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REVIEW

Research Trends of Health Professions Education Model from 2005 to 2024: A Bibliometric Analysis via CiteSpace

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Objective: This study seeks to offer medical educators, researchers, and clinical practitioners a novel, comprehensive, and visually engaging perspective on the field. It accomplishes this by analyzing the research trends, frontier topics, and pressing issues related to Health Professions Education Model (HPEM) over the past two decades from 2005 to 2024.

Methods: This study employed CiteSpace 6.4.R1 and R-tool (version 4.5.1) software to conduct an analysis of articles pertaining to the Health Professions Education Model within the Web of Science Core Collection (WoSCC) database. The analysis encompassed various aspects, including keywords, disciplines, countries, institutions, authors, and references.

Results: A total of 2,953 articles were incorporated into this study. The predominant research topics within this domain encompassed "interprofessional education (IPE)", "competency-based continuing professional development (CPD)", and "student-led professional experiences (SLEs)." The five countries with the highest number of publications related to Health Professions Education Model (HPEM) were the United States, Australia, Canada, England, and China. Notable authors in this field included Olle ten Cate, Frank Jason R. Eric S. Holmboe, and Carol Carraccio. Additionally, the journals that emerged as the leading publications in this discipline were Academic Medicine, Medical Education, and Medical Teacher.

Conclusion: This study emphasizes the critical importance of international cooperation and exchange, particularly highlighting the necessity to strengthen collaboration among relevant institutions and prominent scholars in Europe, the United States of America, and China. Furthermore, it underscores current trends in the development of HPEM, specifically interprofessional education and competency-based continuing professional development. The research offers valuable insights for medical educators, scholars, and clinicians, enhancing their understanding of prevailing research trends and future directions within Health Professions Education Model.

Keywords: bibliometric analysis, citespace, health professions education, model

Introduction

The Flexner report, published over a century ago, continues to have a profound impact on the Health Professions Education Model (HPEM) today. The Health Professions Education Model (HPEM) represents a comprehensive framework that explores the interconnections between educational systems and health systems. It is centered on individuals as co-producers and primary drivers of needs and demands in both spheres. Through interactions within the labor market, the provision of educational services facilitates the supply of an educated workforce to address the demand for professionals in the health system.[1] HPEM represents the comprehensive culmination of the process involved in the implementation of medical talent education.[2] This model identifies three key dimensions of education: institutional design, which specifies the structure and functions of the education system; instructional design, which focuses on processes; and educational outcomes, which pertain to the desired results.[1]

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The Lancet Commission identified three generations of reforms in Health Professions Education Model.[1] The initial phase of educational restructuring following the Flexner Report placed a significant emphasis on the integration of scientific principles into medical curricula in the early 20th century. Half a century later, the subsequent wave introduced innovative approaches centered around problem-solving methodologies and interactive pedagogical strategies. This paradigm shift emphasized clinical reasoning development through case-based instructional techniques rather than traditional lecture formats, reflecting evolving understandings of medical knowledge acquisition and professional competency formation. Contemporary pedagogical frameworks are undergoing their third wave of pedagogical restructuring, demanding comprehensive systemic strategies focused on optimizing healthcare system efficacy. This transformative process requires context-specific customization of essential occupational proficiencies while strategically implementing internationally recognized expertise. The evolution emphasizes creating synergistic learning environments that bridge theoretical knowledge with practical healthcare applications across diverse cultural landscapes.[3]

Over recent decades, HPEM has undergone significant shifts marked by multiple educational innovations.[4] Key developments encompass competency-driven model,[5] interprofessional and interdisciplinary education model,[6] technology-assisted learning environment,[7] outcome-based education framework, integrated educational approaches, student-centered learning paradigms, among others.[8] The emergence of artificial intelligence has brought forth novel possibilities and complexities within HPEM research. This underscores the necessity of developing a thorough grasp of prevailing research trajectories and intellectual developments in this domain.[9]

However, existing research on HPEM primarily concentrates on specific key components of the model, and there is currently a lack of macroscopic studies examining the temporal changes in the model. Conventional article reviews analyses tend to concentrate on isolated investigative themes or provide selective summaries of pivotal findings within specialized areas, often primarily examining theoretical aspects of academic advancement. Such methodologies demonstrate inherent limitations in capturing the multifaceted nature of scholarly progress across interconnected disciplines. Consequently, this approach falls short in helping readers rapidly and effectively grasp the current state and developmental trends of HPEM research.

