as a virtual tutor, adaptable and personalized, mitigates the shortage of expert instructors. Simulating clinical scenarios and integrating multimedia enrich practical learning experiences. Its integration into healthcare education aligns with prevailing technology trends in developing countries. The potential of technology-enhanced learning in education within sub-Saharan Africa has been documented [29], emphasizing how ChatGPT's features can complement these trends, enhancing both the quality and accessibility of medical or healthcare education to different learners.

ChatGPT fosters personalized learning experiences, useful in writing papers, abstracts, and discharge summaries [26]. Catering to individual needs, it enhances understanding and retention of critical medical knowledge. Learners receive tailored explanations and targeted practice, bolstering their grasp of medical concepts. Additionally, ChatGPT's continuous availability addresses time constraints and logistical issues, particularly valuable for learners in developing countries with work or family commitments [29]. Access during non-traditional hours aids in balancing education with other responsibilities.

ChatGPT's interactive capabilities facilitate the transition from theory to practice by simulating patient interactions and medical scenarios [28]. This practical approach enhances clinical skills, crucial for healthcare professionals with limited clinical exposure. Additionally, its multilingual functionality promotes cultural inclusivity in healthcare education, addressing diverse contexts and sensitivities [29]. Integration of ChatGPT into health education in tackles unique challenges, offering personalized learning, accessibility, interactive simulations, and multilingual instruction. Leveraging AI-driven technology can overcome educational barriers, nurture skilled healthcare professionals, and ensure quality medical education.

3.2 Potential challenges of ChatGPT in healthcare education

AI, notably ChatGPT, holds promise for enhancing healthcare education [30, 31]. However, its implementation poses risks that warrant examination [32]. Here, we assess the potential implications and associated risks of integrating ChatGPT into healthcare education.

ChatGPT in healthcare education faces challenges due to language, cultural, and economic disparities globally [33]. While it accommodates multiple languages, variations in training data quality and availability exist [33, 34], leading to unequal learning opportunities. Primarily trained in English, ChatGPT's translations may miss contextual nuances [17, 34, 35], impacting communication effectiveness. Cultural and regional healthcare practices might not be adequately addressed [36], posing barriers to knowledge dissemination.

Larger economies' influence over AI training and infrastructure could lead to biased healthcare education experiences, disadvantaging learners from smaller economies [37]. ChatGPT aims for equal information access but its subscription-based model, like ChatGPT 4.0, may widen the digital gap between urban–rural areas and diverse socioeconomic groups. Global internet disparities hinder ChatGPT's adoption [17, 34], particularly in regions with limited connectivity [38, 39]. This digital divide exacerbates healthcare education inequalities, affecting disadvantaged communities' access [39, 40].

The use of ChatGPT in healthcare education may pose a threat to the quality and accuracy of information presented due to its potential for errors. The nature of ChatGPT's impact emphasizes the importance of ensuring the quality and accuracy of the information it provides [17, 42, 43]. The model learns from diverse datasets, some of which may contain outdated or biased information [44]. This could result in the dissemination of misinformation on a global scale, potentially leading to widespread medical errors and compromised patient outcomes. There is the need to ensure the accuracy and reliability of AI generated information.

ChatGPT's use in healthcare education may restrict personalized feedback crucial for tailored learning [44, 45]. Unlike human instructors, ChatGPT offers generalized feedback from trained data, potentially hindering learners' unique educational paths [17, 46, 47, 48]. This limitation could diminish healthcare education effectiveness and impede future practitioners' professional growth.

The integration of ChatGPT in healthcare education poses ethical concerns, notably surrounding data privacy and confidentiality [37, 42, 47]. While AI can gather extensive student data for educational improvement [17, 50], this raises privacy issues and necessitates informed consent. The absence of an international AI regulatory framework in healthcare education may result in ethical discrepancies [34, 47], potentially compromising resource reliability. Unaddressed issues include accountability in cases of system errors or misinformation [47].

ChatGPT raises ethical concerns regarding its potential impact on students, particularly those from marginalized backgrounds. There's apprehension that it could exacerbate existing educational inequalities by failing to address diverse student needs, thus disadvantaging already vulnerable groups [51]. Proper regulation is essential to prevent widening disparities in educational outcomes and opportunities. Academics and scientists play a crucial role in educating stakeholders about the ethical implications of algorithmic use [52], fostering a generation that prioritizes inclusivity and diversity in AI development and curriculum design.

ChatGPT's emergence raises concerns about over-reliance on AI in healthcare education, potentially marginalizing human instructors and professionals [47]. Long-term, this trend could lead to job displacement and social disparities [47]. Social interaction, integral to healthcare education, may suffer with increased AI usage [38]. While AI enhances learning, maintaining a balance with human expertise is crucial to accommodate diverse learning styles and cultural preferences [17]. Human instructors offer essential insights, empathy, and real-world experience complementing AI's capabilities [35].

In conclusion, integrating ChatGPT into healthcare education presents challenges that could hinder the training of future healthcare professionals. Language barriers, accessibility issues, data quality concerns, and reliance on AI demand careful attention and proactive solutions. International cooperation is vital to address these challenges, necessitating

investments in infrastructure, data accuracy promotion, and universal ethical frameworks. By globally addressing these issues, we can harness AI's potential to advance healthcare education while upholding principles of inclusivity, accuracy, and ethics.

3.3 Opportunities of ChatGPT in healthcare education

ChatGPT plays a crucial role in health education and healthcare delivery, despite some challenges [53]. A systematic review found that 85% of studies highlighted its benefits, particularly in enhancing scientific writing and research efficiency [42]. In health education, ChatGPT effectively assesses students' papers, analyzing sentence structure, vocabulary, grammar, and clarity. This helps students refine their writing and workflow, producing higher-quality work. Lecturers can also use ChatGPT to clarify confusing terms and evaluate student work, and it can address difficult student questions with valuable feedback.

The integration of ChatGPT in healthcare education provides numerous benefits. Students experience higher engagement by using ChatGPT to access information related to their coursework [47]. Additionally, educators benefit from this tool by streamlining teaching tasks and accessing relevant information quickly [33].

ChatGPT's potential enhances learning and teaching in healthcare education, improving educational outcomes [27]. Its versatility enables curriculum development, personalized tutoring, exam preparation, medical research, and scenario simulation [19]. Responsible implementation can revolutionize healthcare education, empowering future professionals to excel in their careers and improve patient care. Salam [42] highlighted ChatGPT's value in healthcare for accurate documentation and enhancing health literacy. Patients and providers can use it to access information on medical conditions and procedures. Some authors also noted that integrating ChatGPT improves communication, understanding, and decision-making, enhancing patient care [53]. For effectiveness, ChatGPT needs precise, up-to-date medical data to provide reliable suggestions and treatment options.

