Education in Medicine Journal

REVIEW ARTICLE

Title: Mapping the Knowledge Structure of Online Learning Research in Health Sciences Education: A Bibliometric Network Analysis

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Submitted Date: 26-02-2024

Accepted Date: 08-06-2025

Please cite this article as: Azizan A. Mapping the Knowledge Structure of Online Learning Research in Health Sciences Education: A Bibliometric Network Analysis. Education in Medicine Journal. 2025 (early view).

Mapping the Knowledge Structure of Online Learning Research in Health Sciences Education: A Bibliometric Network Analysis

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ABSTRACT

Online learning has become a vital tool in health sciences education, transforming access to content and pedagogical approaches across medicine, nursing, pharmacy, dentistry and more. This bibliometric analysis aimed at illuminating the knowledge structure underlying research on online learning across health disciplines. Using the Web of Science and Scopus databases, 2,436 publications between 1981 and 2024 were analyzed for trends, contributors, citations, and conceptual themes. Results showed an exponential growth trajectory, indicating rising prominence of e-learning research. The United States led in terms of productivity, followed by other Western nations and emerging countries. Highly cited works established e-learning's viability if well-implemented, but uncertainties regarding competency development and blended models remained. Analysis of author keywords revealed a multidimensional scope spanning technologies, pedagogy, learner experiences, pandemic impacts, assessments, and health disciplines. However, comparative research across fields and stakeholder perspectives beyond academia are limited. While the exponential knowledge base growth confirms e-learning's increasing role in transforming health professions education, critical gaps persist around equitable access, infrastructure, faculty training, blended models, competency tracking, and translating evidence to practice. Proactive efforts engaging diverse stakeholders, strengthening developing country participation, utilizing mixed methods, and addressing persistent challenges are vital future directions. This bibliometric analysis provides valuable insights into the structure and evolution of research on integrating online learning in the health professions.

Keywords: *Bibliometric analysis, Education, E-learning, Health sciences, Online learning*

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INTRODUCTION

Online learning has become a vital tool for health professional education in recent years. Defined as the delivery of educational content through the internet, online learning has played a crucial role in providing flexible and accessible learning opportunities for health professionals (1). The growth of e-learning platforms, digital resources, and educational technologies has transformed access to contentand pedagogical approaches across fields like medicine, nursing, pharmacy, dentistry, and more (2,3). The use of online learning in health sciences education has significantly affected the way students and professionals acquire, retain, and apply knowledge in their respective disciplines (2,4). The benefits of online learning in health sciences education are numerous, including increased accessibility, flexibility, and the ability to reach a larger and more diverse audience (5-7). Additionally, the integration of multimedia, interactive assessments, and virtual simulations has enhanced the learning experience and improved knowledge retention (8)

Health sciences education is crucial for the sustainability of health services. Medical schools play a vital role in producing skilled professionals, advancing health research, and ensuring quality patient care (9). The cost and logistical requirements of traditional medical education have led to a growing interest in e-learning among educators in the field. Research has indicated similar outcomes between e-learning and face-to-face education in medical schools, further driving the adoption of online learning platforms within this academic discipline (10,11).

Assessing the capacity of different countries and global regions to offer equitable and accessible e- learning in health sciences education is crucial. The absence of e-learning in any country is viewed as a limitation, indicating an inadequate response of the education system to natural disasters or infectious disease outbreaks like COVID-19. One potential way to gauge a country's capacity for implementing and embracing e-learning methods is by examining the quantity and caliber of research papers on e-learning methodologies.

Considering the rapid growth of online learning in the health discipline, bibliometric analysis can provide important insights (12) into the structure, productivity, collaboration, and conceptual focal areas of this emerging research domain. By mapping publication and citation patterns, this study delineated the scope, influential works, networks, and knowledge clusters that characterize scholarship in this multidisciplinary field. The findings will identify current strengths, gaps, and future directions to research and practice in online health professions education.

The overarching goal of this bibliometric network analysis is to illuminate the knowledge structure underlying online learning research across health disciplines (13). While there are several bibliometric studies that investigated and assessed general research activity on e-learning (12,14-16), no bibliometric study was published on e-learning in health sciences education using both databases such as Web of Science (WoS) and Scopus.

