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Original Article

Bibliometric top ten healthcare-related ChatGPT publications in the first ChatGPT anniversary

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Abstract

Since its public release on November 30, 2022, ChatGPT has shown promising potential in diverse healthcare applications despite ethical challenges, privacy issues, and possible biases. The aim of this study was to identify and assess the most influential publications in the field of ChatGPT utility in healthcare using bibliometric analysis. The study employed an advanced search on three databases, Scopus, Web of Science, and Google Scholar, to identify ChatGPT-related records in healthcare education, research, and practice between November 27 and 30, 2023. The ranking was based on the retrieved citation count in each database. The additional alternative metrics that were evaluated included (1) Semantic Scholar highly influential citations, (2) PlumX captures, (3) PlumX mentions, (4) PlumX social media and (5) Altmetric Attention Scores (AASs). A total of 22 unique records published in 17 different scientific journals from 14 different publishers were identified in the three databases. Only two publications were in the top 10 list across the three databases. Variable publication types were identified, with the most common being editorial/commentary publications (n=8/22, 36.4%). Nine of the 22 records had corresponding authors affiliated with institutions in the United States (40.9%). The range of citation count varied per database, with the highest range identified in Google Scholar (1019–121), followed by Scopus (242–88), and Web of Science (171–23). Google Scholar citations were correlated significantly with the following metrics: Semantic Scholar highly influential citations (Spearman's correlation coefficient $\rho=0.840$, $p<0.001$), PlumX captures ($\rho=0.831$, $p<0.001$), PlumX mentions ($\rho=0.609$, $p=0.004$), and AASs ($\rho=0.542$, $p=0.009$). In conclusion, despite several acknowledged limitations, this study showed the evolving landscape of ChatGPT utility in healthcare. There is an urgent need for collaborative initiatives by all stakeholders involved to establish guidelines for ethical, transparent, and responsible use of ChatGPT in healthcare. The study revealed the correlation between citations and alternative metrics, highlighting its usefulness as a supplement to gauge the impact of publications, even in a rapidly growing research field.

Keywords: ChatGPT in healthcare, bibliometric analysis, citation metric, publication impact, generative AI in healthcare

Introduction

The accelerated advancement in generative artificial intelligence (AI) could have a transformative impact on different scientific and societal aspects [1-3]. In particular, the utility of AI-based conversational chatbots can be paradigm-shifting in healthcare [4-6]. Consequently, the

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integration of generative AI models in healthcare education, research, and practice offers unique and unprecedented transformative opportunities [7,8]. For example, AI-based models can help in data analysis, refinement of clinical decision-making, and improving personalized medicine and health literacy [7,9-11]. Additionally, integration of the generative AI models in healthcare settings can help streamline the workflow with subsequent efficient and cost-effective delivery of timely care [7,9,12]. In healthcare education, AI-based conversational chatbots can offer personalized learning tailored to individual student needs and simulate complex medical scenarios for training purposes at lower costs [7,13-15]. The growing prevalence of generative AI use among university students and educators illustrates the expanding opportunities presented by this technology [16-18]. In healthcare-related research, AI-based models can aid in organizing and analyzing massive datasets with expedited novel insights, besides the ability to aid in medical writing [7,19,20].

Since its public release on November 30, 2022, ChatGPT, developed by OpenAI (San Francisco, California, US), has emerged as the prime, popular, and widely used example of AI-based conversational models. The wide use of ChatGPT was highlighted in various studies that investigated its utility and applications in healthcare [7,21]. ChatGPT demonstrated considerable potential in various healthcare-related applications based on its perceived usefulness and ease of use [7,16,21]. Applications of ChatGPT in healthcare that have been identified so far include facilitating health professional-patient interactions, helping in medical documentation, assisting in various research aspects, and offering medical education support [7,9,22-24].

The recent rapid increase in the number of studies exploring the potential of ChatGPT in healthcare demonstrates its potential positive impact in this research field [7,9,25,26]. However, several studies highlighted valid concerns and weaknesses that should be addressed for the successful and responsible use of ChatGPT in healthcare [7,9,20]. These limitations are mainly related to ethics, privacy, cybersecurity issues, and potential biases in ChatGPT algorithms [7,9,27]. Therefore, it is crucial to address ChatGPT-related concerns to ensure the safe, responsible, ethical, and effective utilization of this generative AI model in healthcare [7,9,28].

Bibliometric analysis is a helpful and widely used approach to assess the impact and trends of academic literature [29-31]. The investigation of bibliographic data involves tracking several metrics of scientific records, such as citation counts, authorship features, and publication outreach; thereby, bibliometric analysis can provide valuable insights into the impact and trends of research within a specific scientific field [32]. Several bibliometrics measures are currently used to assess the impact and outreach of publications [29]. For example, the Semantic Scholar (SS) highly influential citations (HICs) tool can be used to highlight references that have a significant impact on the citing publication [33,34]. Another measure is the PlumX from Plum Analytics (Philadelphia, Pennsylvania, US), which offers the following metrics to highlight a publication impact [35-39]: (1) The “PlumX Captures” metric measures engagement with a publication via tracking publication downloads, saves, and bookmarks; (2) the “PlumX Mentions” metric which shows the publication relevance in society highlighted by the frequency of publication use by various digital media platforms; (3) the “PlumX Social Media” metric which assesses the social media interactions [40]. In addition, the Altmetric Attention Score (AAS) (Altmetric Limited, London, UK) aggregates attention across diverse platforms with different weights of different sources, indicating the publication's social and news impact [41-43].

