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TRENDS IN CLINICAL REASONING ASSESSMENT: A BIBLIOMETRIC ANALYSIS SPANNING 1974-2024

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ABSTRACT

Introduction: Clinical reasoning guides diagnosis and patient care. Bibliometric analysis helps navigate scholarly publications, offering insights into trends and influential works, aiding evidence-based decisions, and improving patient outcomes. This study aims to analyze clinical reasoning assessment literature, exploring distribution across document types and languages, influential sources, volume of publications and citations, thematic clusters from author keywords, and innovative research shaping the forefront of investigation. Materials and Methods: A bibliometric analysis was performed using the Scopus database as of February 10th, 2024, covering data from 1974 to the research date. Data extraction involved document types, languages, key sources, globally cited publications, and trends over time, with network visualization of author keywords. Analysis employed the Bibliometrix package in Rstudio and VOSviewer software. Reporting adhered to PRIBA guidelines by Koo & Lin. Results: The Scopus database search yielded 1827 documents, predominantly in English in the article format. Notable sources included BMC Medical Education (UK), Academic Medicine (USA), Advances in Health Sciences Education (Netherlands), and Diagnosis (Germany). Trends from 1974 to 2024 showed increasing publications and citations. Recent publications highlighted emerging themes such as artificial intelligence, electronic health records, and chatGPT, reflecting the evolving landscape of medical assessment practices. Conclusions: This bibliometric analysis highlights the evolving landscape of clinical reasoning assessment within medical education, where recent trends embrace innovative methodologies like artificial intelligence,

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electronic health records, and chatGPT. These trends reflect a dynamic shift towards the use of technology to enhance diagnostic accuracy and decision-making processes.

Keywords: Clinical Reasoning. Education. Medical. Technology. Clinical Decision-Making. Analysis. Bibliometric.

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INTRODUCTION

Clinical reasoning is a cornerstone in medical practice, guiding accurate diagnosis and optimal patient care. The early generation of diagnostic hypotheses plays a pivotal role in enhancing diagnostic accuracy, with clinicians relying on past experiences to navigate intricate clinical scenarios [1]. This multifaceted process involves gathering and analyzing patient data, interpreting information, and making informed decisions regarding diagnosis, treatment, and patient management [2,3].

Understanding trends in clinical reasoning research holds paramount importance for healthcare practice and education. It serves as the foundation for informed decision-making and patient safety. Analyzing these trends enables educators to refine training programs, ensuring the optimal preparation of future healthcare professionals. Moreover, delving into the efficiency of decision-making processes is critical, considering its understudied nature in clinical reasoning research. Identifying trends not only addresses existing gaps and challenges but also leverages technologies to enhance diagnostic efficiency and overall patient care. In summary, staying abreast of clinical reasoning trends advances knowledge, thereby contributing to the continuous improvement of healthcare delivery and education [4].

The rising popularity of bibliometric analysis can be attributed to several factors, including the exponential growth of scholarly publications across various disciplines. With the proliferation of research output, manual data analysis becomes increasingly challenging and time-consuming. Bibliometric analysis provides an efficient and systematic approach to navigating this vast sea of literature, allowing researchers to identify trends, patterns, and influential works with greater ease and precision [5,6]. The choice of bibliometric analysis for evaluating clinical reasoning assessment literature stems from its ability to unveil publication trends, influential authors, and emerging themes, offering a comprehensive view of the scholarly landscape. By analyzing citation patterns and co-authorship networks, this method informs evidence-based decision-making, guides future research, and fosters interdisciplinary collaborations. Insights derived from the analysis have significant potential to impact research, education, and clinical practice in clinical reasoning assessment. They inform fruitful research directions, enhance educational strategies, and guide evidence-based clinical decision-making, ultimately improving healthcare delivery and patient outcomes.