ChatGPT offers personalized recommendations for nutrition, exercise, and psychological support [54], enhancing healthcare delivery by providing valuable information to patients and providers. In Saudi Arabia, healthcare workers found ChatGPT useful for decision-making (39.5%), patient support (44.7%), literature appraisal (48.5%), and research assistance (65.9%) [55]. With responsible use and oversight, ChatGPT can revolutionize healthcare practices and improve patient outcomes.

Table 2 provides an overview of various studies exploring the use of ChatGPT in healthcare education, highlighting its applications, findings, and recommendations across different health fields, such as medicine, general health, oncology, and dental education.

3.4 ChatGPT's research focus in health areas

Research on ChatGPT has largely concentrated on its impact across various health disciplines, with a strong focus on improving patient awareness and engagement. Many studies have highlighted ChatGPT's role in delivering information on diverse health topics—ranging from general health to specific conditions like breast cancer and infectious diseases—helping patients stay informed [34, 57]. ChatGPT has also been valuable in supporting patients as they interact with healthcare providers, assisting them in making more informed health decisions [65]. Furthermore, healthcare students have utilized ChatGPT as an educational tool, benefiting from its support in completing assignments and enhancing their engagement with learning material [47, 56, 60]. Figure 3 summarizes the key health areas where ChatGPT has been most frequently applied, with the greatest emphasis on Medicine (42.4%), followed by General Health (24.2%) and Pediatrics (6.1%). See Fig. 3 for additional details.

3.5 Research focus years for ChatGPT publications

The focus years for research were 2023–2024, as ChatGPT was introduced in 2022. Since it was newly launched, most 2022 publications were preliminary or grey literature. See Fig. 4 below for the publication years.

Table 2 Overview of studies used for the scoping review

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
Reasons for the Trends of ChatGPT in healthcare education								
1	Liu & Liu [28]	2023	The application of ChatGPT in medical education	Literature review	China	ChatGPT's instruction in learners' native languages enhances accessibility and reaches underserved communities	Medicine	Educators and institutions should thoroughly evaluate the accuracy and reliability of ChatGPT's responses in a medical context. This could involve rigorous testing and validation of the AI model
2	Wang et al. [26]	2023	Performance and exploration of ChatGPT in medical examination, records and education in Chinese: Pave the way for medical AI	Qualitative	China	ChatGPT can understand medical knowledge, accurately provide answers to medical examinations, promote medical development, facilitate group learning, enhance discharge summaries, and promote positive human-machine interaction	General health	We must consider the benefits and limitations of ChatGPT during usage and keep up with the pace of its development.
3	Yigit et al. [56]	2024	Views of health sciences undergraduates on ChatGPT	Qualitative	Turkey	ChatGPT promotes learning process outlines complex ideas and provides tailored feedback, offering a personalised learning experience for students	General health	It is recommended to apply critical thinking when incorporating AI models into educational settings and to use AI responsibly
4	Mheidly [57]	2024	Unleashing the power of AI: Assessing the reliability of ChatGPT in disseminating breast cancer awareness	Qualitative comparative analysis	USA	ChatGPT provides adequate and correct information on breast cancer compared to the CDC website, collects information from multiple authentic resources, and provides better access to information	Oncology	It recommended that future research should explore ChatGPT efficacy other diseases

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
5	Cherrez-Ojeda et al. [58]	2024	Understanding Health Care Students' Perceptions, Beliefs, and Attitudes Toward AI-Powered Language Models: Cross-Sectional Study	Quantitative Cross-sectional	Argentina, Mexico and Columbia	About 67.98% (1809/2661) wanted to learn about the applications of ChatGPT in particular cases of medical practice, followed by homework support and understanding the benefits and limits of ChatGPT	General health	It is recommended that medical educators should explore how ChatGPT may be included in undergraduate health care education programs
6	Al-Worafi et al. [59]	2024	The Use of ChatGPT for Education Modules on Integrated Pharmacotherapy of Infectious Disease: Educators' Perspectives	Qualitative content analysis	Yemen	Findings revealed that ChatGPT was able to describe the need for the integrated pharmacotherapy curriculum in general for health care students and describe the issue of antibiotic resistance	Medicine	Increase workshops on AI technologies can help make informed decisions and implement best practices
7	Kavadella et al. [60]	2024	Evaluation of ChatGPT's Real-Life Implementation in Undergraduate Dental Education: Mixed Methods Study	Mixed method study	Cyprus	Undergraduate Dental Students using ChatGPT performed significantly better in the knowledge examination than their fellow students who used the literature research methodology. The depth of the information provided by ChatGPT depended on the quality and wording of the questions asked	Dental health	Educators should consider integrating ChatGPT into curriculum design. Awareness programs are warranted to educate both students and educators about the limitations of ChatGPT, encouraging critical engagement and responsible use

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
8	Lin et al. [61]	2024	Ethical and Professional Decision-Making Capabilities of Artificial Intelligence Chatbots: Evaluating ChatGPT's Professional Competencies in Medicine	cross-sectional study	USA	ChatGPT was significant in the average medical school applicant on PREview as reported with few incorrect responses, GPT-3.5 and GPT-4 scored in the 78th and 93rd percentiles, respectively. ChatGPT is capable of applying ethical principles in medicine	Medicine	It is recommended in healthcare training and decision-making
9	Güner et al. [62]	2024	The challenges of ChatGPT in healthcare education Perspectives and experiences of health sciences academics regarding ChatGPT: A qualitative study	Qualitative	Türkiye	The misuse of ChatGPT by students for assignments and exams negatively impacts their critical thinking and information retrieval skills	General health	Institutions should incorporate ChatGPT with clear guidelines to ensure its benefits are maximized while preserving academic integrity
10	Kazleva et al. [63]	2024	Is use of ChatGPT cheating? Students of health professions perceptions	Quantitative cross-sectional	USA	Majority of students in Health-related professions believe that using ChatGPT during exams (90.2%) and writing academic papers is cheating, and 330 (84.3%) reported doing so is not morally right	General health	Faculty should provide clear guidelines on how students, particularly those in health professions, should use ChatGPT
11	Baumgartner [64]	2023	The opportunities and pitfalls of ChatGPT in clinical and translational medicine	Qualitative	Austria	The study identified the following challenges with ChatGPT; Bias in training data, privacy concerns, accuracy of information, dependency on AI	Clinical and Translational Medicine	Improving accuracy and data training. Ensuring data privacy is maintained ethically