The use of bibliometric analysis can be a valuable tool to systematically map the landscape of research tackling ChatGPT applications in healthcare [25]. The potential insights of bibliometric analysis can provide an overview of the key research themes and influential publications within an emerging and swiftly evolving research subject, namely AI in healthcare [44]. Additionally, bibliometric analysis can help to identify gaps in research and shape the trajectory of ongoing and future studies addressing the utility of ChatGPT in healthcare [25,45,46].

Therefore, the aim of this study was to conduct a bibliometric analysis to identify and assess the most influential publications addressing ChatGPT utility in healthcare. To achieve this aim, this study relied on a systematic search across prominent and widely used scientific databases (i.e., Scopus, Web of Science, and Google Scholar), with the search process coinciding with the first anniversary of ChatGPT public release [47,48]. A robust bibliometric analysis in publications can offer valuable insights into the research trends involving ChatGPT applications and challenges in healthcare. Bibliometric analysis can also help to identify the topics that received the most attention from researchers, media, and the general public. Additionally, the identification of the most influential publications in this growing field can help delineate the current and future research priorities, which in turn can help facilitate the successful integration of AI technologies, including ChatGPT, in healthcare.

Methods

Study design

This descriptive bibliometric analysis study was designed to identify and analyze the top publications addressing ChatGPT utility in healthcare that were published over a period of one year. The classification was based on the citation counts in three academic databases (Scopus, Web of Science, and Google Scholar). These scientific databases were selected based on their extensive coverage of scholarly literature, including healthcare and technology [47,48]. While PubMed/MEDLINE is considered a significant and widely-used academic database in healthcare research, the decision to exclude this relevant database from the search process was based on the lack of a clear feature for direct retrieval of citation counts in PubMed/MEDLINE. The search process concluded on November 30, 2023, ensuring the inclusion of all relevant publications up to the first anniversary of ChatGPT's public release [21].

Detailed search strategies

In Scopus, the search strategy focused on the article title, abstract, and keywords. The exact search string was as follows: (TITLE-ABS-KEY ("ChatGPT" OR "GPT-3" OR "GPT-3.5" OR "GPT-4") AND TITLE-ABS-KEY ("healthcare" OR "medical" OR "health care")). The search in Scopus was conducted at 11:08 GMT on November 27, 2023. For the Web of Science database, the search was conducted using the topic search (TS) field. The exact search was as follows: TS=("ChatGPT" OR "GPT-3" OR "GPT-3.5" OR "GPT-4") AND TS=("healthcare" OR "health care"). This search was completed at 11:27 GMT on November 27, 2023. The Google Scholar search was conducted using the Publish or Perish software (Version 8) [49]. The search covered the years 2022–2023 and was concluded at 10:36 GMT on November 27, 2023. In the "Title words" function of the software, the following search terms were used: ("ChatGPT" OR "GPT-3" OR "GPT-3.5" OR "GPT-4") AND ("healthcare" OR "health care").

The data from the three databases were retrieved separately as comma-separated values (CSV) files, and the results were sorted based on citation counts in descending order. Then, the top 10 records in each database were identified based on the screening of the title and abstract. For inclusion in this study, the record must have evaluated any aspect of ChatGPT applications in healthcare education, research, or practice [7].

Data on the 2022 journal impact factor was obtained via the Clarivate Journal Citation Reports [50], while the 2022 CiteScore data were obtained directly from Scopus [51].

Alternative metrics retrieval

For the top ten records identified in each database, a manual search for the alternative metrics was conducted. These alternative metrics included (1) the highly influential citations (SS HICs) identified through Semantic Scholar [52]; the PlumX metrics were sourced from Scopus [40,51]; and the Altmetric Attention Scores (AASs) were procured directly from each respective record if available [41]. The SS HICs are citations characterized by having a significant impact on the citing record. The determination of HICs was performed by a machine-learning model that analyzed multiple factors, including the frequency of citations and the context in which the reference was used [52,53]. Each unique record title was manually entered into the Semantic Scholar search tool, and the corresponding Semantic Scholar HICs metric were retrieved directly for each title as of November 30, 2023.