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This study endeavors to conduct a comprehensive bibliometric analysis of clinical reasoning assessment literature, seeking to unveil pivotal insights in the field. The following inquiries guide our exploration:

1. How is clinical reasoning assessment literature distributed across document types and languages?
2. Which sources and publications exert significant influence in clinical reasoning assessment research?
3. How has the volume of publications and citations in medical education research, particularly regarding clinical reasoning assessment, evolved over the past five decades?
4. What thematic clusters and evolving trends emerge from the co-occurrence of author keywords?
5. What pioneering developments and cutting-edge methodologies characterize the forefront of clinical reasoning assessment literature?

MATERIALS AND METHODS

This study comprises a bibliometric analysis of the literature on clinical reasoning assessment. To accomplish this, we followed the PRIBA guidelines proposed by Koo & Lin [7]. They introduced the PRIBA guideline, consisting of seven main sections identical to those in the PRISMA 2020 Checklist. The individual items were adapted and expanded specifically for bibliometric studies.

LITERATURE SEARCH AND DATA EXTRATION

The literature search was conducted in the electronic database Scopus on 10th February 2024. Scopus, launched in 2004 by Elsevier, is a vast and meticulously curated abstract and citation database featuring over 76 million publication records from 1788 to current days. Its content spans diverse disciplines, sourced from global publishers, conferences, and books. The database undergoes rigorous selection processes to ensure inclusion of high-quality scientific publications. Scopus offers balanced subject coverage, includes non-English content, and maintains high precision and recall for citation linking. It generates author profiles and prioritizes quality assurance through internal review processes and continuous improvement efforts, establishing itself as a trusted resource for

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bibliometric analysis and research evaluation [8]. The data sources, selection, and extraction are listed in Table 1.

Table 1: Data sources, selection, and extraction details

Category	Specific standard requirements
Research Database	Scopus
Database characteristics	Scopus, launched in 2004, encompasses over 76 million records across diverse disciplines, meticulously selected for quality and citation accuracy. Widely utilized in
Time span	Before 1960 to Present (Oldest publication found was from 1974)
Data extraction time	10th February 2024
Eligibility criteria	Inclusion criteria: All languages, all Document types. Exclusion criteria: None
Research Keywords	(("clinical reasoning") and ("measurement" or "evaluation" or "assessment" or "examination" or "assessing" or "exam" or "test" or “tests” or "testing" or “judgment” or “appraisal” or “analysis” or “performance”) and ("medical education" or “resident” or “residents” or "medical student" or "medical students" or “physician” or “physicians” or “medical doctor” or “medical doctors” or “medical school” or “medical
Research fields	Article title, Abstract, Keywords
Sample size	1827
Data extraction	Export CSV with all Citation information, all Bibliographical information, all Abstract & keywords and Include references.

DATA ANALYSIS – INDICATORS AND SOFTWARES

1. Document types: This indicator assesses the distribution of publication types (such as articles, books, etc.) among the total publications. The analysis was conducted using Bibliometrix package [9] in Rstudio (Build 402) [10]., in the overview section.
2. Languages: This indicator evaluates the distribution of languages (English, Spanish, etc.) among the total publications. The analysis was conducted using Bibliometrix package [9] in Rstudio (Build 402) [10], with language data manually retrieved through filter options. Articles with undefined languages were also manually retrieved and checked.
3. Most relevant sources: We identified the top 10 most relevant sources based on total publications from the dataset. The analysis was conducted using Bibliometrix package [9] in Rstudio (Build 402) [10] . Additionally, we retrieved the Scimago Journal Ranking (SJR) for 2022 and obtained the corresponding H-index from their website [11].
4. Most globally cited publications: We identified the top 10 most globally cited publications based on total publications from the dataset. 'Globally cited' refers to considering all citations of the articles in the Scopus database, not just those

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within the dataset. The analysis was conducted using the Bibliometrix [9] package in Rstudio (Build 402) [10].