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
12	Cheng et al. [34]	2023	Potential Use of Artificial Intelligence in Infectious Disease: Take ChatGPT as an Example	Literature Review	China	ChatGPT could provide misleading information. The AI could lead to lack of human interaction, ethical issues, language barrier, accessibility – will further deepen the inequality gap	Infectious diseases	The need to train AI with holistic data, to ensure contextual accuracy of ChatGPT's answers
13	Corsello & Santangelo [37]	2023	May Artificial Intelligence Influence Future Pediatric Research? The Case of ChatGPT	Qualitative	Italy	Bias and fairness. Over-reliance on technology. Ethical concerns – privacy, transparency, need for informed consent	Paediatrics	Ethical and social implications of ChatGPT should be considered and evaluated before its deployment
14.	Dave [49]	2023	ChatGPT in medicine: an overview of its applications, advantages, limitations, future prospects, and ethical considerations	Literature Review	Ukraine	ChatGPT may infringe copyright laws, biased and harmful results, inaccurate results, and unreliable sources	Medicine	The training of ChatGPT need to be improved to help address its current limitations
15	De Angelis et al. [46]	2023	ChatGPT and the Rise of Large Language Models: The New AI-Driven Infodemic Threat in Public Health	Review Article	Italy	Disinformation. Generalized and unreliable responses	Public Health	Develop policies to safeguard the use of ChatGPT in public health
16	Eysenbach [44]	2023	The Role of ChatGPT, Generative Language Models, and Artificial Intelligence in Medical Education: A Conversation With ChatGPT and a Call for Papers	Qualitative	Canada	ChatGPT has a limitation in producing reliable references and cannot create visual animations	Medicine	N/A

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
17	Khan et al. [30]	2023	ChatGPT—Reshaping medical education and clinical management	Literature Review	Pakistan	ChatGPT is limited to the data used to train it, which presents the risk for errors	Medicine	The training of educational AI technologies should be diligent to ensure there is reduced risk for errors, etc
18	Lee [47]	2023	The Rise of ChatGPT: Exploring its Potential in Medical Education	Literature review	Korea	ChatGPT can provide incorrect and misleading information. There is the risk of over-reliance on AI, which, may lead to cheating. Ethical issues: Bias and discrimination resulting from the limited data used to train ChatGPT. Transparency and accountability	Medicine	Further research is needed to ensure the use of AI is done ethically and safely, while preserving academic integrity
19	Loh [43]	2023	ChatGPT and generative AI chatbots: challenges and opportunities for science, medicine and medical leaders	Literature review	Australia	Accuracy and reliability of information. Data privacy and confidentiality	Medicine	There must be a process in place to ensure the safe and ethical development of AI
20	Qi et al. [32]	2023	The promise and peril of ChatGPT in geriatric nursing education: What We know and do not know	Literature Review	USA	Risk of plagiarism and encouraging cheating. Misinformation. Increase digital inequalities. ChatGPT could lead to challenges in training critical thinkers, due to increasing availability of knowledge or information	Geriatric Nursing	N/A

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
21	Sallam [42]	2023	ChatGPT Utility in Healthcare Education, Research, and Practice: Systematic Review on the Promising Perspectives and Valid Concerns	Systematic Review	Jordan	Incorrect information. Ethical, transparency and privacy concerns. Lack of originality and copyright issues	General health	Collaborations needed to address the threats posed by ChatGPT
22	Sedaghat [31]	2023	Early applications of ChatGPT in medical practice, education and research	Literature Review	Germany	Potential for errors and misinformation in ChatGPT generated reports	Medicine	Further improvements need to ensure the safe use of ChatGPT in medical practice, education and research
23	Jo et al. [35]	2024	to compare the medical accuracy of GPT-4 with human experts in providing medical advice using real-world user-generated queries, with a specific focus on cardiology	Cross-sectional survey	Korea	Human experts outperformed GPT-4 in specific question categories, notably those related to drug or medication information and preliminary diagnoses. These findings highlight the limitations of GPT-4 in providing advice based on clinical experience	Cardiology	ChatGPT-4 hold significant potential in augmenting medical education, providing medical advice
Opportunities of ChatGPT in healthcare education								

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
24	Sallam [42]	2023	ChatGPT utility in healthcare education, research, and practice: systematic review on the promising perspectives and valid concerns	Systematic Review	Jordan	These benefits of ChatGPT includes improved scientific writing, enhanced research equity and versatility, utility in healthcare research (such as efficient data analysis and code generation), benefits in healthcare practice (streamlining workflows and improving health literacy), and benefits in healthcare education (personalized learning and critical thinking focus)	General health	An initiative involving all stakeholders in health care education, research, and practice is urgently needed. This will help to set a code of ethics to guide the responsible use of ChatGPT among other LLMs in health care and academia

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
25.	Garg et al. [65]	2023	Exploring the role of ChatGPT in patient care (diagnosis and treatment) and medical research: A systematic review	Systematic review	India	ChatGPT can assist with patient inquiries, note writing, decision-making, trial enrollment, data management, decision support, research support, and patient education	Medicine	Before deploying in a clinical setting, it is essential to ensure that the model can provide accurate and reliable information. The ChatGPT model should be continually updated and improved based on feedback from its users to rectify its limitations. Clear guidelines need to be developed for healthcare professionals and patients on when and how to use ChatGPT as a tool. Policies need to be created to protect patient data and privacy. Ethical guidelines should be developed to address the moral dilemmas that arise from using ChatGPT in healthcare
26	Lee [47]	2023	The rise of ChatGPT: Exploring its potential in medical education	Literature review	Republic of Korea	ChatGPT has the potential to increase student engagement and enhance learning, but further research is required to validate this	Medicine	Continued research and evaluation are necessary to ensure the optimal integration of AI- based learning tools into medical education

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
27	Javaid et al. [53]	2023	ChatGPT for health-care services: An emerging stage for an innovative perspective	Literature review	India	ChatGPT is beneficial for patients (virtual assistance, response to queries, help in education), database (record summarizing, updated information, predicting datasets), workflow (data interaction, comparison and training, proximal sampling, work optimization), and services (clinical decision systems, medication reminders, setting appointments, and remote monitoring)	Medicine	Training companies must collaborate with a solution provider that provides integrated learning platform solutions driven by generative AI and GPT to fully realise these technologies' potential. ChatGPT is improving the state of all AI technologies
28	Arslan [54]	2023	Exploring the Potential of Chat GPT in Personalized Obesity Treatment	Literature review	Turkey	Chat GPT can provide personalized recommendations on topics, such as nutrition plans, exercise programs, and psychological support	Obesity-related diseases	While further research is needed to fully understand the potential of Chat GPT in obesity treatment, the technology offers promising opportunities for personalized and effective weight management
29	Biswas [19]	2023	ChatGPT and the future of medical writing	Literature review	USA	By using NLP such as ChatGPT, medical writers can potentially create more accurate and consistent documents faster and with less efforts	Medicine	The use of ChatGPT in public health should be carefully considered and implemented with caution

