

Machine Learning-based Chatbot Model for Healthcare Service: A Bibliometric Analysis

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Article Info

Article history:

Submitted June 4, 2025

Accepted June 23, 2025

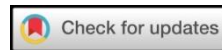
Published September 15, 2025

Keywords:

Chatbot;
machine learning;
healthcare service;
bibliometric analysis.

ABSTRACT

While machine learning-based chatbots hold significant potential in healthcare services, a comprehensive synthesis regarding their roles, user demographics, benefits, and limitations remains unavailable, hindering in-depth understanding and future development. This study aims to conduct a bibliometric analysis to identify implementation trends and the research landscape of ML-based chatbot models in healthcare, simultaneously highlighting relevant existing gaps. Analysis of Scopus data using VOSviewer and “Publish or Perish” reveals “machine learning”, “chatbot” and “healthcare” as dominant keywords, indicating intensive research focus areas with stable publication growth. The United States emerges as a central hub for international research collaboration, particularly in AI for malnutrition; however, several outlier countries require further integration. Deep learning algorithms are identified as a crucial methodological trend for future directions. Chatbots possess the potential to revolutionize healthcare by enhancing accessibility and efficiency. Nevertheless, effective implementation necessitates careful consideration of ethical aspects, privacy, and data quality. The identified research gaps underscore the urgency for a holistic synthesis to guide responsible and effective chatbot innovation.



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1. INTRODUCTION

Healthcare services are one of the main pillars in the development of a nation. The availability and accessibility of quality healthcare services are important indicators of a country's progress and directly influence the quality of life of its people. In a global context, healthcare services encompass various aspects, ranging from health promotion, disease prevention, early diagnosis, treatment, to rehabilitation. Healthcare services play a crucial role in creating a healthy and productive society. Healthy individuals have the ability to actively participate in economic, educational, and social activities, which ultimately contributes to economic growth and social stability. Conversely, a lack of access to or poor quality of healthcare can lead to an increase in morbidity and mortality rates, a decrease in productivity, and an increased economic burden on individuals, families, and the nation.

A chatbot is a computer program designed to simulate human conversation, either through text-based or voice-based interactions with users. Chatbots' ability to understand questions, provide information, and perform specific tasks has transformed the way humans interact with technology and services. The evolution of chatbots is inseparable from the rapid advancements in artificial intelligence (AI), natural language processing (NLP), and machine learning. The application of chatbots has expanded across various sectors, including Customer Service, where they handle common inquiries, provide 24/7 support, and assist with basic orders or problem resolution. In marketing and sales, chatbot guide potential customers, offer product recommendations, and facilitate the purchasing process. In healthcare, chatbot provide health information, assist with appointment scheduling, and offer initial emotional support. For Education, they offer study guidance, answer student questions, and help with administrative processes. Finally, as personal assistants, chatbot manage schedules, provide reminders, and retrieve information.

The integration of chatbots into the healthcare ecosystem demonstrates significant potential in addressing several fundamental challenges previously identified. This can be realized through scenarios where individuals gain rapid and convenient access to basic health information, receive answers to common questions regarding clinical symptoms, or even schedule medical appointments through natural conversational interactions with chatbots, regardless of time or location. Furthermore, chatbots possess the capability to function as personal assistants, able to provide medication reminders, monitor the progression of non-critical health conditions, and even offer initial emotional support to patients in need. This potential not only promises enhanced operational efficiency and a reduction in the workload for medical professionals but also presents a substantial opportunity to improve healthcare accessibility, particularly for populations in remote areas or those with mobility limitations. However, to optimize this potential, an in-depth exploration is required regarding the ethical, safe, and effective implementation of chatbots, while simultaneously ensuring the accuracy of medical information provided and the protection of patient data privacy.