Bibliometric analysis is a widely used and rigorous methodology for investigating and analyzing extensive volumes of scientific data. Which focuses on the quantitative evaluation of scientific literature, encompassing aspects such as research hotspots, emerging trends, and academic impact.[10] As a specialized analytical tool, CiteSpace enables multi-dimensional evaluation through institutional citation patterns, collaborative networks among researchers, and thematic co-occurrence mapping across domains.[11] This software implements knowledge domain visualization methodologies to conduct spatial-temporal analysis of academic landscapes, particularly emphasizing citation network dynamics and conceptual evolution trajectories in scientific literature.[11]

This investigation explores the structural evolution and emerging trends within the designated research field. Our methodology employed a scientometric investigation of scholarly works indexed in the Web of Science Core Collection (WOSCC) database, encompassing publications from 2005 through 2024, using CiteSpace analytical tools. This approach enables a systematic examination of research achievements, current developments, and pivotal focus areas in HPEM studies.

Methods

Data Source and Search Strategies

A sophisticated search methodology was implemented within the Web of Science Core Collection (WOSCC) to methodically locate HPEM-related scholarly works published from January 1, 2005, through December 31, 2024 (Figure 1). The comprehensive search protocol executed on January 9, 2025, resulted in a preliminary collection of 2,953 unique articles suitable for subsequent scientometric analysis. The investigation utilized the following search parameters: ((TS= (Health Professions Education model) AND TS= (The model of Health Professions Education)) OR ((TS= (Health Professional Education model) AND TS= (The model of Health Professional Education)).

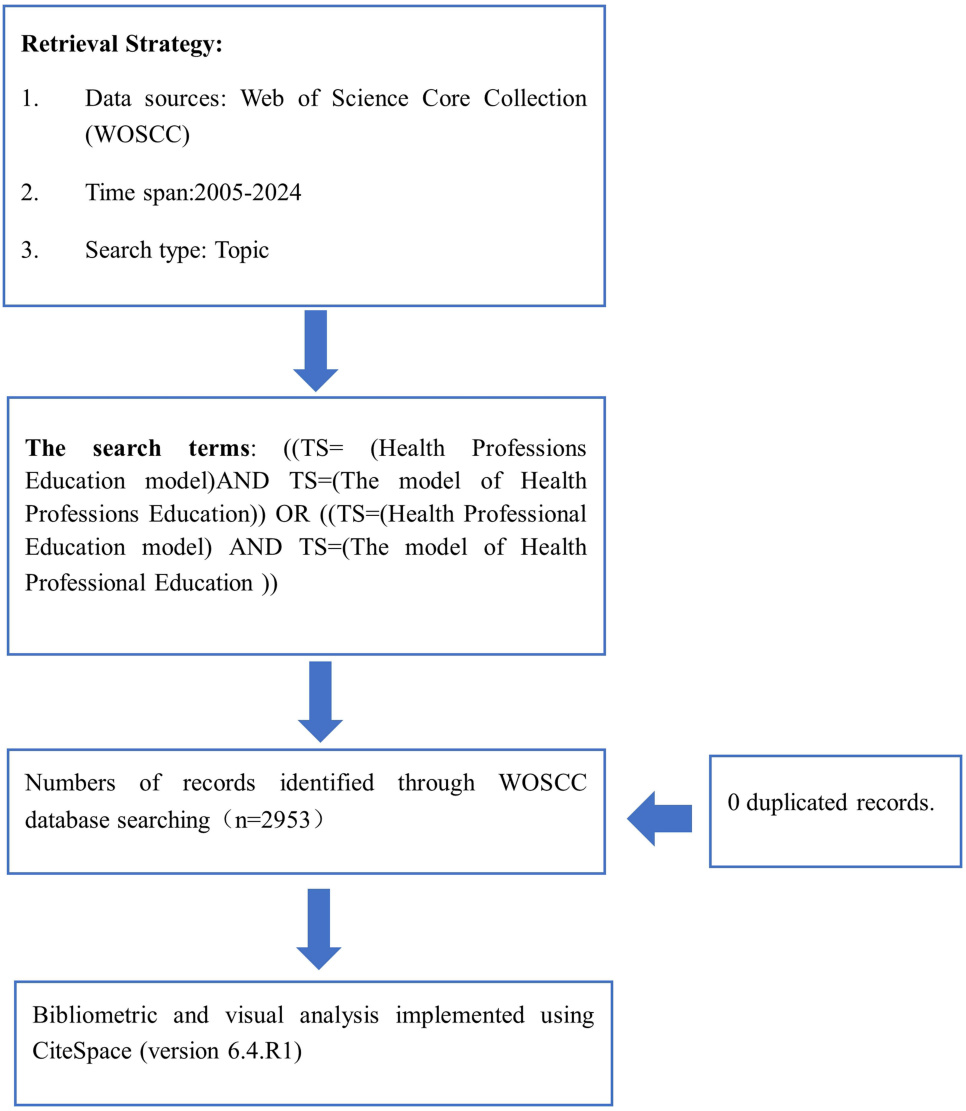

Figure 1 Flow chart of the scientometric study.