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
30	Temsah et al. [55]	2023	Chatgpt and the future of digital health: a study on healthcare workers' perceptions and expectations	A cross-sectional survey	Saudi Arabia	ChatGPT is useful in various aspects of healthcare, such as medical decision-making (39.5%), patient and family support (44.7%), medical literature appraisal (48.5%), and medical research assistance (65.9%). A majority (76.7%) believed ChatGPT could positively impact the future of healthcare systems	General health	Future research should focus on evaluating the clinical outcomes of ChatGPT and benchmarking its performance against other AI Chatbots
31	Wang et al. [66]	2024	Exploring the Performance of ChatGPT-4 in the Taiwan Audiologist Qualification Examination: Preliminary Observational Study Highlighting the Potential of AI Chatbots in Hearing Care	Cross-sectional Survey	Taiwan	ChatGPT-4 has shown significant impact in Taiwan Audiologist Qualification Examination. Categories include 88% for basic auditory science, 63% for behavioral audiology, 58% for electrophysiological audiology, 72% for practice of hearing devices, 80% for health and rehabilitation and 86% for auditory and speech	Audiology	They recommended that in addition to ChatGPT adequate clinical internship hours are crucial requirement for the actual practice of audiology in Taiwan

Table 2 (continued)

No	Authors	Year	Title	Method	Country	Findings	Area of health Research	Recommendations
32	Ba et al. [67]	2024	Enhancing clinical skills in pediatric trainees: a comparative study of ChatGPT-assisted and traditional teaching methods	Cohort study	China	ChatGPT-assisted group showed a statistically significant improvement in in-patient communication and clinical judgment. The AI-teaching approach received positive feedback from the majority of trainees	Paediatrics	The exploration into the broader applications of AI in medical education scenarios
33	Thomae et al. [68]	2024	Integration of ChatGPT Into a Course for Medical Students: Explorative Study on Teaching Scenarios, Students' Perception, and Applications	Mixed Methods	Switzerland	AI-related competencies in medical curriculum were perceived as highly important by medical students. Students identified other potential uses of ChatGPT, supporting clinical practice and serving as a general information source	Medicine	Integration of ChatGPT enhanced learning experiences for medical students

Fig. 3 Health Areas of Chat-GPT Focus

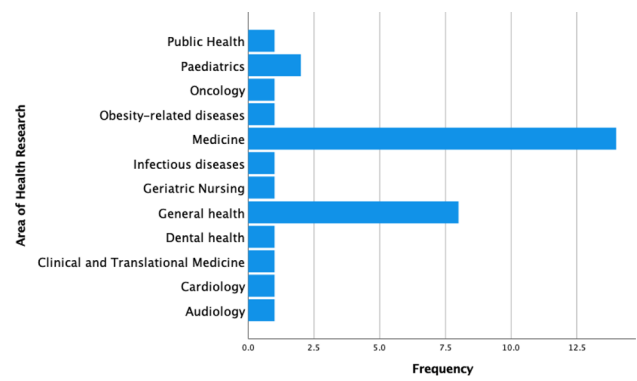


Fig. 4 Yearly Distribution of ChatGPT Research Studies

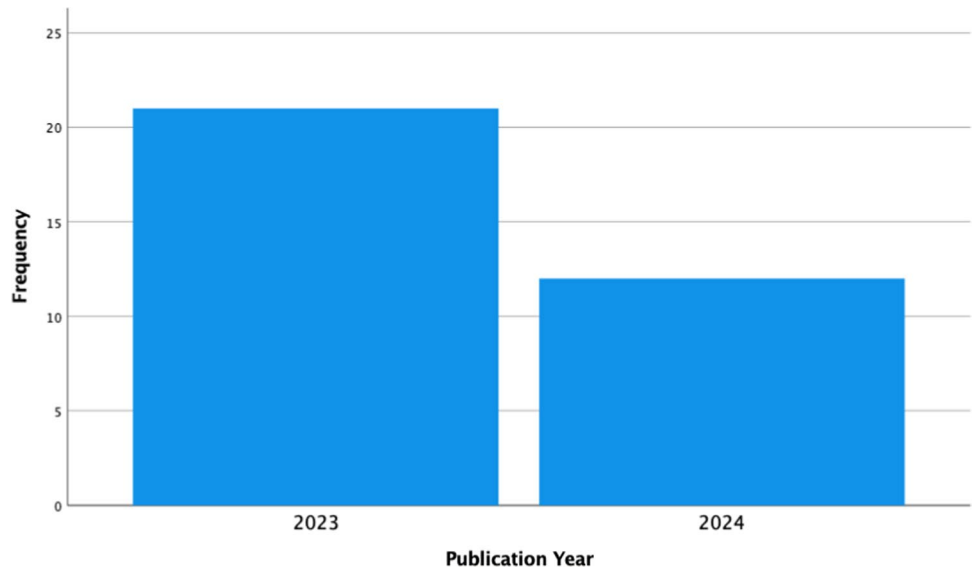
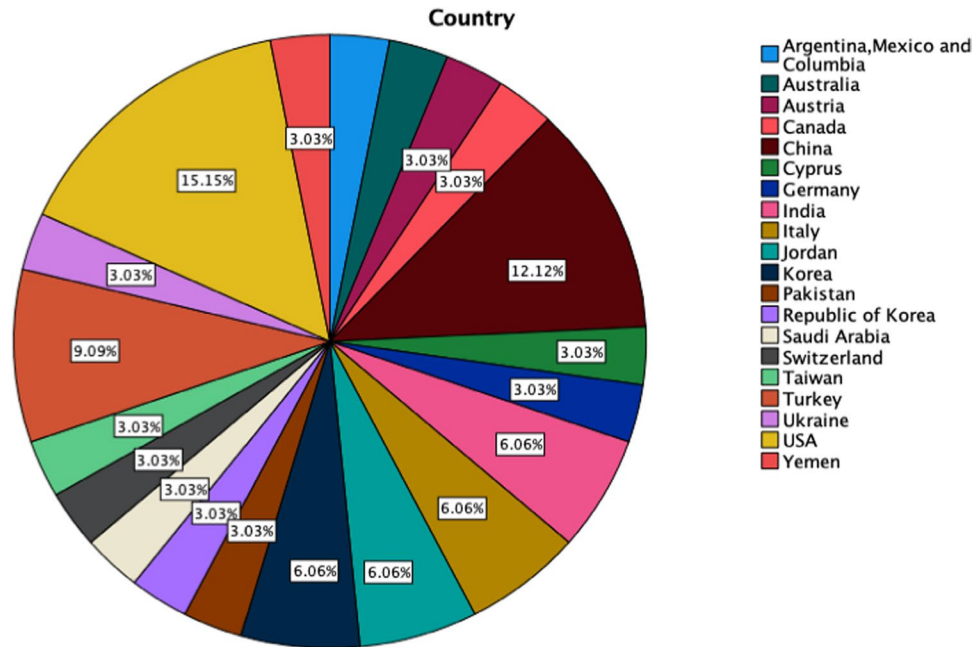


Fig. 5 Country-wise distribution of ChatGPT research studies



3.6 Global distribution of ChatGPT studies across income-level countries

ChatGPT research, comprising literature reviews and both qualitative and quantitative studies, has been conducted across various countries worldwide. The majority of these studies took place in upper-income and upper-middle-income countries, which have the resources and infrastructure to support advanced AI research. In total, studies were conducted in 33 countries, with the highest proportion occurring in the United States (15.2%), followed by China (12.1%) and Turkey (9.1%). Percentages for all other countries are presented in Fig. 5 below.