The application of chatbots has become a crucial issue across various sectors, including healthcare, where they enable human-like communication and information delivery. Meanwhile, machine learning, as a sub-field of artificial intelligence, has proven highly relevant in healthcare due to its ability to manage complex dialogues and adapt flexibly in conversations [1]. Driven by the accelerating advancements in artificial intelligence (AI) and digital technology, chatbots often referred to as conversational agents have transformed into crucial instruments within the realm of healthcare services. These programs are intrinsically designed to simulate human conversational interactions, with the objective of accommodating diverse healthcare needs. However, to date, a comprehensive synthesis elaborating on the roles, user demographics, benefits, and limitations of chatbots within the healthcare context is not yet available. This lack of integrated data impedes the provision of a solid informational basis to guide the future direction of research and application development in this domain [2]. The inclusion of artificial intelligence (AI) in healthcare management represents a significant technological innovation expected to bring substantial changes to healthcare procedures, patient care quality, and emergency response speed. What makes this study scientifically novel is its integrated approach, which combines systematic review and predictive algorithms to deeply understand how AI contributes to improving healthcare management across various conditions [3].

Given the dynamic nature of the healthcare design and construction sector, organizations continuously work to balance customer expectations with the imperative of managing costs, schedules, and quality [4]. The primary aim of this study was to prospectively determine the prevalence of ESBL-producing *Enterobacteriaceae* in the intestinal tracts of Portuguese students enrolled in a Bachelor's degree program in healthcare, and also to identify the molecular characteristics of these ESBL-producing isolates [5]. The aim of this paper is to analyze the effect of horizontal integration among hospitals on their efficiency. Given that approximately half of all healthcare expenditures in the Czech Republic are utilized by hospitals, it is crucial to ensure they operate economically and efficiently [6]. Exposed to diverse natural and anthropogenic risks, Santiago's Metropolitan Region (RMS) in Chile not only requires routine healthcare services but also experiences a substantial increase in demand whenever its inhabitants are affected by disasters [7].

Bibliometric analysis is a proven and widely used technique for exploring and analyzing massive volumes of scientific data. It allows us to not only delineate the evolution of a field but also to identify emerging areas within it. Nevertheless, its application in business research is still relatively new and often not fully utilized. Therefore, this paper endeavors to present an overview of bibliometric methodology, with an emphasis on its various techniques, while offering step-by-step guidelines that can be relied upon to perform bibliometric analysis accurately and confidently [8]. This analysis provides a comprehensive summary of the latest and most significant research in conversational AI within healthcare. By addressing key research questions and offering derived insights, this work aims to be a valuable resource for researchers and professionals in various areas of the digital healthcare sector who want to understand current trends in conversational AI [9].

Based on the description above, the objective of this research is to understand the interrelationship through a literature review among chatbots, healthcare services, and machine learning. Structurally, this research begins with the methodology in Section 2. Subsequently, Section 3 presents the results of the bibliometric analysis, followed by an in-depth discussion of these findings. The study concludes in Section 4 with a summary of the bibliometric analysis findings.

This study contributes to the novelty by: (a) Presenting a structured synthesis concerning publication trends, main keywords, authors, institutions, and inter-country collaboration patterns within the domain of machine learning-supported chatbots in healthcare. (b) Explicitly identifying a research gap, namely the absence of a comprehensive synthesis elaborating on the roles, user demographics, benefits, and limitations of chatbots in the healthcare context. This research bridges this gap by providing an integrated information base to guide future research and development directions. (c) Mapping the research landscape using data from Scopus and visualization tools such as VOSviewer, which enables the identification of intensive research areas as well as potential underexplored domains.

2. RESEARCH METHODS

The method used in this research is bibliometric analysis, with data sourced from the Scopus database as of May 22, 2025. Data processing was performed using Publish or Perish and VOSviewer software to conduct the bibliometric analysis. The stages of this research were carried out following the four steps proposed by Donthu et al [10]:

1. Defining the objectives and scope of the bibliometric analysis
2. Selecting bibliometric analysis techniques
3. Collecting data for the bibliometric analysis
4. Conducting the bibliometric analysis and presenting the findings

The primary focus of this research is the analysis of machine learning-based chatbot model utilization in healthcare services through a bibliometric analysis approach. This analytical process involves forming keyword combinations for data search queries from the Scopus database. A total of ten search queries were established for the bibliometric analysis, referring to an existing theoretical framework, as shown in Table 1.