As is widely known, the WoS provides the most comprehensive citation analysis, while Scopus databases excel in clinical medicine and nursing. Both are extensively utilized in the field of health and medical sciences (17). Therefore, a comprehensive bibliometric analysis utilizing both WoS and Scopus databases provides a holistic understanding of the online learning research landscape in health disciplines. To allow the systematic examination of the articles, several research questions were applied:

RQ1: What are the general publication trends within this online learning within health sciences education?

RQ2: Which are the top countries, and institutions that make up the core outlets and knowledge hubs? RQ3: What are the most cited papers and their practical implications?

RQ4: What are the main topics, concepts, and knowledge clusters?

By applying bibliometric techniques to map patterns within the published literature, this study aims to understand the current state of research on online learning in the health discipline while identifying future needs and directions.

METHODS

Search strategy and Output

The search strategy and all relevant keywords used in the query are shown below: Steps Search strategy and keywords

Step 1 Keywords on e-learning = "blended learning" or "b-learning" or "blearning" or "online learning" or "online education" or moocs or "massive open online courses" or m-learning or "mobile learning" or "mlearning" or "virtual learning" or "web-based learning" or "digital learning" or moodle or "e-learning" or "elearning" or "electronic learning" or "internet learning" or "distributed learning" or "network learning" or "tele-learning" or "computer assisted learning" or "web-based learning" or "distance learning" or "learning management system" or "computer-based learning" or "interactive learning" or "learning management system " or "adaptive learning" or "electronic assessment" or "e-assessment" or "eassessment" or "interactive learning" or "web-based learning" or "digital learning" or "computer-assisted instruction" or "web-based learning" or "internet-based learning" or "multi-media learning" or "technology-enhanced learning" or "distributed learning" or "virtual patients" or "virtual microscopy" or "virtual environment" or "virtual learning"*

Step 2 Keywords on medical education = mediical or medicine or "clinical education" or nurs or pharmac* or dental or pharmacolog* or "health profession*" or "public health" or "healthcare provider*" or "health* education" or dentistry or "continuing medical education" or "medical education" or "health sciences" or "medical sciences" or "public health education" or "nursing education" or "public health nursing" or "allied health education" or "health* worker*" or "contin* pharmacy education" or "contin* nurs* education"*

3 #1 AND #2

This study utilized the WoS and Scopus databases to retrieve relevant literature on online learning in health disciplines. The search was conducted on February 25, 2024 using the keywords "online education" AND "health sciences". No date range or language limits were

applied in order to capture all published studies in this field. The initial search returned 3,333 documents from both databases. After excluding irrelevant document types like editorials and news items, 2,723 papers remained. Further screening for duplicates resulted in a final dataset of 2,436 unique papers (2,228 from WoS and 208 from Scopus).

Bibliometric Indicators and Data Analysis

The retrieved documents were analyzed using a range of bibliometric indicators to examine several key aspects. First, publication trends over time were scrutinized through performance analysis of annual output and growth via ScientoPy analysis (18). This allowed for a comprehensive understanding of how research in the field has evolved and expanded. Secondly, productivity metrics were employed to identify active authors, countries, and institutions who contributed to the literature. This analysis shed light on the major contributors and their roles in shaping the discourse.

Furthermore, a science mapping analysis was conducted on author keywords via VOSviewer (19). This helped to determine the research focus and conceptual structure prevalent in the field, providing insights into the main areas of interest and study. Additionally, network analysis techniques were utilized to visualize connections between various elements such as papers, authors, journals, institutions, countries, and keywords. These visual representations offered a nuanced understanding of the relationships and collaborations within the research landscape. Analysis focused on illuminating general publication and citation patterns, collaboration networks, prolific contributors, core journals and publications, and the conceptual structure of the research field.

Trends were analyzed longitudinally to understand the evolution of online health education literature. Network graphs mapped connections between entities to identify clusters, hubs, and pivotal works or researchers. Science mapping examined the conceptual landscape to determine core topics versus peripheral ones. Together, these bibliometric techniques profiled the scope, influence, collaboration, and conceptual themes of research on online learning within health disciplines.

RESULTS

Publication Trends

Fig. 2 presents the publication trends data on research related to online learning in health disciplines between 1981 and 2024. The data shows a clear upward trajectory in publications over time, indicating increasing research attention and output in this domain. In the early years from 1981- 1995, there was relatively little activity, with 0-9 papers per year published. Research interest and productivity picked up slowly in the late 1990s, with annual output rising into the teens. The period from 2000-2010 saw more rapid expansion, with publication counts climbing from the 20s into the 70s and 80s range by the early 2010s.