3.7 Study types and approaches in ChatGPT research

Most ChatGPT studies consist of literature reviews, comprising 48.5% of the total research, with qualitative studies following at 24.2%, particularly dominating studies conducted in 2024. Quantitative studies, which focus on statistical analyses to assess outcomes and impacts, represent 18.2%, making them the third most common approach. A detailed breakdown of study types is shown in Fig. 6 below.

4 Discussion

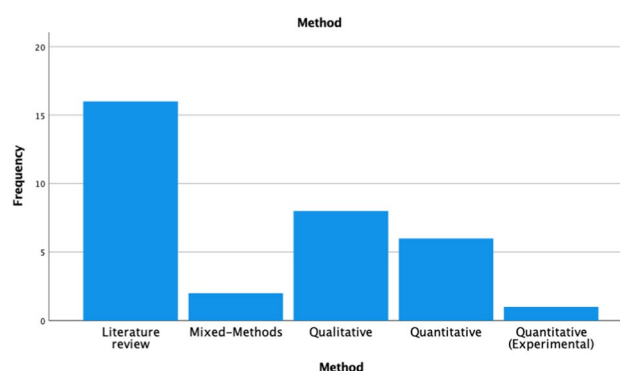
The findings underscore ChatGPT's transformative potential in healthcare education. As shown in this study, ChatGPT addresses significant educational gaps through its adaptability, accessibility, and ability to provide personalized learning.

4.1 Advantages of ChatGPT in healthcare education

The study highlights how ChatGPT, as an advanced AI tool, fills critical gaps in healthcare education by providing a virtual learning platform that is accessible, personalized, and scalable. In resource-constrained settings, where instructor shortages and limited clinical opportunities often impede healthcare education, ChatGPT functions as a virtual tutor that adapts to individual learning needs and allows students to engage with complex medical concepts [25, 27]. Furthermore, its ability to simulate patient interactions offers learners in areas with limited clinical facilities hands-on experiences that are crucial for developing diagnostic and communication skills [28]. By augmenting traditional education with these interactive simulations, ChatGPT bridges gaps in practical training.

The AI's multimedia integration is particularly beneficial for low-resource environments. Incorporating visual aids like images, videos, and diagrams makes learning more engaging and accessible for diverse learner groups [26]. Additionally, ChatGPT's multilingual functionality helps overcome language barriers, which is essential in many countries where healthcare instruction is often hampered by linguistic diversity [28]. Offering education in students' native languages expands access to healthcare knowledge, benefiting underserved communities and making medical information accessible to non-English-speaking populations.

Fig. 6 Frequency of research methods used in ChatGPT studies



4.2 Challenges and potential risks

Despite these advantages, the study identifies several risks associated with ChatGPT in healthcare education, particularly in developing nations. Language, cultural, and economic disparities raise concerns about the uniformity of AI-driven education [33]. ChatGPT's reliance on English-centric training data can impact the quality of translations, potentially missing cultural and contextual nuances essential for effective communication [34]. Additionally, ChatGPT's outputs may not always reflect region-specific healthcare practices, which could limit its relevance to localized health education needs [36].

The digital divide poses another barrier, as internet and technology accessibility in rural or low-income areas remains limited. This lack of access could exacerbate educational inequalities, leaving already disadvantaged communities further behind [34, 41]. Furthermore, ChatGPT's subscription-based model, particularly in its more advanced versions, could restrict access for those unable to afford premium features, deepening socioeconomic disparities in healthcare education [37].

Concerns about accuracy and information quality are particularly relevant in the high-stakes field of healthcare. Given ChatGPT's reliance on large datasets, some of which may include outdated or biased information, there is a risk of misinformation being disseminated to learners [44]. This could result in significant educational gaps, especially in situations where learners lack access to human experts who could validate or contextualize the AI-provided information.

4.3 Ethical considerations and data privacy

ChatGPT's integration into healthcare education also raises ethical considerations related to data privacy and the potential for over-reliance on AI. In countries without robust AI regulatory frameworks, concerns around student data privacy and consent become prominent [36]. The lack of international standards for AI use in education and healthcare complicates efforts to ensure responsible use, particularly in resource-limited settings where regulatory capacity may be weak. Additionally, ChatGPT's limitations in providing nuanced, personalized feedback may hinder its ability to replicate the human mentorship necessary for cultivating empathy, critical thinking, and professional growth in healthcare students [46].

4.4 Opportunities for responsible integration

To mitigate these challenges, there is a need for strategic, collaborative approaches that consider local contexts and invest in necessary infrastructure. With appropriate oversight, ChatGPT can complement traditional learning methods rather than replace them, enhancing educational access while preserving the role of human instructors. Collaboration with local governments, educational institutions, and international organizations could help bridge digital divides or GenAI-divide, making ChatGPT more accessible in under-resourced areas through subsidized programs or infrastructure development. Furthermore, targeted training data and regional adaptation could improve ChatGPT's relevance to local healthcare contexts, ensuring that AI-driven healthcare education remains culturally sensitive and practically applicable. Ensuring data quality and accuracy is crucial, as is the need for a regulatory framework to safeguard ethical use. With these measures in place, ChatGPT can become a powerful tool for advancing healthcare education, particularly in developing nations, preparing future professionals to meet the health needs of their communities.

The analysis of Table 1 and Fig. 3 reveals that while ChatGPT has been applied across various healthcare domains, certain critical areas remain underexplored. For instance, despite the high mortality rates associated with cardiovascular diseases, there is a notable paucity of research utilizing ChatGPT in cardiology. This gap underscores the necessity for future studies to encompass a broader spectrum of medical fields, ensuring that the potential benefits of ChatGPT are leveraged to address diverse healthcare challenges. The focus years for research in this current study were 2023–2024. This is understandable because research on ChatGPT peaked in 2024. This is likely to improve in coming years and cut across all disciplines; hence, the earlier ChatGPT is accepted and used responsibly, the better.