Table 1. Query Strings

#	Search Strings
QS1	chatbot
QS2	chatbot AND “machine learning”
QS3	chatbot AND “machine learning” AND “healthcare”

Data obtained from the search queries are stored in CSV and RIS formats to facilitate analysis. The CSV file is specifically utilized for performance analysis and science mapping via VOSviewer, while the RIS file is allocated for computing citation metrics using “Publish or Perish”, in accordance with the classification by Donthu et al. [8]. It is crucial to underscore that bibliometric analysis is divided into main and enrichment techniques. This research expressly limits its scope to the implementation of the main technique only, which encompasses performance analysis and science mapping.

3. RESULTS AND DISCUSSION

We present two main analyses in this section: performance analysis and science mapping. Performance analysis is responsible for evaluating a study's impact and contribution to a specific field of knowledge, while science mapping focuses on visualizing the relationships and essential structure of the topic under investigation.

3.1 Performance Analysis

To perform performance analysis, we rely on examining metrics of scholarly output and their influence, as measured by the number of citations received, as presented in Figure 1.

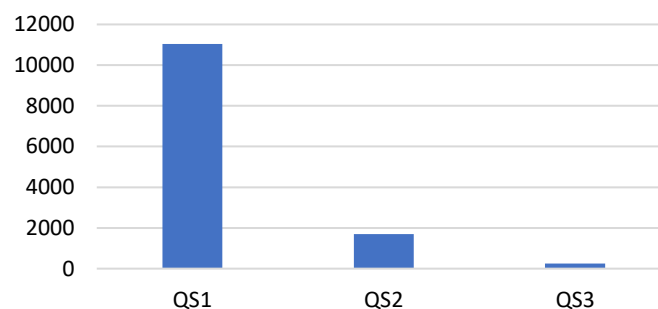


Figure 1. Number of publications per query string

An initial search query analysis identified 11,033 documents related to the keyword “chatbot”, significantly highlighting the high academic relevance and interest in this topic among researchers. This study aims to explore the implementation of machine learning (ML) approaches within the context of chatbot research applied to healthcare services. This investigation was conducted through a series of specific search queries (QS1 to QS3). Preliminary findings from the literature search indicate a lack of studies explicitly discussing the linkage between unsupervised learning methods and chatbot research.

3.1.1 Total publication

Based on Figure 2, the total publications mentioned in Table 1 indicate that, if we disregard the data from 2025, there appears to be a declining trend in the development of research related to chatbots and machine learning (QS2) in that year.

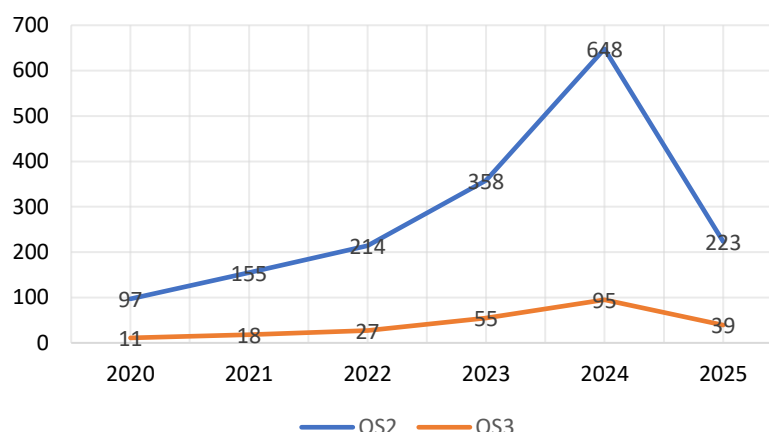


Figure 2. Number of publications per query string

Figure 2 illustrates that the QS2 value peaked in 2024 at 648. This trend signifies an increase, indicating that the integration of Chatbots and Machine Learning represents a significant future research direction in the field of chatbots. The limitations of ChatGPT's initial version in processing visual modalities, specifically photos and videos, significantly resulted in a contextual deficit in the generated interactions. This condition indirectly presented an impediment for individuals within educational contexts who sought to exploit the platform for ethically unsuitable purposes [11]. In this proof-of-concept study, we investigated the capability of large language models, specifically “ChatGPT” and “Google Bard” to simplify the linguistic complexity of three patient information segments extracted from scientific journal literature [12]. Additionally, Figure 2 shows the “Number of publications per query string” from 2020 to 2025, indicating the tracking of publication growth, with the highest citation count of 1435, belonging to the affiliation Department of Pathology, Microbiology and Forensic Medicine, School of Medicine, The University of Jordan, Amman, 11942, Jordan; Department of Clinical Laboratories and Forensic Medicine, Jordan University Hospital, Amman, 11942, Jordan.