Analysis Tools

This research employed CiteSpace (version 6.4.R1, 64 bit), a scientometric analysis software specializing in knowledge domain visualization. Leveraging its capabilities in co-citation analysis, multivariate statistical methods, and time-slicing techniques, the platform methodically constructs visualizations of knowledge domains. This enables the identification of emerging trends and research frontiers within clearly defined temporal and disciplinary parameters. The bibliometric analysis adopted a temporal segmentation approach with 1-year time slice intervals spanning January 1, 2005 to December 31, 2024. Parameter configuration included: (1) Selection criteria: Top 50 most cited articles per slice. (2) Network optimization: Application of network pruning algorithms (Pathfinder and Pruning sliced networks) to enhance topological clarity through elimination of redundant co-citation links.

The knowledge domain visualization comprises discrete nodes and relational linkages, with node categories corresponding to country-level collaborations, institutional affiliations, author networks, and keyword co-occurrence clusters. Node diameter scales proportional to productivity metrics, while linkage width quantifies co-occurrence/ co-citation strength through cosine similarity indices.[11] Furthermore, betweenness centrality serves as an indicator of keyword prominence within the network structure, highlighting their strategic positioning and influence across the academic landscape. In term association networks, elevated centrality scores signify a keyword's pivotal role in facilitating

conceptual linkages. Typically, nodes achieving centrality thresholds exceeding 0.1 are identified as crucial network hubs.[10] Nodes encircled by purple annuli (betweenness centrality ≥ 0.1) designate structural brokers within the network, indicating their role as conceptual transition points mediating knowledge flow across research fronts.[12]

Researchers utilize the CiteSpace clustering methodology, which systematically extracts keywords, titles or abstracts from cited references to generate cluster labels that accurately reflect the co-citation relationships among studies. Each cluster can be regarded as a relatively independent research domain with closely related content and each distinct color block in the figure represents a different cluster region. CiteSpace evaluates the effectiveness of clustering using two metrics: Modularity (Q) and Silhouette (S). Modularity (Q) evaluates the quality of network partitioning, where a higher Q value signifies better-defined clusters. This metric typically ranges between 0 and 1, where values exceeding 0.3 demonstrate meaningful community organization. The Silhouette coefficient (S) measures the homogeneity within clusters; values closer to 1 indicate higher homogeneity. A Silhouette score above 0.7 suggests highly reliable clustering results, while a score above 0.5 is considered reasonable.[13]

The bibliometrix package is an R-based tool designed for comprehensive science mapping analysis. This bibliometric R-package provides quantitative research methodologies applicable to both bibliometrics and scientometrics. It was utilized to assess countries and regions, identify core sources, analyze author keywords and keywords plus, as well as evaluate institutions.[14]

Results

Bibliometric Analysis of Publication Years

The annual volume of scholarly outputs serves as an indicator of research priorities and developmental trajectories within specialized domains. Figure 2 demonstrates the global progression of academic productivity concerning Health Professions Education Model between 2005 and 2024. The quantitative analysis reveals three distinct growth phases in research dissemination. The initial developmental phase exhibits restrained expansion, characterized by yearly averages of about 52 scholarly works, commencing from 2005 to 2010. The subsequent phase, encompassing 2011 through 2018, witnessed steady expansion within this field, reaching an annual output of 167 scholarly works by 2017. The most recent period (2019–2024) saw exponential growth, culminating in 387 peer-reviewed articles published during 2024 alone. This twenty-year progression clearly reflects the maturation of Health Professions Education (HPE) as a global research priority and demonstrates that future investigations into HPEM development are poised to attain new milestones.