The current study also revealed that most of the studies conducted about ChatGPT and health care is concentrated in develop countries with most of the studies coming from USA and China which are the two top countries leading AI investment and research [32, 34, 57, 61]. Little to no studies are found in Africa on this area which demonstrate the paucity of research in technology and African healthcare education as far as advanced chatbots like ChatGPT is concern. Most of thses studies were more of qualitative and literature reviews [19, 32, 37]. there is a need for more quantitative studies, especially those experimental in nature to especially in ChatGPT application in the clinical and educational setting to enhance evidence in these areas.

5 Limitations

This review faced several limitations. First, the majority of existing studies on ChatGPT in healthcare education are conducted in developed countries, with limited representation from developing regions, especially Africa. This geographical disparity limits the generalizability of the findings and may overlook unique challenges faced by healthcare educators in under-resourced settings. Additionally, most studies were qualitative or review-based, highlighting a lack of empirical, quantitative research that could provide more robust evidence on ChatGPT's effectiveness. The reliance on English-centric databases may have also excluded relevant studies in other languages, which is a limitation considering the global scope of healthcare education.

6 Conclusion

The integration of ChatGPT in healthcare education presents both significant opportunities and notable challenges. While it has shown potential to enhance learning through accessibility, personalized experiences, and innovative teaching methods, there are also risks related to digital accessibility, data privacy, and potential cultural insensitivity. The findings suggest that, although ChatGPT can serve as a valuable educational tool, its implementation must be handled with caution, particularly in developing regions, to prevent exacerbating existing inequalities. Further research is essential to support the responsible integration of ChatGPT, ensuring it complements human-led teaching and remains sensitive to diverse educational needs.

6.1 Implications for research and practice

The findings underscore the need for more empirical studies, particularly experimental and quantitative research, to evaluate ChatGPT's impact on healthcare education outcomes comprehensively. Research should prioritize exploring ChatGPT's applicability across a broader spectrum of medical fields, such as cardiology and rural health, which are currently underexplored. Additionally, there is a clear need for studies that investigate ChatGPT's impact in low-resource settings, especially within African healthcare education, where studies are currently sparse. Such research would help to close the knowledge gap and adapt AI tools more effectively to diverse global contexts.

For healthcare educators and policymakers, the study suggests a need for strategic implementation of ChatGPT that respects local contexts and resources. In practice, this involves partnering with local institutions and governments to develop infrastructure and ensure equitable access to AI-enhanced educational tools. Additionally, incorporating regional adaptation features and training data sensitive to local healthcare practices can make ChatGPT more relevant and culturally appropriate. By taking these steps, healthcare education practitioners can leverage ChatGPT as a supplementary tool to traditional teaching, enhancing student learning experiences while addressing critical barriers in resource-constrained environments.

Author contribution All authors contributed to the study conception and design. .