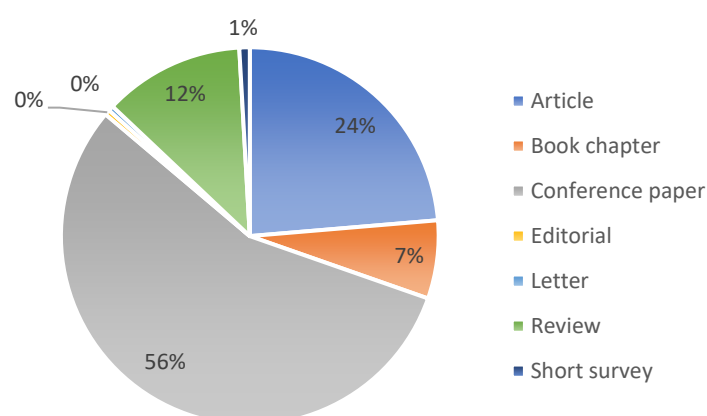


Figure 3. Publication according to document type

The publication type distribution for QS3: “chatbot” AND “machine learning” AND “healthcare” is illustrated in Figure 3. Of the eight document types identified, conference papers are the most common (56%), followed by articles (24%) and reviews (12%). This proportion indicates that publications related to the application of machine learning in chatbots within healthcare services largely originate from conference activities.

3.1.2 Citation-related Metrics

The citation data from the analyzed publications, as presented in Table 2, indicates that two papers stand out with a remarkably high citation impact, reaching 1446. “ChatGPT” in healthcare education, research, and practice, and to highlight its potential limitations [13] and To evaluate how the model would perform on a separate test set created by user interactions with the assistant [14] with 1446 citations. This paper highlights pre-existing ethical issues in the computing domain and discusses how “ChatGPT” could potentially create new challenges to these ethical concepts. Furthermore, this study also identifies the inherent biases and limitations of

ChatGPT [15] with 1319 citations. This research aims to provide a comprehensive overview of the various dimensions of security in chatbot-based communication [16] with 138 citations.

Citation data, which includes publications with the highest number of citations as well as articles from the journals Healthcare (Switzerland) and Internet of Things and Cyber-Physical Systems, is presented in Table 2. It's important to note that both of these journals are categorized within Quartile 1 and Quartile 2, respectively, based on their SCImago Journal Rank (SJR).

Table 2. Citation From Publication

Journal	Citation	Paper	SJR 2024
Healthcare (Switzerland) (2227-9032)	1446	2	Q2 0.75
Internet of Things and Cyber-Physical Systems (2667-3452)	1319	1	Q1 3.95
Concurrency and Computation: Practice and Experience (1532-0626, 1532-0634)	138	1	Q2 0.43
IEEE Internet of Things Journal (2327-4662)	104	1	Q1 2.48
Journal of Personalized Medicine (2075-4426)	87	4	Q2 0.86
Aesthetic Surgery Journal (1090-820X, 1527-330X)	80	1	Q1 1.25
2020 International Conference on Power Electronics and IoT Applications in Renewable Energy and its Control, PARC 2020	66	1	-
npj Digital Medicine (2398-6352)	63	1	Q1 4.16
IEEE Access (2169-3536)	62	2	Q1 0.84
Proceedings of the ACM on Human-Computer Interaction (2573-0142)	57	1	Q1 0.91
2021 International Conference on Intelligent Technologies, CONIT 2021	48	1	-
Proceedings of the World Conference on Smart Trends in Systems, Security and Sustainability, WS4 2020	46	1	-
Clinical Infectious Diseases (1058-4838, 1537-6591)	42	1	-
Handbook of Research on Instructional Technologies in Health Education and Allied Disciplines	36	1	Q1 2.99
2021 2nd International Conference for Emerging Technology, INCET 2021	34	1	-
Computers, Materials and Continua (15462218, 15462226)	34	1	Q2 0.43
Proceedings of the 2nd International Conference on Applied Artificial Intelligence and Computing, ICAAIC 2023	33	1	-
Frontiers in Digital Health (2673253X)	32	1	Q1 1.07
IEEE Technology and Society Magazine (02780097)	32	1	Q2 0.33
Proceedings - 2020 International Conference on Intelligent Computing and Human-Computer Interaction, ICHCI 2020	32	1	-