For the PlumX metrics, the "PlumX Captures" tracks and aggregates the frequency of downloads, saves, or bookmarks of a record, giving an indication of engagement in the scientific community [40]. The "PlumX Mentions" is a metric that assesses the frequency with which a publication is being mentioned or referenced in news media, blogs, and Wikipedia, reflecting the broader societal engagement [40]. The "PlumX Social Media" metric assesses social media engagement via tracking shares, likes, posts, and other forms of social media interactions to measure the publication visibility and impact in social media (e.g., Vimeo, Facebook, Amazon, Goodreads, SourceForge, YouTube, and Figshare) [40]. The PlumX metrics were retrieved manually through individual entry of each unique record title into the Scopus search tool. This was followed by a manual inspection of the PlumX metrics for each record under the Scopus sub-title "Metrics" for each record on November 30, 2023. The AAS is a composite metric by Altmetric Limited (London, UK) that measures the attention received by a publication across various social media and digital platforms, including news media, social media, policy documents, and online forums, reflecting broad visibility [41,43]. The AAS for each unique record was manually retrieved from the central position of the Altmetric donut on each publication page on November 30, 2023.

To unify the final comparisons, Google Scholar citations, as of November 30, 2023, were used for the final included publications, with data retrieved directly from Google Scholar for each publication approximately between 11:00 and 12:00 GMT. This decision was made since all the retrieved records were available on Google Scholar with the exception of a single reference, for which the citation count was obtained directly through Crossref (Lynnfield, Massachusetts, US) on the publication website [54].

Statistical and data analysis

The statistical analysis was conducted using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp, New York, US). The level of statistical significance was p=0.05. Correlations between the citation counts and the alternative metrics were assessed using Kendall's tau-b (τb) correlation coefficient and Spearman's rank-order correlation coefficient (ρ) based on the non-normality of metrics for the majority of variables as assessed using the Shapiro-Wilk test. The correlation between publication metrics as scale variables and the region of the corresponding authors was measured using the Kruskal-Wallis H (K-W) test.

Results

Top 10 records in Scopus, Web of Science, and Google Scholar by citation count

The top 10 identified records in Scopus varied in citation count from 242 to 88 citations (**Table 1**). Based on the first affiliations of the corresponding authors, the records were mostly US-based (n=5, 50%). Record types varied from editorial/comment (n=3, 30%), special/brief report or perspective (n=3, 30%), original article/investigation (n=2, 20%), and review (n=2, 20%). The 10 records were published in nine different scientific journals, with 2022 CiteScores ranging from 0.9 to 134.4, and the journals were published by nine different publishers (**Table 1**).

The top 10 identified records in Web of Science varied in citation count from 171 to 23 citations (**Table 2**). Based on the first affiliations of the corresponding authors, the records were varied, with two being US-based (n=2/9, 22.2%) and two being India-based (n=2/9, 22.2%) records. Record types varied and included editorial/comment (n=4, 40%), review (n=3, 30%), original article (n=2, 20%), and a brief report (n=1, 10%). The 10 records were published in 8 different scientific journals with a 2022 impact factor ranging from 1.2 to 82.9, and the journals were published by 6 different publishers.

The top 10 identified records in Google Scholar varied in citation count from 1019 to 121 citations (**Table 3**). Based on the first affiliations of the corresponding authors, the records were variable, with three US-based (30%) and two Italy-based (20%) records. Record types varied, including editorial/comment (n=4, 40%), brief report/perspective/special communication (n=3, 30%), original article (n=2, 20%), and a review (n=1, 10%). The 10 records were published in 8 different scientific journals, and the journals were published by 8 different publishers.

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Table 1. Top ten ChatGPT records in healthcare in the Scopus database

Authors	Title	Scopus citation count	Record type	Affiliation and country of the corresponding author	Journal, (CiteScore), publisher
Sallam [7]	ChatGPT utility in healthcare education, research, and practice: Systematic review on the promising perspectives and valid concerns	242	Review	The University of Jordan, Jordan	Healthcare (Switzerland), (2.7), MDPI
Gilson *et al.* [55]	How does ChatGPT perform on the United States Medical Licensing Examination? The implications of large language models for medical education and knowledge assessment	225	Article	Yale University, US	JMIR Medical Education, (5.0), JMIR Publications Inc.
Lee *et al.* [56]	Benefits, limits, and risks of GPT-4 as an AI chatbot for medicine	174	Special report	Microsoft Research, US	New England Journal of Medicine, (134.4), Massachusetts Medical Society
Shen *et al.* [57]	ChatGPT and other large language models are double-edged swords	157	Editorial	New York University, US	Radiology, (34.2), Radiological Society of North America Inc.
Patel and Lam [22]	ChatGPT: The future of discharge summaries?	145	Comment	St Mary's Hospital, UK	The Lancet Digital Health, (33.1), Elsevier Ltd
Liebrenz *et al.* [58]	Generating scholarly content with ChatGPT: Ethical challenges for medical publishing	131	Comment	University of Bern, Switzerland	The Lancet Digital Health, (33.1), Elsevier Ltd
Ayers *et al.* [59]	Comparing physician and artificial intelligence chatbot responses to patient questions posted to a public social media forum	129	Original Investigation	University of California, US	JAMA Internal Medicine, (43.2), American Medical Association
Biswas [60]	ChatGPT and the future of medical writing	124	Perspective	University of Tennessee, US	Radiology, (34.2), Radiological Society of North America Inc.
Cascella *et al.* [61]	Evaluating the feasibility of ChatGPT in healthcare: An analysis of multiple clinical and research scenarios	112	Brief report	University of Parma, Italy	Journal of Medical Systems, (11.8), Springer
Ray [62]	ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope	88	Review	Sikkim University, India	Internet of Things and Cyber-Physical Systems, (0.9), KeAi Communications Co.