Major growth occurred in the last decade, as annual output jumped over 100 papers by 2015 and continued rising sharply. The publication surge over the past 5 years is especially noteworthy, with over 260 papers in both the WoS and Scopus yearly since 2020. This points to the continued relevance of online learning as a vital issue and evolving research front in

health sciences education.

Overall, the trend shows an exponential growth pattern typical of an emerging research domain, transitioning from early conceptual foundations to solidification as a distinct field with dedicated scholarship and rising productivity. The data highlights that research on e-learning in the health disciplines has gained significant momentum and reached a critical mass over the past decade. Mapping this growth trajectory provides context on the nascence, evolution, and increasing centrality of this literature.

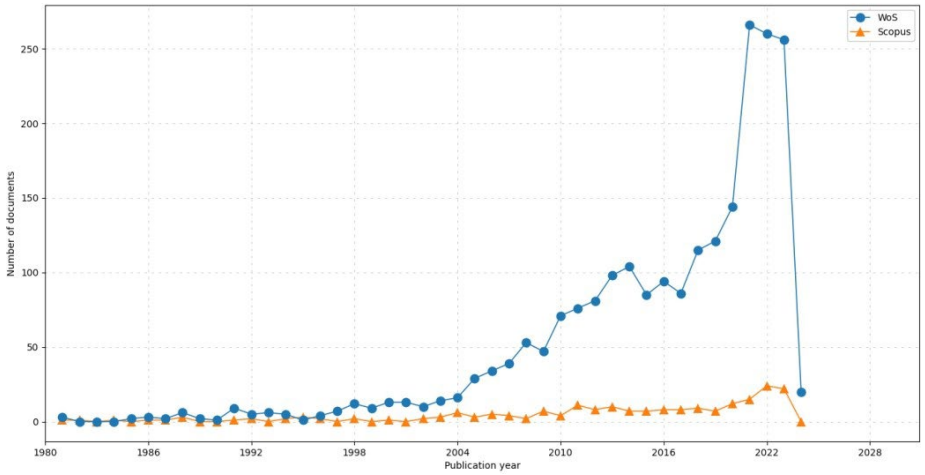

Figure 1: The publication trends
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Top countries and institutions

Figure 2 shows the top 10 most productive countries in research on online learning in health sciences education. The United States ranked as the leading country by a wide margin, with 428 publications contributing to this research domain. This indicates a high degree of interest, resources, and expertise supporting online health sciences education research in the US academic system. The prominence of the US is unsurprising given its overall scientific output, technological innovation, and many influential health sciences schools. The United Kingdom, Germany, Australia, Canada, and China formed the next tier of highly productive countries in this research area. The UK (258 papers) has been an early pioneer in e-learning and has many established health education programs investigating digital innovations. Germany, Australia, and Canada similarly boast advanced universities and medical/health sectors conducive to progress in e-learning. China is rapidly growing its health sciences education infrastructure, reflected in its rising publication output.

Countries like India (100 papers), Iran (92), Saudi Arabia (88) and Taiwan (80) constituted a third tier of moderately productive nations in this research. The activity of developing and technologically maturing countries highlights the global relevance of optimizing online

learning for health education and practice. As e-learning diffuses more widely, its research dimensions will engage more countries seeking to harness technologies for health workforce training. Overall, the international spread of research on this topic reflects its salience for health sciences education systems across varying developed and developing contexts. However, opportunities exist for greater participation from lower- income countries, where e-learning innovations have high potential utility and impact in strengthening health training programs. More diverse global perspectives would enrich the knowledge base.