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

References

1. Xu T, Weng H, Liu F, Yang L, Luo Y, Ding Z, Wang Q. Current status of ChatGPT use in medical education: potentials, challenges, and strategies. *J Med Internet Res*. 2024;26: e57896. <https://doi.org/10.2196/57896>.
2. Barbour AB, Frush JM, Gatta LA, McManigle WC, Keah NM, Bejarano-Pineda L, Guerrero EM. Artificial intelligence in health care: insights from an educational forum. *J Med Educ Curric Dev*. 2020;6:2382120519889348. <https://doi.org/10.1177/2382120519889348>.
3. Grunhut J, Wyatt AT, Marques O. Educating future physicians in artificial intelligence (AI): an integrative review and proposed changes. *J Med Educ Curric Dev*. 2021;8:23821205211036836.
4. Wong R-Y. ChatGPT in medical education: promoting learning or killing critical thinking? *Educ Med J*. 2024;16(2):177–83. <https://doi.org/10.2131/eimj2024.16.2.13>.
5. Harmon J, Pitt V, Summons P, Inder KJ. Use of artificial intelligence and virtual reality within clinical simulation for nursing pain education: a scoping review. *Nurse Educ Today*. 2021;97: 104700. <https://doi.org/10.1016/j.nedt.2020.104700>.
6. Lareyre F, Adam C, Carrier M, Chakfé N, Raffort J. Artificial intelligence for education of vascular surgeons. *Eur J Vasc Endovasc Surg*. 2020;59(6):870–1. <https://doi.org/10.1016/j.ejvs.2020.02.030>.
7. Ahuja AS, Polascik BW, Doddapaneni D, Byrnes ES, Sridhar J. The digital metaverse: applications in artificial intelligence, medical education, and integrative health. *Integr Med Res*. 2023;12(1): 100917. <https://doi.org/10.1016/j.imr.2022.100917>.
8. Gordon M, Daniel M, Ajiboye A, Uraiby H, Xu NY, Bartlett R, Hanson J, Haas M, Spadafore M, Grafton-Clarke C, Gasiea RY, Michie C, Corral J, Kwan B, Dolmans D, Thammasitboon S. A scoping review of artificial intelligence in medical education: BEME Guide No. 84. *Med Teacher*. 2024;46(4):446–70. <https://doi.org/10.1080/0142159X.2024.2314198>.
9. Chang I-C, Shih Y-S, Kuo K-M. Why would you use medical chatbots? Interview and survey. *Int J Med Inf*. 2022;165: 104827. <https://doi.org/10.1016/j.ijmedinf.2022.104827>.
10. Fryer LK, Nakao K, Thompson A. Chatbot learning partners: connecting learning experiences, interest and competence. *Comput Hum Behav*. 2019;93:279–89. <https://doi.org/10.1016/j.chb.2018.12.023>.
11. Lin Y, Yu Z. A bibliometric analysis of artificial intelligence chatbots in educational contexts. *Interact Technol Smart Educ*. 2023. <https://doi.org/10.1108/ITSE-12-2022-0165>.
12. Stathakourou N, Nifakos S, Karlgren K, Konstantinidis ST, Bamidis PD, Pattichis CS, Davoody N. Students' perceptions on chatbots' potential and design characteristics in healthcare education. *Stud Health Technol Inform*. 2020;272:209–12. <https://doi.org/10.3233/SHTI200531>.
13. Fadhil, A., & Gabrielli, S. (2017). Addressing challenges in promoting healthy lifestyles: The ai-chatbot approach. *Proceedings of the 11th EAI International Conference on Pervasive Computing Technologies for Healthcare*, 261–265. <https://doi.org/10.1145/3154862.3154914>.
14. Tilili A, Shehata B, Adarkwah MA, Bozkurt A, Hickey DT, Huang R, Agyemang B. What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. *Smart Learn Environ*. 2023;10(1):15. <https://doi.org/10.1186/s40561-023-00237-x>.
15. Mohammad-Rahimi H, Khoury ZH, Alamdari MI, Rokhshad R, Motie P, Parsa A, Tavares T, Sciubba JJ, Price JB, Sultan AS. Performance of AI chatbots on controversial topics in oral medicine, pathology, and radiology. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2024;137(5):508–14. <https://doi.org/10.1016/j.oooo.2024.01.015>.
16. Lund BD, Wang T. Chatting about ChatGPT: How may AI and GPT impact academia and libraries? *Library Hi Tech News*. 2023. <https://doi.org/10.1108/LHTN-01-2023-0009>.
17. Dwivedi YK, Kshetri N, Hughes L, Slade EL, Jeyaraj A, Kar AK, Baabdullah AM, Koohang A, Raghavan V, Ahuja M, Albanna H, Albashrawi MA, Al-Busaidi AS, Balakrishnan J, Barlette Y, Basu S, Bose I, Brooks L, Buhalis D, Wright R. "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy. *Int J Inf Manag*. 2023. <https://doi.org/10.1016/j.ijinfomgt.2023.102642>.
18. Thorp HH. ChatGPT is fun, but not an author. *Science*. 2023;379(6630):313–313. <https://doi.org/10.1126/science.adg7879>.
19. Biswas SS. Role of chat GPT in public health. *Ann Biomed Eng*. 2023. <https://doi.org/10.1007/s10439-023-03172-7>.
20. Bettayeb AM, Abu Talib M, Sobhe Altayasinah AZ, Dakalbab F. Exploring the impact of ChatGPT: conversational AI in education. *Front Educ*. 2024. <https://doi.org/10.3389/educ.2024.1379796>.
21. Yang SJH, Ogata H, Matsui T, Chen N-S. Human-centered artificial intelligence in education: Seeing the invisible through the visible. *Comput Educ: Artif Intell*. 2021;2: 100008. <https://doi.org/10.1016/j.caeai.2021.100008>.
22. Baidoo-Anu, D., & Owusu Ansah, L. (2023). Education in the Era of Generative Artificial Intelligence (AI): Understanding the Potential Benefits of ChatGPT in Promoting Teaching and Learning (SSRN Scholarly Paper 4337484). <https://doi.org/10.2139/ssrn.4337484>.
23. Rudolph J, Tan S, Tan S. ChatGPT: Bullshit spewer or the end of traditional assessments in higher education? *J Appl Learn Teach*. 2023;6(1):1. <https://doi.org/10.3707/jalt.2023.6.1.9>.
24. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*. 2005;8(1):19–32. <https://doi.org/10.1080/1364557032000119616>.
25. Safranek CW, Sidamon-Eristoff AE, Gilson A, Chartash D. The role of large language models in medical education: applications and implications. *JMIR Med Educ*. 2023;9: e50945.
26. Wang, H., Wu, W., Dou, Z., He, L., & Yang, L. (2023). Performance and exploration of ChatGPT in medical examination, records and education in Chinese: Pave the way for medical AI. *International Journal of Medical Informatics*, 177, 105173. <https://doi.org/10.1016/j.ijmedinf.2023.105173>.
27. Mhlanga, D. (2023). ChatGPT in Education: Exploring Opportunities for Emerging Economies to Improve Education with ChatGPT. Available at SSRN.
28. Liu, J., & Liu, S. (2023). The application of ChatGPT in medical education.
29. Dirckinck-Holmfeld L, Bygholm A, Tabo GO. Transforming education through ICT: exploring students study practices in a resource-constrained university setting. *Br J Educ Technol*. 2023. <https://doi.org/10.1111/bjet.13367>.
30. Khan RA, Jawaid M, Khan AR, Sajjad M. ChatGPT - reshaping medical education and clinical management. *Pak J Med Sci*. 2023;39(2):605. <https://doi.org/10.1266/PJMS.39.2.7653>.