AI: artificial intelligence

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Table 2. Top ten ChatGPT records in healthcare in the Web of Science database

Authors	Title	Web of Science Core citation count	Record type	Country of the corresponding author	Journal, (impact factor), publisher
Sallam [7]	ChatGPT utility in healthcare education, research, and practice: Systematic review on the promising perspectives and valid concerns	171	Review	The University of Jordan, Jordan	Healthcare (Switzerland), (2.8), MDPI
Alkaissi and McFarlane [63]	Artificial hallucinations in ChatGPT: Implications in scientific writing	102	Editorial	Kings County Hospital Center, US	Cureus Journal of Medical Science, (1.2), Springer
Cascella *et al.* [61]	Evaluating the feasibility of ChatGPT in healthcare: An analysis of multiple clinical and research scenarios	78	Brief report	University of Parma, Italy	Journal of Medical Systems, (5.3), Springer
Nature Medicine Editorial [54]	Will ChatGPT transform healthcare?	48	Editorial	NA	Nature Medicine, (82.9), Nature portfolio
Korngiebel and Mooney [64]	Considering the possibilities and pitfalls of Generative Pre-trained Transformer 3 (GPT-3) in healthcare delivery	45	Comment	The Hastings Center Garrison, US	npj Digital Medicine, (15.2), Nature Research
Dave *et al.* [23]	ChatGPT in medicine: An overview of its applications, advantages, limitations, future prospects, and ethical considerations	34	Review	Bukovinian State Medical University, Ukraine	Frontiers in Artificial Intelligence, (4.0), Frontiers Media SA
Vaishya *et al.* [65]	ChatGPT: Is this version good for healthcare and research?	31	Article	Indraprastha Apollo Hospitals, India	Diabetes and Metabolic Syndrome-Clinical Research and Reviews, (10.0), Oxford University Press
Hopkins *et al.* [66]	Artificial intelligence chatbots will revolutionize how cancer patients access information: ChatGPT represents a paradigm-shift	26	Commentary	Flinders University, Australia	JNCI Cancer Spectrum, (4.4), Oxford University Press
Sinha *et al.* [67]	Applicability of ChatGPT in assisting to solve higher order problems in pathology	24	Article	All India Institute of Medical Sciences, India	Cureus Journal of Medical Science, (1.2), Springer
Temsah *et al.* [68]	Overview of early ChatGPT's presence in medical literature: Insights from a hybrid literature review by ChatGPT and human experts	23	Review	Universiti Sains Malaysia, Malaysia	Cureus Journal of Medical Science, (1.2), Springer

Table 3. Top ten ChatGPT records in healthcare in the Google Scholar database

Authors	Title	GS citation count	Record type	Country of the corresponding author	Journal, publisher
Kung *et al.* [69]	Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models	1019	Article	AnsibleHealth, Inc Mountain View, US	PLOS Digital Health, PLOS
Sallam [7]	ChatGPT utility in healthcare education, research, and practice: Systematic review on the promising perspectives and valid concerns	523	Review	The University of Jordan, Jordan	Healthcare (Switzerland), MDPI
Gilson *et al.* [55]	How does ChatGPT perform on the United States Medical Licensing Examination? The implications of large language models for medical education and knowledge assessment	430	Article	Yale University, US	JMIR Medical Education, JMIR Publications Inc.
Shen *et al.* [57]	ChatGPT and other large language models are double-edged swords	309	Editorial	New York University, US	Radiology, Radiological Society of North America Inc.
Patel and Lam [22]	ChatGPT: The future of discharge summaries?	255	Comment	St Mary's Hospital, UK	The Lancet Digital Health, Elsevier Ltd
Liebrenz *et al.* [58]	Generating scholarly content with ChatGPT: Ethical challenges for medical publishing	255	Comment	University of Bern, Switzerland	The Lancet Digital Health, Elsevier Ltd
Cascella *et al.* [61]	Evaluating the feasibility of ChatGPT in healthcare: An analysis of multiple clinical and research scenarios	249	Brief report	University of Parma, Italy	Journal of Medical Systems, Springer
Khan *et al.* [70]	ChatGPT - reshaping medical education and clinical management	180	Special Communication	PharmEvo (Pvt) Ltd, Pakistan	Pakistan Journal of Medical Sciences, Professional Medical Publications
Eysenbach [14]	The role of ChatGPT, generative language models, and artificial intelligence in medical education: A conversation with ChatGPT and a call for papers	179	Editorial	JMIR Publications, Canada	JMIR Medical Education, JMIR Publications Inc.
De Angelis *et al.* [71]	ChatGPT and the rise of large language models: The new AI-driven infodemic threat in public health	121	Perspective	University of Pisa, Italy	Frontiers in Public Health, Frontiers Media SA