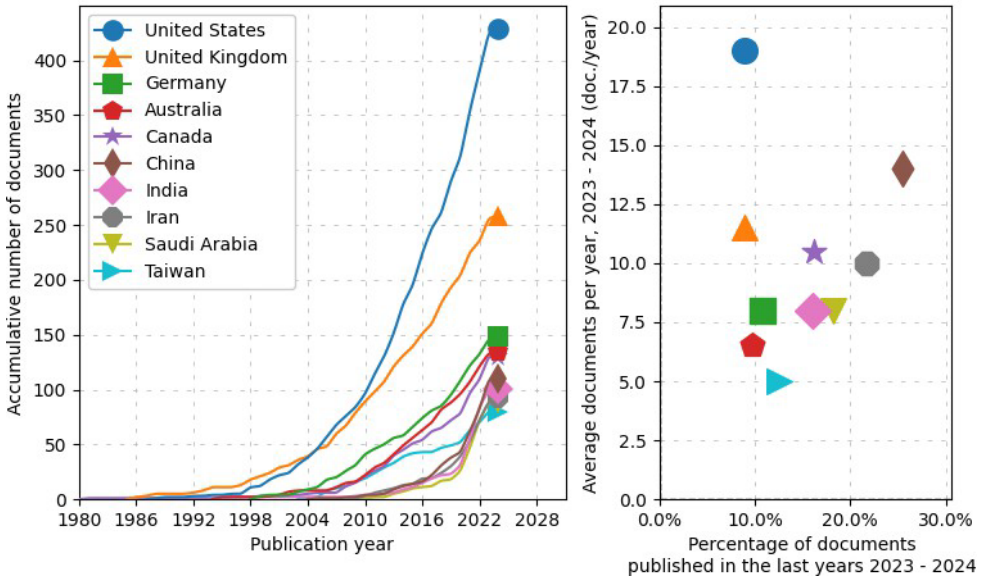

Figure 2: Top 10 active countries

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Meanwhile, Figure.3 presents the top 10 most productive institutions in research on online learning in health sciences education. The institutional analysis shows significant contributions from universities in Canada, Australia, the United Kingdom, Saudi Arabia, and Brazil. King Saud University in Saudi Arabia ranked first with 26 publications, indicating focused research activity on e- learning for health education in the country. The University of Toronto and the University of British Columbia also made strong showings, with 19 and 13 publications respectively. Canada's prominence highlights its established excellence in both health research and online/digital technologies. Australian institutions like Griffith University and the University of Sydney were also well represented, reflecting Australia's reputation as an early adopter of distant education and e-learning innovations. Their health programs have translated this experience into the study of online learning for health disciplines.

Major UK universities including Kings College London and UCL who are in the top 10 demonstrate the country's strengths in health research and education. Brazil's University of Sao Paulo likewise shows the growth of e-learning research capabilities beyond traditional centers. The institutional concentration implies that while e-learning health research has expanded internationally, it remains centered around pioneering universities with specialized expertise and resources. Broadening the contributions from diverse institutions across geographic regions could further enrich this scholarship domain.

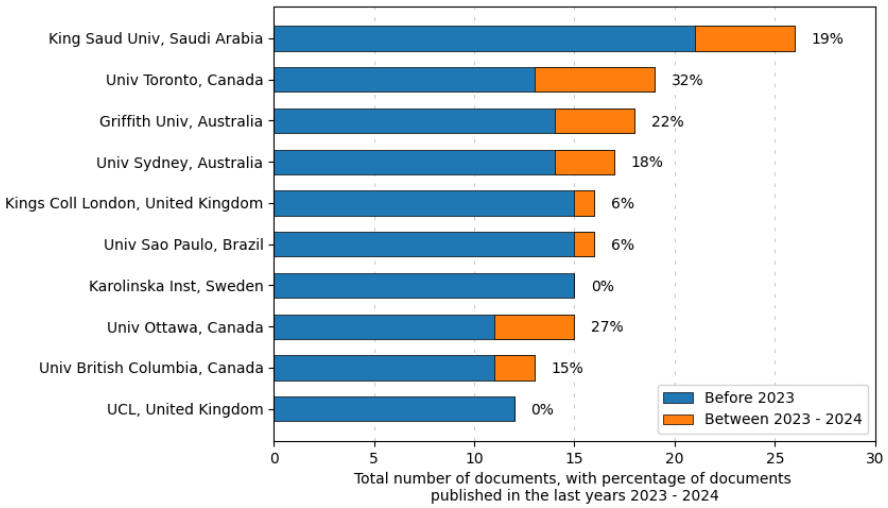

Figure 2: Top 10 active institutions

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Most cited papers and their practical implications

Table 1 presents the 10 most cited papers on online learning in health sciences education and the practical implications of their findings. The most cited paper by Jorge et al. (3) provides an early review on how e-learning can enhance medical education as a complement to traditional instructor- led training. Consequently, this has implications for blending online resources into curricula and providing faculty support/incentives for e-learning efforts. Jo et al. (20) proposed an attention gated network model to improve medical image analysis by focusing on salient regions. This demonstrates the potential of AI-based approaches to augment health education without needing additional external tools. Moreover, Diane et al. (21) identified barriers like lack of institutional support and solutions like instructional design/technology support for online medical education. This highlights the need for a systematic approach in implementing and sustaining e-learning.