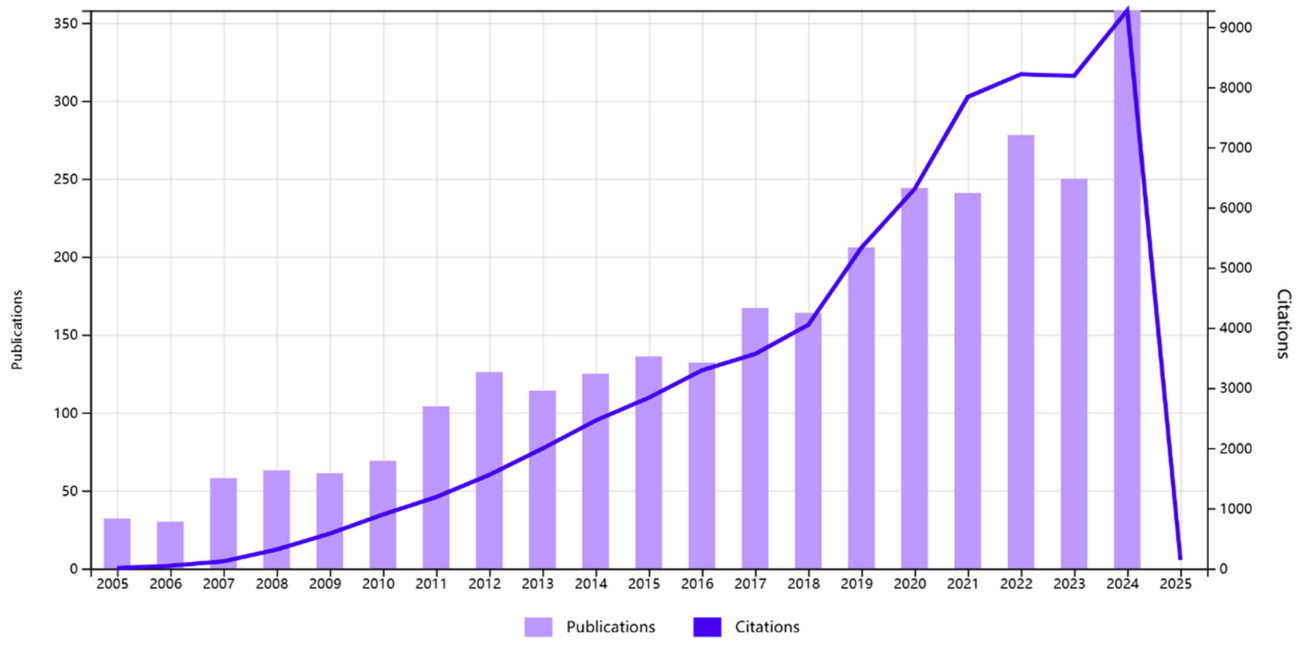

Figure 2 Annual publication and citation trend visualization. Data spans from 1 January 2005 through 31 December 2024.

Co-Occurrence Network Analysis of Author Keywords and Phrases, Cluster and Citation Bursts

Keywords play a pivotal role in academic literature retrieval, serving as condensed representations and conceptual elevation of scholarly works. Through employing visualization tools to examine keyword frequency patterns within research databases, scholars can methodically identify emerging trends and focal points within specific disciplines. Co-occurrence frequency metrics offer a clear depiction of term prevalence across publications, with elevated statistical values indicating greater scholarly attention and thematic relevance within the research community. Scholars have increasingly directed their focus and engagement toward these subject areas.

A keyword co-occurrence network analysis was performed on 2,953 publications spanning January 2005 to December 2024, with annual intervals applied to generate a temporal visualization comprising 593 interconnected nodes and 2,898 relational links (Figure 3A). Each node symbolically represents distinct keywords, where dimensional variations correspond to term prevalence while chromatic variations in nodes and connectors indicate temporal progression from earlier to more recent periods. The analysis revealed ten most frequently occurring keywords including education, model, health, care, medical education, students, impact, healthcare systems, interprofessional education, and outcome (Table 1). The application of visual mapping techniques to phrase examination offers valuable insights into prevailing research priorities and trending subjects within this domain (Figure 3B). Within the highest-ranking 25 phrases, recurrent themes emerged as health professions education, healthcare disciplines, interprofessional education, medical training programs, and healthcare practitioners, which are arranged from highest to lowest based on their occurrence rates.

As illustrated in Figure 3C, the examination effectively reveals eleven separate keyword cluster labels that demarcate specialized research domains within HPEM studies. These research themes are categorized into four distinct groups: The initial classification combines clusters #0 and #8, emphasizing fundamental healthcare delivery systems and population