AI: artificial intelligence; GS: Google Scholar; USMLE: United States Medical Licensing Examination

Compiled list of top unique records across the three databases and emerging topics for future research

The number of unique records identified in the three databases was 22. Only two records appeared in the top ten list in the three databases out of the 22 records (9.1%) [5,55], while four appeared in two databases (18.2%) [17,49,51,52]. The geographic distribution of the top records across the three databases based on the affiliations of the corresponding authors varied, with the most common being US-based (**Figure 1**).

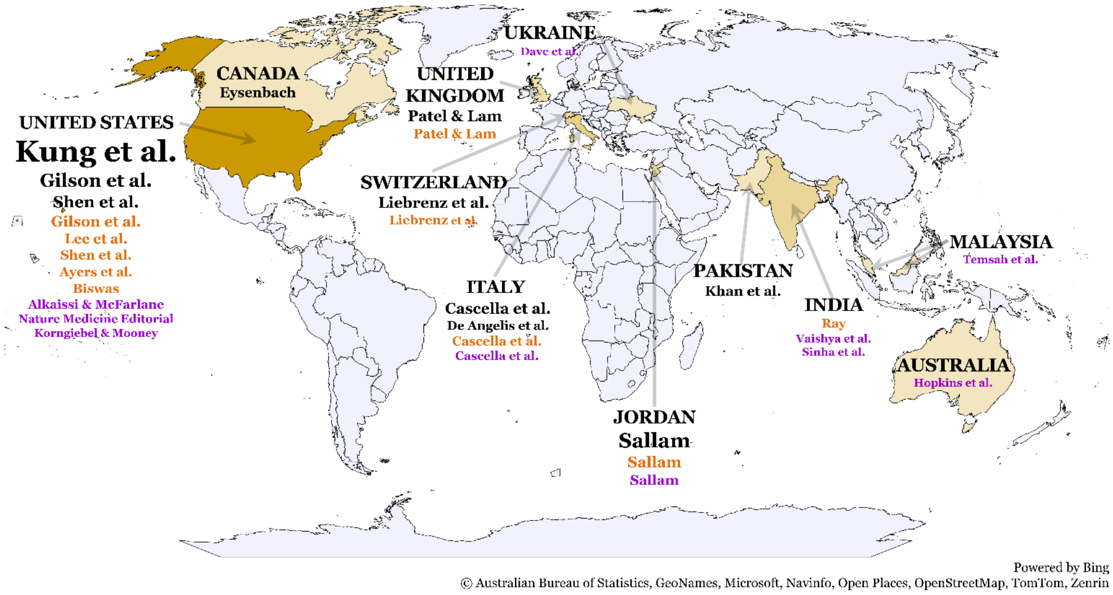

Figure 1. The top 10 healthcare-related ChatGPT records based on citation count across Scopus, Web of Science, and Google Scholar databases. Records in Scopus are shown in orange, Web of Science in violet, and Google Scholar in black. The font size of the authors is relative to the citation count. The map was generated in Microsoft Excel, powered by Bing, ©GeoNames, Microsoft, Navinfo, TomTom, and Wikipedia.

Six themes emerged from the final list of 22 ChatGPT healthcare-related influential publications. The first theme is the enhancement of healthcare education, which involves the exploration of ChatGPT's potential to improve academic performance and cost-effectiveness in education [7,55,69]. The second theme is assistance in academic editorial and review processes, which includes the investigation of ChatGPT's utility as an academic editor or peer reviewer in healthcare research and developing policies for its ethical integration to ensure scientific integrity [7,57,58,61,63,65]. The third theme focuses on improving patient engagement and interactions, entailing the evaluation of the effectiveness of ChatGPT in patient communications, understanding patient preferences for AI versus human support, and assessing the impact of ChatGPT on improving health literacy [57,62,66]. The fourth theme addresses the proactive mitigation of misinformation, which involves addressing the risks of misinformation from ChatGPT and developing comprehensive guidelines for its responsible use in healthcare [58,71]. The fifth theme, benchmarking the performance of ChatGPT in healthcare, involves establishing standard methodologies for the evaluation of ChatGPT performance in various tasks in different healthcare settings [66]. The last theme is the effective integration of ChatGPT in healthcare settings, which involves establishing best practices for effective integration of ChatGPT with human expertise in healthcare, including training for ethical and judicious use, developing quality standards, and engaging stakeholders to maximize ChatGPT benefits while mitigating its risks [54,64,71].

Correlation between Google Scholar citation count and alternative metrics

The full bibliometrics for the final 22 influential records retrieved across the three scientific databases are illustrated in **Table 4**.