3.2 Science Mapping

To perform science mapping, this study employs co-word analysis and co-authorship analysis. To uncover the relationships between keywords and authors, we utilized the “VOSviewer” software [17].

3.2.1 Co-word analysis

Co-word Analysis in chatbot research using the VOSviewer software, we conducted a co-word analysis by setting a minimum keyword occurrence threshold of 5. Out of a total of 1968 keywords, 114 keywords met this criterion. The chosen keywords were then categorized into three homogeneous clusters, each visually distinguished by a unique color. The word “machine learning” appeared most frequently, resulting in its node appearing larger in the visualization. Besides “machine learning” other significant keywords included “chatbot”, “healthcare”, “human”, “artificial intelligence” and “natural language processing” as presented in Figure 4.

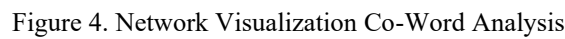
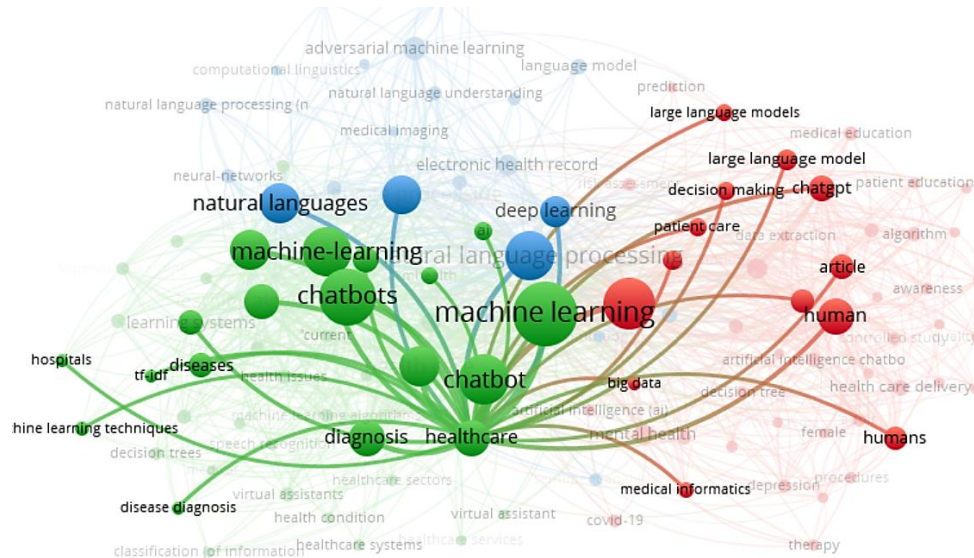
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Figure 5, areas with high visual intensity may indicate fields of study that have reached a level of maturity or even saturation, suggesting that subsequent innovation might demand more disruptive approaches. Conversely, areas with relatively low density, particularly those situated between robust clusters, potentially offer significant opportunities for innovative interdisciplinary research exploration. This section reviews the central keywords of this research, including chatbot, healthcare, machine learning, artificial intelligence, NLP,

In Figure 6, the strong interlinkage between the terms 'chatbot' and 'diagnosis' and 'human' indicates a substantial research focus on the capabilities of chatbots in performing initial clinical assessments and facilitating direct patient interaction. This is highly relevant to the endeavor of achieving improved accessibility and efficiency in healthcare service provision. Similar developmental processes also underpin the emergence of various other AI tools in this domain [18]. The concept of “agentic outcome” refers to the proactive initiatives students undertake to achieve their goals in a constructive manner [19].