5. Publications and citations over time: This indicator assess the number of publications and the yearly citation of the documents over time. The analysis was conducted using Bibliometrix [9] package in Rstudio (Build 402) [10].
6. Network visualization map of the co-occurrence of author keywords: This indicator displays the interconnectedness of author keywords within the dataset through a network visualization map. It visually represents the relationships and patterns of co-occurrence among author keywords, offering insights into the thematic clusters and interdisciplinary connections present in the research. The analysis was performed using VOSviewer [12], a software tool specifically designed for constructing and visualizing bibliometric networks and maps. Additionally, the main keywords were extracted and summarized by the authors, providing a concise overview of the key themes identified in the dataset.
7. Trend topics: This indicator assesses the emerging or recurring themes or topics within a particular field of study over time. It helps researchers identify patterns in scholarly literature, such as which topics are gaining prominence or declining in interest, the frequency of occurrence of certain keywords or topics, and how these trends evolve over time. The analysis was conducted using Bibliometrix package [9] in Rstudio (Build 402) [10]. Parameters (Field = Author's keywords; Timespan = 1974 to 2024; Word minimum frequency = 5; Number of words per year = 3).

RESULTS

The search process was straightforward as there were no exclusion criteria; thus, all 1827 documents meeting the predefined search criteria in the Scopus database were utilized for this bibliometric analysis.

BIBLIOMETRIC INDICATORS

Articles comprise the majority of total publications at 82.32%, followed by reviews at 9.36% (Table 2). Other document types collectively represent the remaining publications, with conference papers, notes, and book chapters being moderately prevalent, while

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editorials, short surveys, and letters are less common. Books, conference reviews, and errata are the least prevalent categories.

Table 2. Document Types

Document types	Total Publications (TP)	Percentage (%)
Article	1504	82.32
Review	171	9.36
Conference paper	66	3.61
Note	23	1.26
Book chapter	13	0.71
Editorial	13	0.71
Short survey	13	0.71
Letter	12	0.66
Book	10	0.55
Conference review	1	0.05
Erratum	1	0.05
Total	1827	100.00

English is the predominant language among total publications, accounting for 95.57% (Table 3). French and Spanish follow at 1.59% and 0.93%, respectively. Other languages, including Dutch, Italian, Chinese, German, Japanese, Korean, Portuguese, Croatian, Danish, Greek, Hebrew, Norwegian, and Polish, collectively represent the remaining publications, each constituting less than 1% of the total.

Table 3. Languages

Language	Total Publications (TP)	Percentage (%)
English	1746	95.57
French	29	1.59
Spanish	17	0.93
Dutch	6	0.33
Italian	5	0.27
Chinese	4	0.22
German	4	0.22
Japanese	4	0.22
Korean	3	0.16
Portuguese	3	0.16

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Croatian	1	0.05
Danish	1	0.05
Greek	1	0.05
Hebrew	1	0.05
Norwegian	1	0.05
Polish	1	0.05
Total	1827	100.00

The top 10 most relevant sources in medical education research (Table 4) are led by BMC Medical Education, followed closely by Medical Education and Medical Teacher, all primarily originating from the United Kingdom. These journals contribute significantly to the scholarly discourse in the field and boast high Scimago Journal Rankings (SJR) and H-Index values. Other notable sources include Academic Medicine from the United States, Advances in Health Sciences Education from the Netherlands, and Diagnosis from Germany.

Table 4. 10 most relevant sources in medical education research

Sources	Articles	Country	SJR 2022	H-Index
BMC Medical education	115	United Kingdom	0.914	87
Medical Education	81	United Kingdom	1.629	155
Medical Teacher	81	United Kingdom	1.217	131
Academic Medicine	69	United States	1.579	173
Advances in health sciences education	60	Netherlands	1.200	75
Diagnosis	47	Germany	1.172	26
Journal of General Internal Medicine	33	United States	1.814	203
MedEdPORTAL	32	United States	0.498	14
Medical Science Educator	26	United States	0.393	20
Teaching and learning in medicine	24	United States	1.145	55

SJR = Scimago Journal Ranking

Table 5 presents the top 10 globally cited articles in medical education research, along with their titles, authors, publication years, total citations (TC), and total citations per year (TCpY). These articles cover a range of topics, including professional competence, medical expertise theory, clinical reasoning, risk prediction models, virtual patients in

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education, cognitive interventions to reduce diagnostic error, stroke recognition instruments, and teaching clinical reasoning. Given their high citation counts, these articles likely offer seminal insights and evidence-based practices that are pivotal for understanding key concepts and advancing research in medical education.