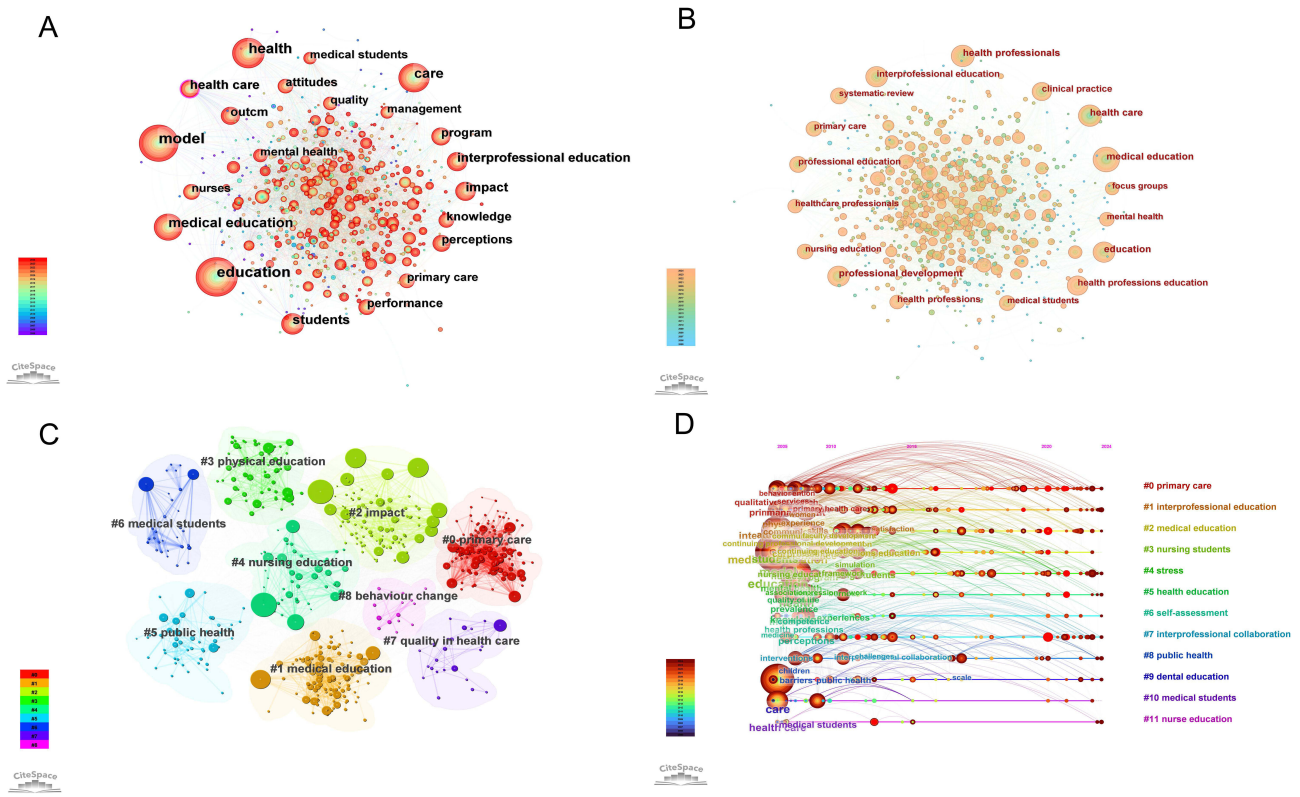

Figure 3 CiteSpace keyword network analysis in HPEM research. (**A**) Co-occurring keyword network diagram. (**B**) Phrase co-occurrence network visualization. (**C**) Keyword cluster analysis. (**D**) Temporal evolution of keyword networks.

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Table 1 High-Frequency Keywords and Phrases in HPEM Studies (Top 10)

Rank	Keywords	Count	Phrases	Count
1	Education	501	Education	243
2	Model	487	Medical education	242
3	Health	326	Health professionals	232
4	Care	312	Professional development	201
5	Medical education	288	Health care	181
6	Students	213	Interprofessional education	174
7	Impact	183	Health professions education	167
8	Health care	170	Clinical practice	156
9	Interprofessional education	154	Health professions	147
10	Outcome	139	Professional education	131

health initiatives, reflecting HPEM's evolutionary progression. The second group encompasses clusters #1, #2, #5, #7, #9, and #11, primarily investigating pedagogical frameworks and methodological innovations in health professions education and its branches. This grouping seeks to deliver both theoretical frameworks and practical insights for the enduring and resilient growth of HPEM through examining multiple factors involved in their formation. The practical orientation within this category emphasizes crucial elements of cross-disciplinary pedagogical research. Clusters (#3) and (#10) constitute the third classification, which examines pedagogical frameworks and career trajectories for medical trainees. Clusters (#4) and (#6) form the fourth classification, focusing principally on this framework centers around strategies designed to improve psychological well-being. It highlights the necessity of sustaining ongoing professional commitment and compassionate patient engagement, while ensuring practitioners receive thorough education in medical humanities to provide superior patient care (Table 2).