In Figure 7, the identification of outlier countries, such as Indonesia, Turkey, and the Philippines, indicates a substantial disparity in international research collaboration participation within this domain. This phenomenon can be attributed to various factors, including limited access to funding, insufficient connectivity with global research networks, or an orientation towards local contextual issues that have not yet gained traction on the global stage. After receiving input, the chatbot will store data in its database, extract keywords from sentences, evaluate whether a query needs to be answered, and then provide relevant information [20]. The goal is to employ artificial intelligence to develop a medical chatbot that, when presented with symptoms, can diagnose a patient's condition before the patient ever sees a doctor [21]. Around the world, many people struggle to access affordable and timely medical care. Medibot, an intelligent healthcare conversational AI developed with cutting-edge technology, tackles these challenges head-on [22]. By leveraging techniques like machine

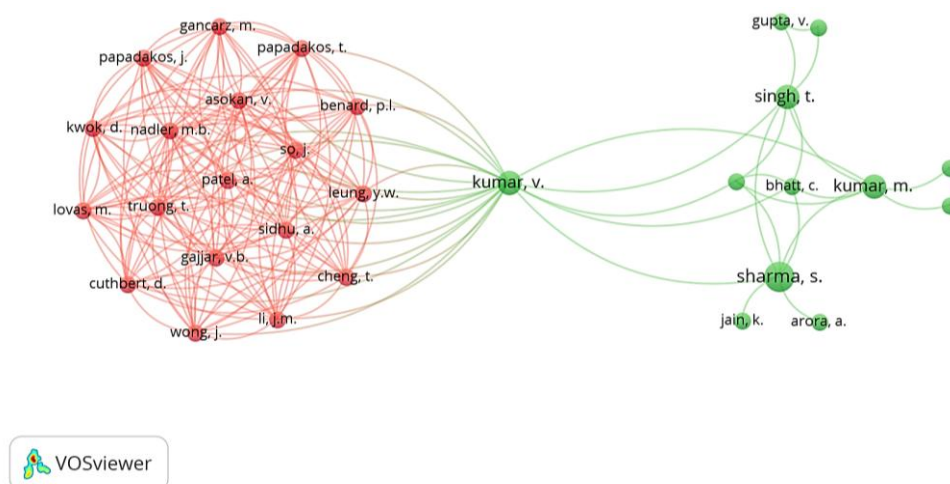


Figure 9. Network Visualization Co-Authorship Analysis

In Figure 9, authors prominently identified in this visualization can serve as ideal candidates for qualitative interview studies, in order to gain a more comprehensive understanding of the collaborative dynamics and research orientations within this field. Co-authorship analysis result 16 author with name Kumar, v in network visualization. This initiative is designed for healthcare costs reduction, enhance access to medical resources, and ultimately contribute to an improved state of overall well-being. The proposed solution outlines a multilingual healthcare voice operated chatbot system designed to analyse user Symptoms and predict the Disease on the Symptoms basis [33]. Overall, the main implication is that chatbots have the potential to revolutionize healthcare provision by improving accessibility and efficiency, but their implementation requires careful consideration of ethical, privacy, and data quality challenges.

4. CONCLUSION

The increasing annual volume of publications substantiates the rapid growth in research concerning chatbot utilization in healthcare. This study conducted a bibliometric analysis of 245 documents from the Scopus database to examine this phenomenon. We reviewed several aspects, including performance analysis and science mapping, utilizing VOSviewer and Publish or Perish software. The analysis indicates that machine learning algorithms currently dominate this research area, surpassing convolutional neural networks and deep learning in prevalence. The primary application of these algorithms is in chatbot models for healthcare services. However, recent trends clearly suggest that deep learning algorithms are emerging as a crucial future direction for chatbot model development in this sector, correlating with a rising number of studies leveraging deep learning to advance the research topic. Furthermore, information classification and medical information present promising avenues for the continued evolution of healthcare chatbots. A limitation of this research is its reliance on a single database for data sourcing. Consequently, future research should integrate data from multiple sources such as Web of Science, SpringerLink, and IEEE to broaden the scope of analysis.

ACKNOWLEDGMENTS

The author would like to thank Universitas Ahmad Dahlan and Politeknik TEDC for the opportunity to support doctoral studies in the field of Informatics.

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