Table 4. Full bibliometrics of the 22 ChatGPT-related healthcare influential records

Authors	Title	GS citation count	SS HICs	PlumX captures	PlumX mentions	PlumX social media	AAS
Kung *et al.* [69]	Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models	1032	35	-	-	-	1541
Sallam [7]	ChatGPT utility in healthcare education, research, and practice: Systematic review on the promising perspectives and valid concerns	540	17	675	3	13	51
Gilson *et al.* [55]	How does ChatGPT perform on the United States Medical Licensing Examination? The implications of large language models for medical education and knowledge assessment	441	14	550	113	52	478
Lee *et al.* [56]	Benefits, limits, and risks of GPT-4 as an AI chatbot for medicine	381	8	278	60	0	775
Alkaissi and McFarlane [63]	Artificial hallucinations in ChatGPT: Implications in scientific writing	334	5	319	18	0	212
Shen *et al.* [57]	ChatGPT and other large language models are double-edged swords	317	5	229	9	0	95
Ray [62]	ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope	306	10	734	20	0	7
Ayers *et al.* [59]	Comparing physician and artificial intelligence chatbot responses to patient questions posted to a public social media forum	284	4	327	573	0	6086
Patel and Lam [22]	ChatGPT: The future of discharge summaries?	261	1	218	10	37	143
Liebrenz *et al.* [58]	Generating scholarly content with ChatGPT: Ethical challenges for medical publishing	255	6	288	3	34	50
Cascella *et al.* [61]	Evaluating the feasibility of ChatGPT in healthcare: An analysis of multiple clinical and research scenarios	253	4	394	2	0	19
Biswas [60]	ChatGPT and the future of medical writing	253	5	198	12	0	389
Eysenbach [14]	The role of ChatGPT, generative language models, and artificial intelligence in medical education: A conversation with ChatGPT and a call for papers	188	4	384	109	9	463
Khan *et al.* [70]	ChatGPT - reshaping medical education and clinical management	184	4	-	-	-	2
De Angelis *et al.* [71]	ChatGPT and the rise of large language models: The new AI-driven infodemic threat in public health	124	5	138	1	0	18
Dave *et al.* [23]	ChatGPT in medicine: An overview of its applications, advantages, limitations, future prospects, and ethical considerations	121	0	213	1	18	94
Korngiebel and Mooney [64]	Considering the possibilities and pitfalls of Generative Pre-trained Transformer 3 (GPT-3) in healthcare delivery	111	1	137	4	0	94
Vaishya *et al.* [65]	ChatGPT: Is this version good for healthcare and research?	92	2	139	1	24	14
Hopkins *et al.* [66]	Artificial intelligence chatbots will revolutionize how cancer patients access information: ChatGPT represents a paradigm-shift	78	1	113	7	1	73
Nature Medicine Editorial [54]	Will ChatGPT transform healthcare?	70	0	93	10	0	134
Sinha *et al.* [67]	Applicability of ChatGPT in assisting to solve higher order problems in pathology	64	0	75	0	0	3
Temsah *et al.* [68]	Overview of early ChatGPT's presence in medical literature: Insights from a hybrid literature review by ChatGPT and human experts	49	3	96	0	0	10

AAS: altmetric attention score; AI: artificial intelligence; GS: Google Scholar; SS HICs: Semantic Scholar highly influential citations; USMLE: United States Medical Licensing Examination

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To determine the possible correlations between the latest Google Scholar citations as of 30 November 2023 and the alternative metrics (PlumX, SS HICs, and AASs), Kendall's tau-b (τb) correlation coefficient and Spearman's rank-order correlation coefficient (ρ) were used. Significant positive correlations were detected between the Google Scholar citations and SS HICs (τb=0.696, ρ=0.84, $p<0.001$ for both), PlumX captures (τb=0.67, ρ=0.831, $p<0.001$ for both), PlumX mentions (τb=0.456, $p=0.006$, ρ=0.609, $p=0.004$), and AASs (τb=0.396, $p=0.010$, ρ=0.542, $p=0.009$) (**Table 5**). The PlumX mentions and AAS were significantly associated with the region of the corresponding author's affiliation, with the highest being in the United States or Canada (**Table 6**).

Table 5. Correlation between Google Scholar citation count and alternative metrics

Metrics	Kendall's tau-b (τb) correlation coefficient	GS citation count	SS HICs	PlumX captures	PlumX mentions	PlumX social media	AAS
Spearman's correlation coefficient (ρ)	-		τb	τb	τb	τb	τb
GS citation count	ρ	-	0.696**	0.670**	0.456**	0.144	0.396*
	p-value		<0.001	<0.001	0.006	0.418	0.010
SS HICs	ρ	0.840**	-	0.554**	0.295	0.034	0.190
	p-value	<0.001		0.001	0.081	0.853	0.231
PlumX captures	ρ	0.831**	0.739**	-	0.406*	0.195	0.237
	p-value	<0.001	<0.001		0.013	0.269	0.144
PlumX mentions	ρ	0.609**	0.411	0.547*	-	0.007	0.745**
	p-value	0.004	0.072	0.013		0.971	<0.001
PlumX social media	ρ	0.169	0.056	0.244	0.005	-	0.072
	p-value	0.476	0.813	0.299	0.984		0.685
AAS	ρ	0.542**	0.27	0.287	0.805**	0.092	-
	p-value	0.009	0.225	0.219	<0.001	0.699	