Figure 3D displays a chronological visualization of keyword cluster distributions to enhance clarity in referenced literature analysis. Figure 4 highlights the 25 most frequently cited keywords demonstrating citation bursts. Blue lines represent temporal ranges while crimson segments denote periods of intensified keyword citation activity. The lexical item "strategy" exhibits the most prominent citation surge, first emerging in 2017 with exceptional citation frequency

Table 2 Keyword Cluster Analysis

Cluster ID	Size	Silhouette	Cluster Name	Label (LLR)	Average Year
#0	90	0.625	Primary care	Primary care; primary health care; management; focus groups; people	2013
#1	61	0.657	Interprofessional education	Interprofessional education; collaborative practice; pre-qualifying/pre-licensure; surveys; pre-registration	2013
#2	61	0.652	Medical education	Medical education; health professions education; program evaluation; faculty development; continuing education	2015
#3	60	0.677	Nursing students	Nursing students; nursing education; mo education; program	2012
#4	58	0.644	Stress	Stress; social support; mental health; work; anxiety	2015
#5	57	0.687	Health education	Health education; quality of life; outcome; health promotion; project echo	2012
#6	42	0.657	Self-assessment	Self-assessment; school; perceptions; health professions; working	2011
#7	40	0.729	Interprofessional collaboration	Interprofessional collaboration; allied health occupations; global health; interprofessional learning; professional education	2016
#8	37	0.683	Public health	Public health; racism; adolescents; active learning; vaccination	2015
#9	34	0.733	Dental education	Dental education; care; qualitative study; health professionals; cultural competence	2013
#10	28	0.821	Medical students	Medical students; attachment; physician workforce; childhood maltreatment; integrative medicine	2011
#11	16	0.915	Nurse education	Nurse education; clinical placements; clinical education; professional issues; psychology	2012

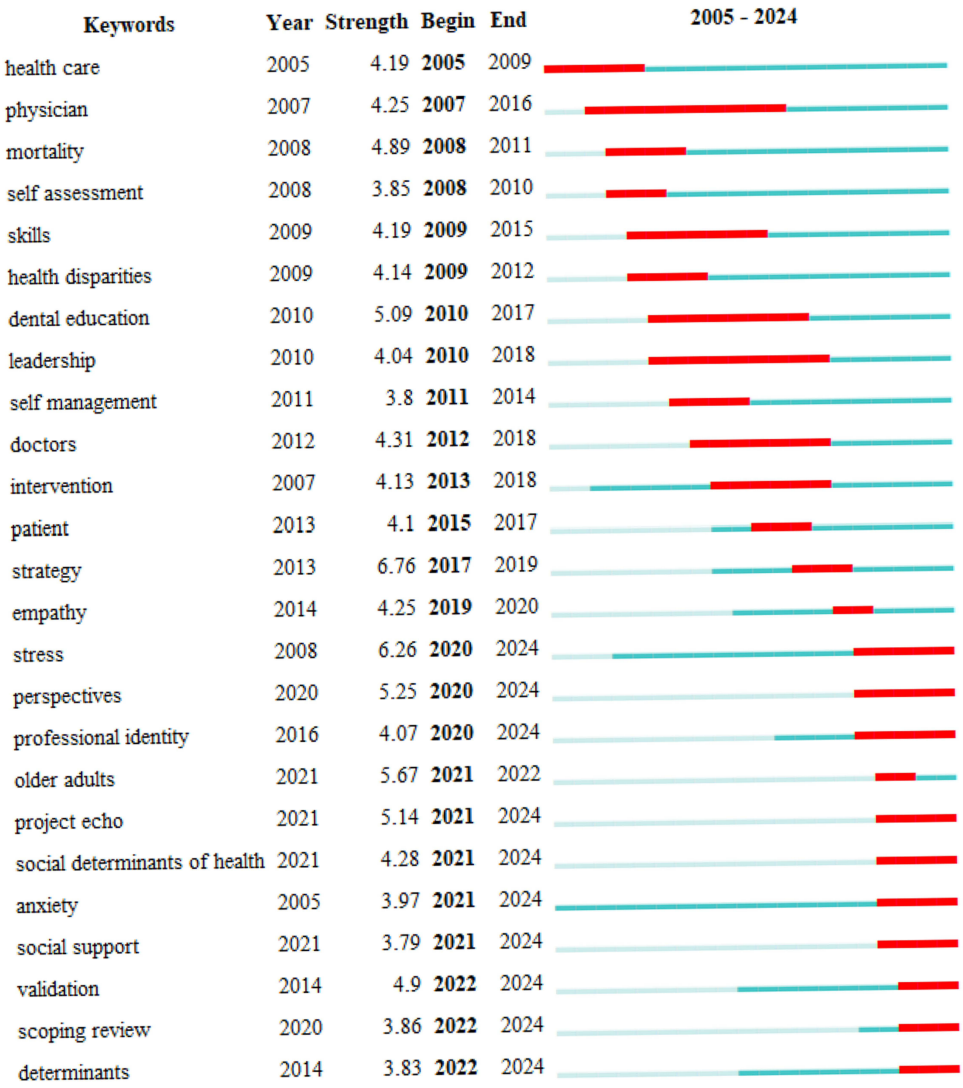

Figure 4 Most influential keywords ranked by citation burst intensity (Top 25).

during that calendar year, reflecting heightened scholarly attention within this research domain during the specified timeframe.