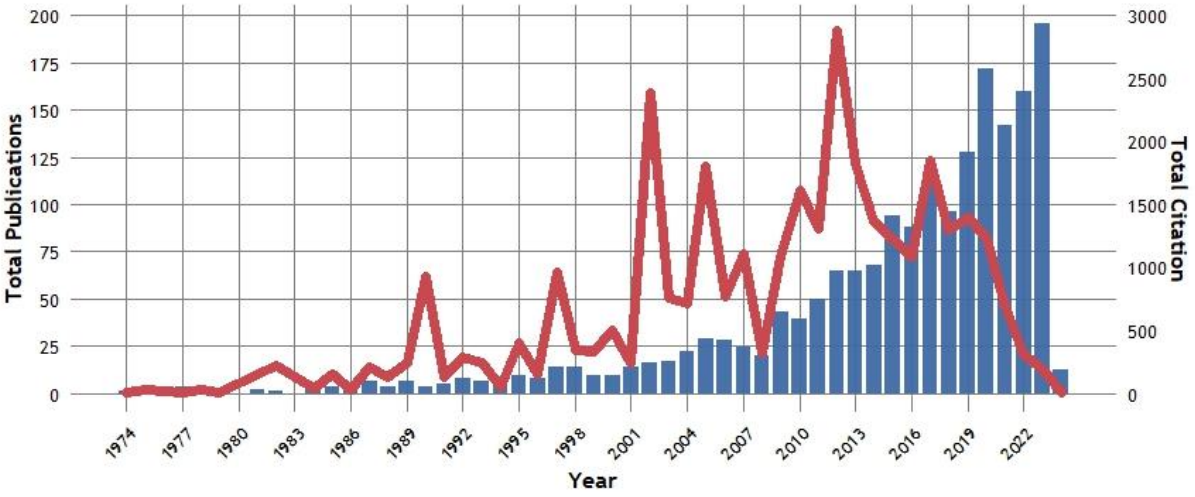
Table 5: Top 10 globally cited articles

Author	Title	Year	TC	TCp
Epstein and Hundert	Defining and Assessing Professional Competence	200	192	83.4
Schmidt, Norman and Boshuizen [14]	A cognitive perspective on medical expertise theory and implication [published erratum appears in Acad Med 1992 Apr;67(4):287]	1990	913	26.09
Norman G. [15]	Research in clinical reasoning: past history and current	200	635	31.7
Moons et al. [16]	Risk prediction models: I. Development, internal validation, and assessing the incremental value of a new (bio)marker	2012	634	48.77
Estrada, Isen and Young [17]	Positive Affect Facilitates Integration of Information and Decreases Anchoring in Reasoning among Physicians	1997	396	14.14
Cook, Erwin and Triola [18]	Computerized Virtual Patients in Health Professions Education: A Systematic Review and Meta-Analysis	2010	347	23.13
Graber et al. [19]	Cognitive interventions to reduce diagnostic error: a	201	324	24.9
Croskerry P. [20]	Cognitive Forcing Strategies in Clinical Decisionmaking	200	298	13.5
Nor et al. [21]	The Recognition of Stroke in the Emergency Room (ROSIER) scale: development and validation of a stroke recognition instrument	2005	277	13.85
Kassirer J. [22]	Teaching Clinical Reasoning: Case-Based and Coached	201	262	17.4

TC = Total citations TCpY = Total citations per year

Figure 1 illustrates the trends in total publications and total citations within medical education research from 1974 to 2024.

Figure 1: Publications and citations over time – Blue bars (Total Publications); Red Line (Total citations)



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The VOSviewer network visualization map of the co-occurrence of authors keywords analysis in medical education research reveals 12 distinct clusters representing interconnected thematic groupings (Figure 2). These clusters provide a comprehensive overview of the interconnected themes and topics within the realm of medical education research.