AAS: altmetric attention score; GS: Google Scholar; SS HICs: Semantic Scholar highly influential citations
* Correlation is significant at $p=0.05$
** Correlation is significant at $p=0.01$

Table 6. Association of publication metrics with the region of the affiliation of the corresponding author

Region	US or Canada	Australia, Italy, UK, Switzerland, or Ukraine	India, Jordan, Malaysia, or Pakistan	*p*-value [a]
	Mean±SD	Mean±SD	Mean±SD	
GS citation count	341.1±268.83	182±83.08	205.83±189.66	0.214
SS HICs	8.1±10.2	2.83±2.48	6±6.36	0.456
PlumX captures	279.44±137.93	227.33±102.77	343.8±330.74	0.884
PlumX mentions	100.89±182.22	4±3.69	4.8±8.58	0.007
PlumX social media	6.78±17.22	15±17.32	7.4±10.85	0.291
AAS	1026.7±1830.26	66.17±48.02	14.5±18.43	<0.001

AAS: altmetric attention score; GS: Google Scholar; SS HICs: Semantic Scholar highly influential citations
[a] Analyzed using Kruskal-Wallis H (K-W) test

Discussion

In the current study, bibliometric analysis was used to examine the growing literature that addressed the utility of ChatGPT in healthcare over a single year. Bibliometric analysis used in the current study involved a systematic search across three prominent academic databases, with a ranking of influential publications based on the frequency of citations received by the retrieved publications [72-74]. The use of bibliometric analysis in this study was justified by the previous evidence highlighting the valuable role of this approach in enhancing the collective understanding of scientific research dynamics, especially in growing research topics [75-77].

The major finding in this study was the demonstration of the rapid growth of literature addressing ChatGPT in healthcare and the swift impact of publications on this emerging research topic. Marking the first anniversary of ChatGPT's public release and its recognition as the fastest-growing web-based platform with active users ever [78], the current study pointed to the intricate interplay between AI and healthcare. This dynamic interaction promises major improvements in medical science and patient care, but it also requires careful handling of the expected technical, ethical, and regulatory issues [79].

A major finding in this study was the identification of the seminal study by Kung *et al*. highlighting the impressive ChatGPT performance in the United States Medical Licensing Examination (USMLE) as the most influential publication [69]. In less than a year, the impact of Kung *et al*.'s study was highlighted by more than 1,000 citations in Google Scholar, underlining the potential of ChatGPT in medical education which is gaining a huge momentum [7,20,55,69,80-82]. Notably, the publication by Kung *et al*. has not been identified in both Scopus and Web of Science databases. The absence of this publication from these prominent academic databases is attributed to its publication in the newly established, yet-to-be-indexed scientific journal, PLOS Digital Health [69]. This result suggests the necessity of Google Scholar's inclusion in bibliometric analyses and systematic reviews, considering its comprehensive coverage and immediate indexing for various scholarly sources [83].

Additionally, a systematic review that explored the applications of ChatGPT in healthcare education, research, and practice has been identified in this study as one of the most frequently cited publications across the three databases, being the most commonly cited publication in Web of Science and Scopus [7]. Despite being published in a journal with a relatively modest impact factor (2.8 in 2022) and CiteScore (2.7 in 2022), the aforementioned review achieved a significant level of citations within a short period of time. This result suggests that influential research can transcend the traditional metrics of journal impact [84,85].

Geographical analysis that involved the affiliations of corresponding authors of the top publications in this study revealed a wide range of contributing countries in spite of the relative predominance of US-based publications [54-57,59,60,63,64,69]. This result can be related to the forefront role and influence of US-based research with advanced research infrastructure and funding opportunities [86]. Nevertheless, the presence of an additional ten countries contributing to healthcare-related ChatGPT influential research can point to the global interest in this emerging scientific field. This diversity appears valuable since the utility of ChatGPT in healthcare should be guided by the consideration of varied healthcare systems and patient demographics worldwide.

The current study identified 22 unique records in the top healthcare-related ChatGPT publications list, a figure that surpassed the anticipated number of 10 publications across the three searched scientific databases. This result demonstrates the notable variation in citation counts across different scientific databases [87]. Therefore, variability in citations per database highlights the necessity for reliance on multiple databases in bibliometric analysis to avoid biases in publication impact evaluation [88]. Additionally, it is important to emphasize that while a high citation count can be indicative of a high impact, the current study showed clear discrepancies in citation counts per database. This result suggests that the sole dependence on conventional citation metrics to assess publications' influence is an inadequate approach, particularly in emerging research topics such as ChatGPT utility in healthcare [89].