Bibliometric Analysis of Networks of Subject Categories

The analysis of networks comprising subject categories tends to reflect the primary research subfield within HPEM. Figure 5 illustrates that the co-occurring subject categories are predominantly represented in health care science and services, nursing, education and scientific disciplines.

Bibliometric Analysis of Collaboration Networks Across Countries and Institutions

Globally, 132 nations and 465 research organizations contributed publications in the HPEM domain. In this study, the researchers aimed to evaluate the impact of different countries by analyzing several scientometric indices, including the publication counts (Table 3), single-country publication (SCP), multi-country publication (MCP), h-index, g--index, m-index, total citations (TC), number of publications (NP), and publication year (PY).[14] The h-index indicates that a given author has published h articles, each of which has received "h" or more citations. The g-index is calculated for a specific set of articles based on their citation counts ranked in descending order. The m-index is another variant of the h-index that presents the annualized h-index since its initial publication (Table 4).[14] The United States emerged as the

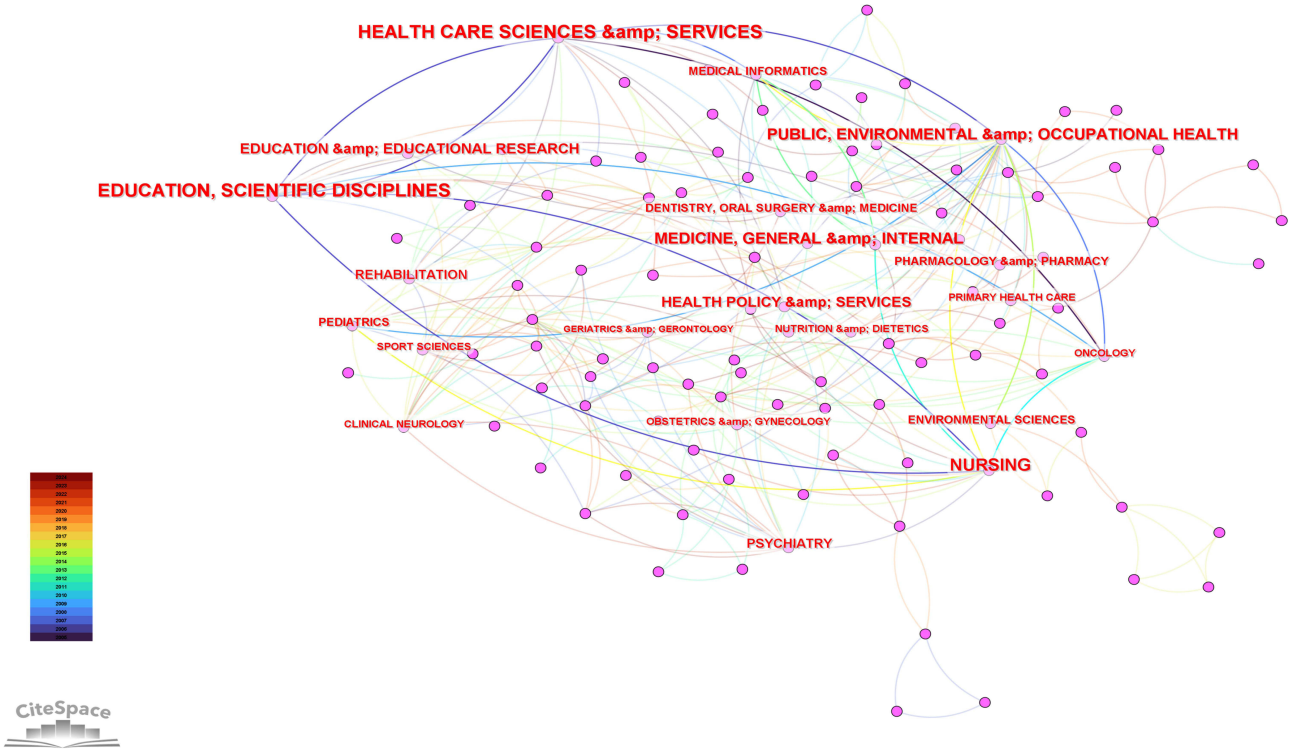

Figure 5 A network map of co-occurring subject categories.

most prolific contributor, with Australia, Canada, the United Kingdom, and China following closely in research output, indicating these nations' pioneering efforts in this domain (Table 5). Analysis of collaboration patterns revealed the United States and England demonstrated exceptional centrality metrics (0.50 and 0.13 respectively), positioning them as crucial hubs within international cooperation networks (Figure 6).