Ellaway & Masters (22) put forth foundational principles and best practices for e-learning, teaching and assessment in medical education. Their guidelines provide an important starting point for effectively designing online health sciences training. Similarly, Rehana et al. (23) found that synchronized online learning was positively received by medical students during the pandemic. However, balancing virtual and in-person clinical experiences remains vital. Additionally, McCutcheon et al. (24) showed online learning can teach clinical skills as effectively as face-to-face instruction in nursing curricula when implemented carefully. Blended learning holds promise but requires more research. Furthermore, Pei & Wu (7) demonstrated online learning improves knowledge and skills in undergraduate medical settings, adding to the evidence it should be integrated thoughtfully rather than viewed skeptically.

Mahmoud et al. (25) highlighted distance learning's potential but also its dependence on robust technical infrastructure and support systems, especially in developing countries. Meanwhile,

Alsoufi et al. (9) emphasized online training's role in providing continuous medical education during crises but cautioned that virtual clinical experiences alone are insufficient. Finally, Wutoh et al. (26) established that Internet-based continuing medical education programs can impart knowledge equivalently to in- person formats but questioned whether this knowledge translates to practice. Therefore, these seminal papers provide accumulating evidence on the viability of e-learning in health sciences training when implemented deliberately. However, key questions remain regarding best practices, infrastructure needs, blending with in-person learning, and translating knowledge gains to clinical skills.

Table 1: Top 10 most cited articles (minimum of 300 citations above)

Ranks	Title	Cited by	Practical Implications
1	The impact of e-learning in medical education (3)	1392	• E-learning can enhance medical education and be used as a complement to traditional instructor-led training. • Faculty can be recognized and rewarded for their dedication to e-learning efforts.
2	Attention gated networks: Learning to leverage salient regions in medical images (20)	875	• The proposed attention gate (AG) model improves prediction performance in medical image analysis. • AGs eliminate the need for explicit external tissue/organ localisation modules.
3	Barriers and solutions to online learning in medical education - an integrative review (21)	441	• Postgraduate training bodies and medical schools should be aware of barriers and solutions to online learning in medical education. • Institutional support is crucial for promoting and maintaining online learning.
4	AMEE Guide 32: e-Learning in medical education - Part 1: Learning, teaching and assessment (22)	410	• The paper covers the basics of e-learning, e-teaching, and e-assessment. • It highlights the ability of new approaches to shed light on underlying philosophies and practices in medical education.
5	The sudden transition to synchronized online learning during the COVID-19 pandemic in Saudi Arabia: a qualitative study exploring medical students' perspectives (23)	373	• Synchronized online learning was well-received by medical students. • Preclinical students preferred online lectures for the next academic year.
6	A systematic review evaluating the impact of online or blended learning vs. face-to-face learning of clinical skills in undergraduate nurse education (24)	354	• Online learning for teaching clinical skills is no less effective than traditional means. • More research is needed on the implementation of blended learning for clinical skills.
7	Does online learning work better than offline learning	342	• Online learning can enhance knowledge and skills in undergraduate medical

	in undergraduate medical education? A systematic review and meta-analysis (7)		education. • Offline learning does not show evidence of being more effective.
8	Distance learning in clinical medical education amid COVID-19 pandemic in Jordan: current situation, challenges, and perspectives (25)	320	• Distance learning is a growing approach for undergraduate and postgraduate education. • Technical and infrastructural resources are major challenges for implementing distance learning
9	Impact of the COVID-19 pandemic on medical education: Medical students' knowledge, attitudes, and practices regarding electronic learning (9)	317	• Online training and virtual clinical experience can minimize disruption in medical education. • Hands-on experience should be provided in a safe environment.
10	eLearning: a review of Internet-based continuing medical education (26)	311	• Internet-based CME programs are as effective as traditional formats in imparting knowledge. • More studies are needed to assess if knowledge changes translate into practice.