31. Sedaghat S. Early applications of ChatGPT in medical practice, education and research. *Clin Med*. 2023;23(3):1–2. <https://doi.org/10.7861/CLINMED.2023-0078>.
32. Qi X, Zhu Z, Wu B. The promise and peril of ChatGPT in geriatric nursing education: what we know and do not know. *Aging Health Res*. 2023;3(2): 100136. <https://doi.org/10.1016/J.AHR.2023.100136>.
33. Farrokhnia M, Banihashem SK, Noroozi O, Wals A. A SWOT analysis of ChatGPT: implications for educational practice and research. *Innov Educ Teach Int*. 2023;00(00):1–15. <https://doi.org/10.1080/14703297.2023.2195846>.
34. Cheng K, Li Z, He Y, Guo Q, Lu Y, Gu S, Wu H. Potential use of artificial intelligence in infectious disease: take ChatGPT as an example. *Ann Biomed Eng*. 2023;51:1130–5. <https://doi.org/10.1007/S10439-023-03203-3>.
35. Baumgartner C. The opportunities and pitfalls of ChatGPT in clinical and translational medicine. *Clin Transl Med*. 2023;13(3):2–5. <https://doi.org/10.1002/ctm2.1206>.
36. Kasneci E, Sessler K, Küchemann S, Bannert M, Dementieva D, Fischer F, Gasser U, Groh G, Günemann S, Hüllermeier E, Krusche S, Kutyniok G, Michaeli T, Nerdel C, Pfeffer J, Poquet O, Sailer M, Schmidt A, Seidel T, Kasneci G. ChatGPT for good? on opportunities and challenges of large language models for education. *Learn Individ Differ*. 2023;103: 102274. <https://doi.org/10.1016/J.LINDIF.2023.102274>.
37. Corsello A, Santangelo A. May artificial intelligence influence future pediatric research?-the case of ChatGPT. *Children*. 2023;10(757):1–5. <https://doi.org/10.3390/CHILDREN10040757>.
38. Adarkwah MA. “I’m not against online teaching, but what about us?”: ICT in Ghana post Covid-19. *Educ Inf Technol*. 2021;26(2):1665–85. <https://doi.org/10.1007/S10639-020-10331-Z/FIGURES/1>.
39. Cullinan J, Flannery D, Harold J, Lyons S, Palcic D. The disconnected: COVID-19 and disparities in access to quality broadband for higher education students. *Int J Educ Technol High Educ*. 2021;18(1):1–21. <https://doi.org/10.1186/S41239-021-00262-1/TABLES/3>.
40. Heeks R. Digital inequality beyond the digital divide: conceptualizing adverse digital incorporation in the global South. *Inf Technol Dev*. 2022;28(4):688–704. <https://doi.org/10.1080/02681102.2022.2068492>.
41. Imran A. Why addressing digital inequality should be a priority. *E J Inf Syst Dev Countries*. 2023. <https://doi.org/10.1002/ISD2.12255>.
42. Sallam M. ChatGPT utility in healthcare education, research, and practice: systematic review on the promising perspectives and valid concerns. *Healthcare*. 2023;11(887):1–20. <https://doi.org/10.3390/HEALTHCARE11060887>.
43. Athaluri SA, Manthena SV, Kesapragada VSRKM, Yarlagadda V, Dave T, Duddumpudi RTS. Exploring the boundaries of reality: investigating the phenomenon of artificial intelligence hallucination in scientific writing through ChatGPT references. *Cureus*. 2023;15(4):1–5. <https://doi.org/10.7759/CUREUS.37432>.
44. Loh E. ChatGPT and generative AI chatbots: challenges and opportunities for science, medicine and medical leaders Commentary. *BMJ Leader*. 2023. <https://doi.org/10.1136/leader-2023-000797>.
45. Eysenbach G. The role of ChatGPT, generative language models, and artificial intelligence in medical education: a conversation with ChatGPT and a call for papers. *JMIR Med Educ*. 2023. <https://doi.org/10.2196/46885>.
46. Burgess A, van Diggele C, Roberts C, Mellis C. Feedback in the clinical setting. *BMC Med Educ*. 2020;20(2):1–5. <https://doi.org/10.1186/S12909-020-02280-5/TABLES/3>.
47. Chaika O. The role of artificial intelligence in higher education. *Молодь і ринок*. 2023;6(214):69–74.
48. De Angelis L, Baglivo F, Arzilli G, Privitera GP, Ferragina P, Tozzi AE, Rizzo C. ChatGPT and the rise of large language models: the new AI-driven infodemic threat in public health. *Front Public Health*. 2023;11(1166120):1–8. <https://doi.org/10.2139/ssrn.4352931>.
49. Lee H. The rise of ChatGPT: exploring its potential in medical education. *Anat Sci Educ*. 2023;00:1–6. <https://doi.org/10.1002/ASE.2270>.
50. Dave T. ChatGPT in medicine : an overview of its applications, advantages, limitations, future prospects, and ethical considerations. *Front Artif Intell*. 2023. <https://doi.org/10.3389/frai.2023.1169595>.
51. Zheng L, Zhong L, Niu J. Effects of personalised feedback approach on knowledge building, emotions, co-regulated behavioural patterns and cognitive load in online collaborative learning. *Assess Eval Higher Educ* ISSN. 2022;47(1):109–25. <https://doi.org/10.1080/02602938.2021.1883549>.
52. Koo M. The importance of proper use of ChatGPT in medical writing. *Radiology*. 2023. <https://doi.org/10.1148/radiol.230312>.
53. Wang X, Zhang L, He T. Learning performance prediction-based personalized feedback in online learning via machine learning. *Sustainability*. 2022. <https://doi.org/10.3390/SU14137654>.
54. Javaid M, Haleem A, Singh RP. ChatGPT for healthcare services: an emerging stage for an innovative perspective. *BenchCouncil Trans Benchmarks Stand Eval*. 2023;3(1): 100105.
55. Arslan S. Exploring the potential of Chat GPT in personalized obesity treatment. *Ann Biomed Eng*. 2023. <https://doi.org/10.1007/s10439-023-03227-9>.
56. Temsah MH, Aljamaan F, Malki KH, Alhasan K, Altamimi I, Aljarbou R, Al-Eyadhy A. Chatgpt and the future of digital health: a study on healthcare workers’ perceptions and expectations. *Healthcare*. 2023;11(13):1812.
57. Yiğit S, Berşe S, Dirgar E, Gülhan GS. Views of health sciences undergraduates on ChatGPT, an artificial intelligence-powered language model: a qualitative study. *Innov Educ Teach Int*. 2024;14:1–5.
58. Mheidly N. Unleashing the power of AI: assessing the reliability of ChatGPT in disseminating breast cancer awareness. *J Educ Health Promotion*. 2024;13(1):172.
59. Cherez-Ojeda I, Gallardo-Bastidas JC, Robles-Velasco K, Osorio MF, Velez Leon EM, Leon Velastegui M, Pauletto P, Aguilar-Díaz FC, Squassi A, González Eras SP, Cordero CE. Understanding health care students’ perceptions, beliefs, and attitudes toward ai-powered language models: cross-sectional study. *JMIR Med Educ*. 2024;13(10): e51757.
60. Al-Worafi YM, Goh KW, Hermansyah A, Tan CS, Ming LC. The use of ChatGPT for education modules on integrated pharmacotherapy of infectious disease: educators’ perspectives. *JMIR Med Educ*. 2024;10(1): e47339.
61. Kavarella A, Da Silva MA, Kaklamanos EG, Stamatiopoulos V, Giannakopoulos K. Evaluation of ChatGPT’s real-life implementation in undergraduate dental education: mixed methods study. *JMIR Med Educ*. 2024;10(1): e51344.
62. Lin JC, Kurapati SS, Younessi DN, Scott IU, Gong DA. Ethical and professional decision-making capabilities of artificial intelligence chatbots: evaluating ChatGPT’s professional competencies in medicine. *Med Sci Educ*. 2024;34(2):331–3.
63. Gülhan Güner S, Yiğit S, Berşe S, Dirgar E. Perspectives and experiences of health sciences academics regarding ChatGPT: a qualitative study. *Med Teach*. 2024;11:1.

64. Kazley AS, Andresen C, Mund A, Blankenship C, Segal R. Is use of ChatGPT cheating? Students of health professions perceptions. *Med Teach*. 2024. <https://doi.org/10.1080/0142159X.2024.2385667>.
65. Jo E, Song S, Kim JH, Lim S, Kim JH, Cha JJ, Joo HJ. Assessing GPT-4's performance in delivering medical advice comparative analysis with human experts. *JMIR Med Educ*. 2024;10(1):e51282.
66. Garg RK, Urs VL, Agarwal AA, Chaudhary SK, Paliwal V, Kar SK. Exploring the role of ChatGPT in patient care (diagnosis and treatment) and medical research: a systematic review. *Health Promot Perspect*. 2023;13(3):183.
67. Wang S, Mo C, Chen Y, Dai X, Wang H, Shen X. Exploring the performance of ChatGPT-4 in the taiwan audiologist qualification examination: preliminary observational study highlighting the potential of AI Chatbots in hearing care. *JMIR Med Educ*. 2024;10(1): e55595.
68. Ba H, Zhang L, Yi Z. Enhancing clinical skills in pediatric trainees: a comparative study of ChatGPT-assisted and traditional teaching methods. *BMC Med Educ*. 2024;24(1):558.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.