Figure 2: Network visualization map of the co-occurrence of keywords

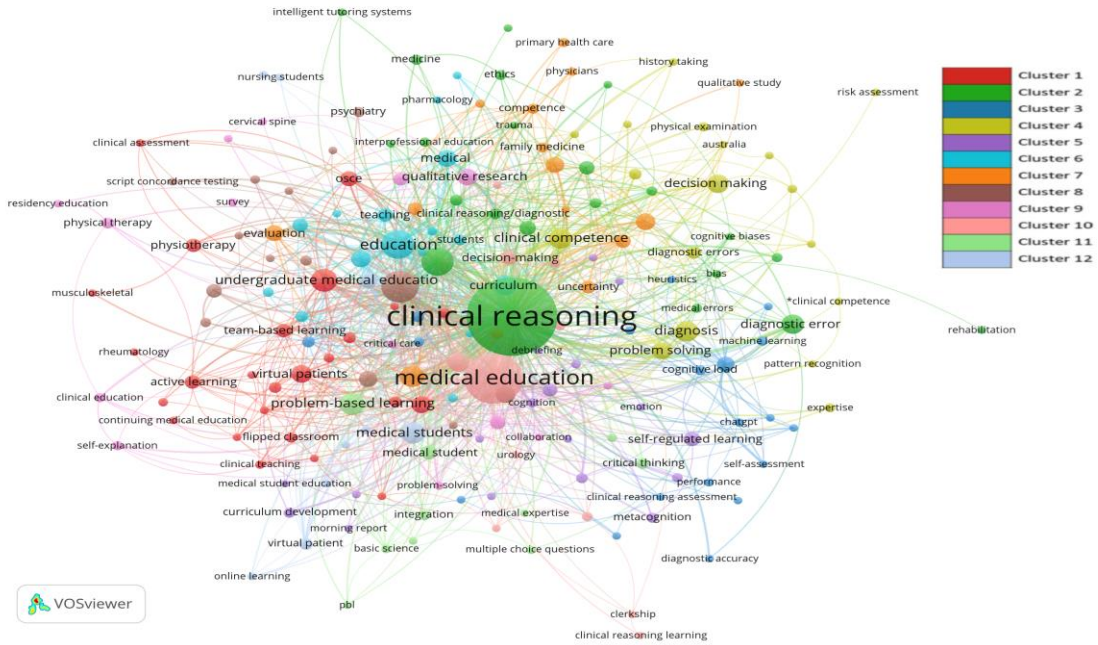

Figure 3 presents the temporal evolution of trend topics in clinical reasoning assessment within the field of medicine. The X-axis denotes the years during which specific keywords attained peak relevance, while the Y-axis enumerates the keywords under consideration. Each data point is represented by a ball, wherein the average year of keyword relevance is visually depicted, with the size of the balls corresponding to the frequency of keyword usage over time. This graphical representation offers insights into the temporal dynamics and prominence of various keywords in clinical reasoning assessment research, facilitating a nuanced understanding of prevailing themes and their longitudinal trajectories within the medical education domain.