Main Topics, Concepts, and Knowledge Clusters

In Figure 4, the author's keywords and clustering in this field are presented. There are six clusters based on the author's keywords, with a minimum threshold set at 15 occurrences. A total of 61 keywords met this threshold.

Cluster 1 (red)- Foundational Education Concepts

This cluster represents core educational concepts like curriculum, teaching, and learning which form the theoretical basis for health sciences training, whether online or in-person (3,27). E-learning enables new curricular approaches like problem-based and simulation-based learning to be delivered remotely (28). However, research must examine how virtual delivery affects curricular outcomes compared to traditional face-to-face instruction (7).

Cluster 2 (green) – E-Learning Platforms and Technologies

E-learning, online education, and educational technologies are central platforms enabling remote instruction, flexibility, and blended learning in health education (29). However, studies indicated that simply digitizing content is insufficient; as effective integration requires instructional design, faculty development, and institutional support (30). More research is needed on optimizing web-based platforms, learning management systems, and virtual simulations for health sciences training.

Cluster 3 (blue) – Learner Attitudes, Experiences, and Perceptions

This cluster reflects studies on learner knowledge, satisfaction, attitudes and qualitative experiences with online health sciences education. Student perspectives are vital for understanding engagement and effectiveness (31,32). Key issues include achieving competency, overcoming isolation, fostering interactions, and student support needs. As further supported by Roberts and Rizzolo (33), clinical faculty with completed online training have a more positive attitude towards online learning and better ability to troubleshoot technical issues, while years of teaching experience does not significantly affect their perceptions.

Cluster 4 (yellow)– Pandemic Impact and Emergency Remote Teaching

The COVID-19 pandemic sharply increased remote instruction out of necessity, elevating issues like student perceptions, satisfaction, and learning outcomes due to rapid virtual transitions (34). It is further reported that, an emergency remote education during COVID-19 led to mixed educational outcomes, with ICT platforms usage being mostly positive but personal adaptation being mostly negative (35). This cluster reflects the unprecedented disruption and how it accelerated online education research across health disciplines.

Cluster 5 (turquoise) – Assessment, Motivation and Engagement

Online learning assessments and student motivation/engagements are active research issues, including how technology-enhanced modalities affect performance and self-directed learning (36). Student interactions, satisfaction, and learning strategies also influence outcomes. In addition, it is believed that continuous weekly summative e-assessments significantly increase student engagement and virtual learning environment activity, improving student satisfaction and experience in blended or online learning environments (37). Perhaps, authentic m-learning activities in computer networking courses enhance student engagement and motivation by promoting personal development, satisfaction, and collaboration (38).

Cluster 6 (purple) – Health Discipline Contexts

This cluster represents scholarship within domain-specific fields like medicine, nursing, dentistry, and pharmacy on online transitions. Each discipline has unique needs, competencies, and student populations requiring tailored e-learning research and solutions (39). Comparative studies can elucidate common challenges and successes across health education contexts. In summary, this knowledge structure illustrates active research foci while highlighting opportunities for further scholarship on optimizing online learning for diverse health professions.

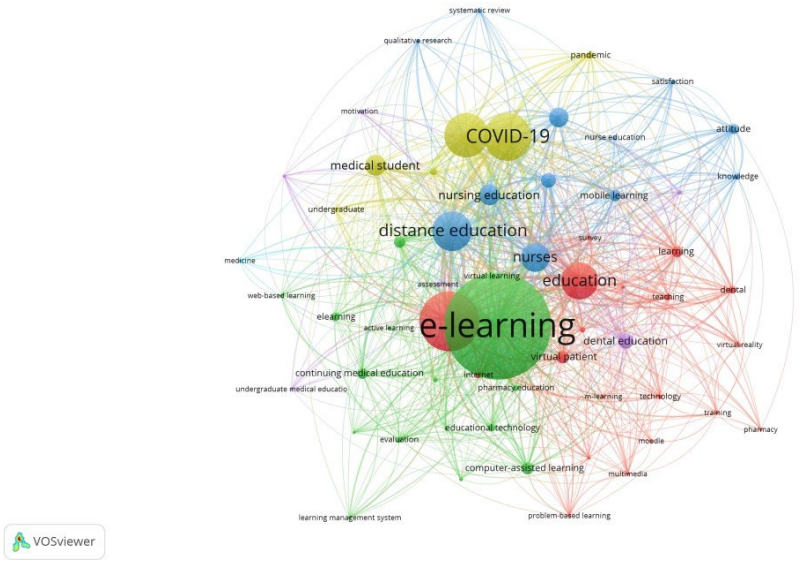

Figure 4: The network visualization of author's keywords
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DISCUSSIONS