A notable finding of this study was the identification of a wide range of influential publications on the role of ChatGPT in healthcare, encompassing editorials, commentaries, perspectives, original research articles, and reviews. This result reflects the dynamic nature of scholarly communication on ChatGPT's role in healthcare. Importantly, the vast majority of top-ranked publications found in this study were published in open access journals, suggesting that open access policies might influence publication impact, although further evidence is needed to confirm this tentative link [90-92].

Another interesting finding in this study was the strong correlation between citation counts and alternative metrics (Semantic Scholar HICs, PlumX metrics, and AASs). This result emphasizes the potential use of alternative publication metrics to refine the assessment of scholarly and societal influence of scientific publications [42]. Thus, the use of alternative publication metrics is important to complement the citation count metric in assessing the outreach and influence of publications involving ChatGPT in healthcare, similar to its use across diverse academic disciplines [93,94].

Finally, the influential publications identified in the current study pointed to three primary application areas of ChatGPT in healthcare. First, enhancing healthcare practice through improved workflows and patient engagement [7,22,56,57,62]. Second, augmenting healthcare education with personalized learning and clinical simulations [7,55,69,70]. Third, supporting medical research in areas like academic writing and data management [7,58,61,62,65]. However, these applications should be made in light of challenges, including the generation of inaccurate content, ethical concerns, and potential biases [7,54,62]. Additionally, future research should prioritize establishing standard methodologies for the design and reporting of generative AI applications in healthcare to ensure the reliability and credibility of assessing AI performance in various healthcare settings [46,66,95-97]. Future research should also focus on multidisciplinary approaches involving AI developers, computer scientists, healthcare professionals, experts in healthcare education, and ethicists [46,98,99].

Limitations

It is important to clearly and explicitly point out that the use of citation counts or alternative metrics is by no means a direct measure of the quality of publications ranked in this study or a reflection of their direct impact. These metrics can only be viewed as a surrogate marker of the publication trends in this newly emerging research field, namely ChatGPT applications in healthcare.

Several other caveats in this study should be highlighted clearly and taken into consideration before any attempt to interpret the study results. First, this study used Scopus, Web of Science, and Google Scholar as the databases for publication selection. Despite the extensive coverage of these databases, it is important to consider that this approach might overlook publications in less prominent or regional journals due to differing indexing criteria and inherent coverage biases. The incorporation of Google Scholar, characterized by comprehensive and immediate indexing, as an additional source for retrieving publications was done to mitigate this limitation to a large extent.

Second, the search strategy focused on the titles and abstracts of the records. This approach may have resulted in inadvertent exclusion of publications that addressed ChatGPT utility in healthcare in the main text but not explicitly in the title/abstract.

Third, the geographic allocation of publications based on the affiliation of the corresponding authors could be viewed as a source of selection bias since this approach might not be fully representative of the authorship and collaboration networks, potentially causing bias in the interpretation of publication sources and subsequent geographic analysis.

Fourth, it is important to reiterate that the use of citation counts and alternative metrics, such as Semantic Scholar HICs, PlumX, and Altmetric AAS for publication ranking is influenced by a variety of factors such as scientific journal perceived impact, journal visibility, the date of publication, and time to indexing of the records in various databases. For example, more recently published articles might have lower citation counts due to a limited time frame for acknowledging their results. Thus, the ranking approach in this study might not represent a direct reflection of the scientific quality or impact of the included publications.

Finally, based on the descriptive nature of the current study, the results were confined to descriptive and subjective identification of trends and correlations, without the ability to elucidate the underlying reasons for such observed attributes of the included publications.

Conclusions

The bibliometric analysis conducted in this study highlighted the dynamic nature of ChatGPT-related research in healthcare. The range of publication types and the variability in citation patterns across the three searched databases highlighted the complexity of the scholarly discourse addressing ChatGPT applications in healthcare. The current study identified 22 influential publications that studied ChatGPT utility in healthcare in Scopus, Web of Science, and Google Scholar. The findings revealed clear correlations between GS citations and various alternative metrics, such as SS HICs, PlumX captures and mentions, and AAS, demonstrating the discernible impact of the identified publications and the usefulness of alternative metrics as an approach for gauging the publication impact. However, the regional affiliations of corresponding authors of the identified records, particularly in the U.S. and Canada, were correlated with higher PlumX mentions and AAS, suggesting the possible influence of research origin on its news coverage and public visibility.

The study identified three key emerging themes regarding ChatGPT's utility in healthcare. ChatGPT has the potential to enhance clinical efficiency, personalize education, and support research. However, it is important to address the emerging challenges of ChatGPT in healthcare, including possible content inaccuracy, ethical issues, and biases. The study calls for standardized methodologies and multidisciplinary collaboration to ensure effective and ethical ChatGPT integration in healthcare.

Ethics approval

Not applicable.

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Competing interests

The authors declare that there are no conflicts of interest.

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Underlying data

The datasets analyzed during the current study are available in the original records included in the study.

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