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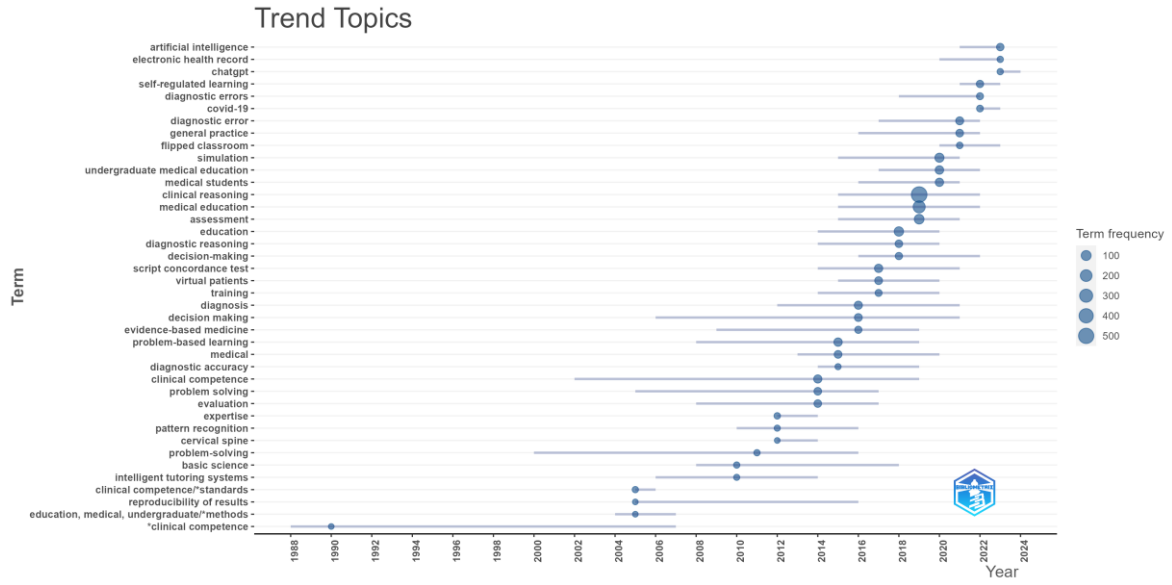
Figure 3: Trend topics in clinical reasoning assessment in medicine over time



DISCUSSION

In this study, we conducted a comprehensive bibliometric analysis of clinical reasoning assessment in medicine. While numerous review studies have explored clinical reasoning assessment and related aspects [23–25], to our knowledge, this study represents the first bibliometric analysis in this domain. Therefore, we undertook this current study to offer a different perspective on the field. We included 1827 publications published since the early 1970s, retrieved from the Scopus database, in our bibliometric analysis. We discussed the bibliometric analysis findings in relation to the five research questions.

Firstly, articles stand out as the primary document type, reflecting the active scholarly engagement and dissemination of research findings in medical education. The presence of diverse document types, such as reviews and other scholarly outputs, underscores the varied methodologies utilized in medical education research. The predominance of English as the primary language of publication aligns with the international reach and accessibility of medical education scholarship, while the inclusion of publications in other languages emphasizes the global nature of scholarly discourse, fostering cross-cultural perspectives and collaborations essential for advancing medical education practice and scholarship.

Secondly, the exploration of significant sources and publications in clinical reasoning assessment research reveals a dynamic landscape influenced by leading journals such as BMC Medical Education, Medical Education, and Medical Teacher, primarily from the United Kingdom, alongside globally renowned sources like Academic Medicine (USA), Advances in Health Sciences Education (Netherlands) and Diagnosis (Germany), each playing a pivotal

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role in shaping the landscape of medical education research. These findings underscore the international collaboration and diversity of sources contributing to advancements in medical education.

Analysis of top-cited articles, including seminal works by Epstein and Hundert [13], Schmidt, Norman, and Boshuizen [14], underscores foundational insights into professional competence and cognitive perspectives in medical expertise theory. These influential sources not only enrich our understanding of clinical reasoning assessment methodologies but also inspire evidence-based practices and future research directions within medical education.

Thirdly, both total publications and total citations exhibit a general upward trajectory over the years, punctuated by fluctuations in certain periods. The surge in citations notably began in the early 2000s, reaching a peak around articles published in 2012 and 2013. It is important to note that newer articles, having had less time available, have not yet received as many citations. Despite this, the number of publications continues to rise steadily, reaching its pinnacle in 2023, indicating a persistent trend of growth in research related to clinical reasoning assessment. Please note that data for 2024 is partial as it is restricted up to February 10th.