This present study provides a comprehensive view of research activity and knowledge structure in the domain of online learning for health sciences education. The exponential growth trajectory indicates rising scholarly interest as e-learning gains prominence globally across medical, nursing, pharmacy, dentistry and allied health (22). While early foundational concepts and technologies enabled this shift, recent research reflects urgent issues sparked by the COVID-19 pandemic's educational disruptions.

The prominence of developed Western nations is expected given their overall research productivity and advanced university systems. However, greater participation from developing countries with rapidly emerging health education infrastructures can provide valuable perspectives on implementing e-learning under resource constraint. Focused research at pioneering institutions has defined discourse, but wider institutional diversity could enrich scholarship.

The practical implications emerging from highly cited papers emphasize e-learning's viability for knowledge gains, but there is lingering uncertainty on translating this to clinical skills. While learner attitudes are generally positive, fostering engagement and motivation in virtual environments remains challenging. Balancing necessary hands-on learning while expanding access and flexibility will be an ongoing balancing act requiring further research.

The knowledge clusters illustrate a multidimensional scope spanning core education concept, technologies, learner experiences, pandemic impacts, assessments, and health disciplines. However, comparative analyses on common challenges and effective strategies across medical, nursing, dental and pharmacy education contexts are currently limited. More convergent research could yield transferable insights to guide context-specific e-learning implementation.

Research foci have responded to urgent necessities, like mitigating pandemic disruptions through emergency remote teaching. However, proactively addressing persistent issues such as equitable access, decentralized infrastructure, faculty development, and blended learning models warrants dedicated attention. Longitudinal studies tracking competencies developed through online versus traditional learning can provide stronger evidence.

While research output has grown exponentially, findings have not necessarily been translated into practice or policy reforms. Most studies emanate from universities, while perspectives from learners, government agencies, accreditation bodies and health sciences associations are scarce. Engaging these stakeholders could help align research with educational needs and priorities on the ground.

Methodologically, more qualitative and mixed-methods studies delving into nuanced learner experiences, faculty viewpoints, and contextual factors would enrich the discourse beyond quantitative outcomes. Scientometric techniques like coupling content analysis with bibliometrics could reveal conceptual and rhetorical shifts over time.

Overall, this systematic bibliometric review provides valuable insights into the structure, prominent contributors, and evolution of online learning research in health sciences education. The findings reveal a solidifying knowledge base, but with critical gaps and future directions to guide evidence- based policies and practices in this vital domain.

CONCLUSION

This bibliometric analysis has provided crucial insights into the knowledge structure, growth trends, prominent contributors, conceptual themes, and research gaps within the domain of online learning in health sciences education. The findings reveal an exponentially expanding evidence base, albeit centered around Western developed nations and pioneering institutions. Highly cited works establish e-learning's viability if thoughtfully implemented, but uncertainties persist around competency development, blended models, learner engagement, and equity barriers. The knowledge structure reflects a complex, multidimensional scope spanning technologies, pedagogy, learner experiences, assessments, pandemic impacts, and health disciplines. Based on identified knowledge gaps, future studies could adopt several new directions and objectives:

- Engage diverse stakeholders beyond academia to strengthen alignment with on-ground educational priorities and needs.
- Widen international perspectives by proactively including developing countries to elucidate region-specific challenges.
- Conduct more comparative research across health disciplines to identify transferable insights.
- Track competency development longitudinally using mixed-methods approaches to deepen understanding.
- Investigate nuanced learner experiences through qualitative studies to inform student-centered e-learning design.
- Analyze conceptual evolution over time using supplementary content analysis coupled with bibliometrics.
- Expand productivity analyses to include other entities like subject categories and

funding bodies.
- Focus dedicated attention on persistent issues like equitable access, infrastructure, faculty development, and blended models.

ACKNOWLEDGEMENTS

The author would like to acknowledge and thank colleagues who helped in the validation process for their recommendations and suggestions.

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