Fourthly, the VOSviewer network visualization map of the co-occurrence of authors keywords analysis revealed 12 clusters. We could identify that cluster 1 focuses on medical education and training practices, encompassing terms such as active learning, bedside teaching, and virtual patients. Cluster 2 revolves around clinical practice and patient safety, featuring keywords like clinical reasoning, diagnostic error, and patient safety. Cluster 3 explores technological advances and AI innovations in clinical reasoning and diagnostic accuracy, including terms like artificial intelligence and machine learning. Cluster 4 delves into the foundations of clinical competence and education, covering topics like diagnostic errors, decision-making, and clinical competence standards. The subsequent clusters, numbered 5 to 12, elucidate various aspects of cognitive processes, undergraduate medical curriculum, family and general medicine, assessment methods, clinical decision-making processes, clinical skill development, critical thought, problem-based learning, and tech-enabled learning.

Fifthly, Figure 3 shows the trend topics in clinical reasoning assessment in medicine over time. Throughout the 1980s, discussions surrounding "clinical competence" gained prominence, reflecting a growing recognition of the importance of sound clinical judgment

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among medical practitioners. As the decade progressed, these foundational concepts laid the groundwork for ongoing efforts to standardize and assess competency among healthcare professionals. In the 1990s, the discourse on "clinical competence" continued to dominate medical education, indicating a sustained focus on competency assessment and professional development within the field.

The turn of the millennium ushered in a new era of medical education characterized by innovative teaching methodologies like "problem-based learning" and "intelligent tutoring systems" The early 2000s saw a shift towards experiential learning approaches aimed at fostering critical thinking and practical problem-solving skills among healthcare learners. As the decade unfolded, these methodologies gained traction, reflecting a broader trend towards learner-centered education and competency-based assessment.

By the 2010s, the landscape of medical education had evolved significantly to encompass a broader focus on "evidence-based medicine", "assessment" and "script concordance test". These emerging trends underscored a growing emphasis on empirical validation and accountability in healthcare practice and education. Furthermore, the advent of the COVID-19 pandemic in the early 2020s catalyzed rapid transformations in medical education and practice, prompting a renewed emphasis on topics such as "covid-19" and "diagnostic error." These emerging themes highlighted the urgent need for adaptability, resilience, and patient safety in the face of unprecedented challenges.

Moreover, the increasing integration of "artificial intelligence", "electronic health record" and "chatGPT" technologies underscored a broader trend towards digitalization and innovation in healthcare delivery and education. Additionally there was a notable surge in interest in "self-regulated learning" and "flipped classroom" models, reflecting a growing recognition of the importance of learner autonomy and active engagement in medical education.

The findings of this study are based on data freely available in the Scopus database, allowing for transparency and reproducibility. Despite the comprehensive analysis, certain limitations must be acknowledged. The study's reliance on Scopus data may introduce biases inherent in the database's coverage and indexing practices. Furthermore, the bibliometric analysis might overlook contributions from non-traditional sources or languages not well-represented in Scopus. Additionally, while citation metrics offer insights into research impact, they may not fully capture the quality or relevance of publications. Future

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research should consider multi-database approaches and alternative impact indicators to mitigate biases and enhance analysis robustness.

CONCLUSIONS

This bibliometric analysis of clinical reasoning assessment literature underscores the dynamic nature of medical education research over the past five decades. Through an examination of document types, languages, influential sources, and thematic trends, this study reveals a robust scholarly discourse characterized by a proliferation of articles and a growing emphasis on innovative methodologies and technologies. The identification of influential sources and globally cited publications underscores the diverse contributions shaping the field, while the temporal evolution of trend topics highlights dynamic shifts in educational paradigms and emerging priorities. Overall, this analysis provides valuable insights for educators, researchers, and practitioners, informing future research endeavors and facilitating advancements in clinical reasoning assessment methodologies and medical education practices worldwide.

Moving forward, embracing innovative methodologies such as artificial intelligence, electronic health records, and ChatGPT. These trends reflect a dynamic shift towards the use of technology to enhance diagnostic accuracy, decision-making processes and electronic assessments.

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AUTHOR CONTRIBUTIONS

All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

COMPETING INTERESTS

Authors state no conflict of interest.

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