When institutions are selected as network nodes, the visualization produces an organizational distribution pattern comprising 465 interconnected nodes and 1,254 relational links (Figure 7). Analysis of centrality measures reveals the University of California San Francisco as the most influential institution, demonstrating 89 scholarly publications and achieving a centrality score of 0.11. Closely following, the University of Sydney ranks second with 60 research outputs and a comparable centrality value of 0.10. As detailed in Table 5, academic institutions dominate the top ten positions, collectively representing substantial scholarly impact within the research domain.

Table 3 The Top Ten Countries with the Highest Volume of Publications are Listed in Descending Order

Country	SCP	MCP	MCP-Ratio	Total Citations	Average Article Citations
United States of America	800	139	14.8	24,374	26.00
Australia	297	91	23.5	7247	18.70
Canada	200	72	26.5	9965	36.60
The United Kingdom	159	64	28.7	6759	30.30
People's Republic of China	148	37	20	2701	14.60
Brazil	61	13	17.6	663	9.00
Netherlands	32	28	46.7	2587	43.10
Spain	46	5	9.8	432	8.50
Germany	41	7	14.6	686	14.30
Sweden	36	10	21.7	897	19.50

Table 4 The Top 10 Countries in Terms of Influence

Country	NP	h_index	g_index	m_index	PY_start
United States of America	127	217	6.05	101,076	2005
Canada	108	197	5.14	56,302	2005
Australia	80	123	3.81	30,449	2005
The United Kingdom	78	147	3.71	28,829	2005
People's Republic of China	42	66	2.10	7730	2006
Netherlands	42	90	2.10	9538	2006
Italy	41	67	1.95	5450	2005
Sweden	35	62	1.84	4637	2007
France	31	51	1.82	2945	2009
Norway	27	70	1.29	5147	2005

Table 5 The Top 10 Co-Country and Co-Institutions of HPEM Research

Rank	Country	Counts	Rank	Institution	Counts
1	United States of America	1099	1	University of Toronto	124
2	Australia	467	2	University of California System	89
3	Canada	363	3	Harvard University	78
4	England	316	4	University System of Ohio	62
5	People's Republic of China	176	5	Monash University	61
6	Netherlands	125	6	University of London	61
7	Brazil	92	7	University of Sydney	60
8	Sweden	76	8	University of British Columbia	54
9	Spain	76	9	University of California San Francisco	49
10	Germany	71	10	University of Melbourne	49

Bibliometric Analysis of Co-Authorship and Co-Cited Authors

An examination of collaborative networks among citing authors revealed prominent research clusters led by Olle, ten Cate (14 studies), Frank, Jason R (9 papers), Holmboe, Eric S (6 works), and Carraccio, Carol (6 publications)

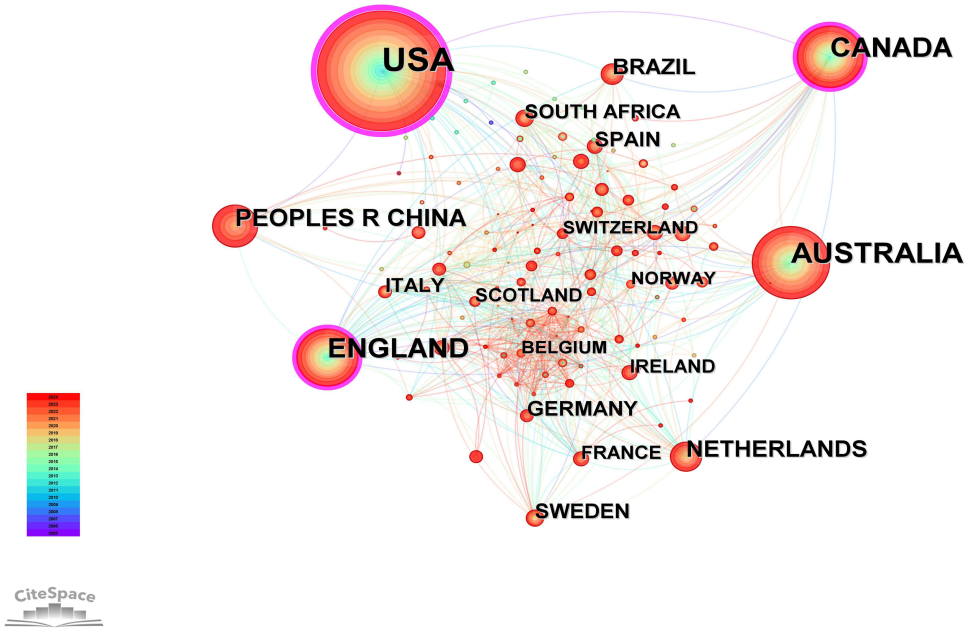

Figure 6 CiteSpace visualization illustrating the countries involved in the research on HPEM.

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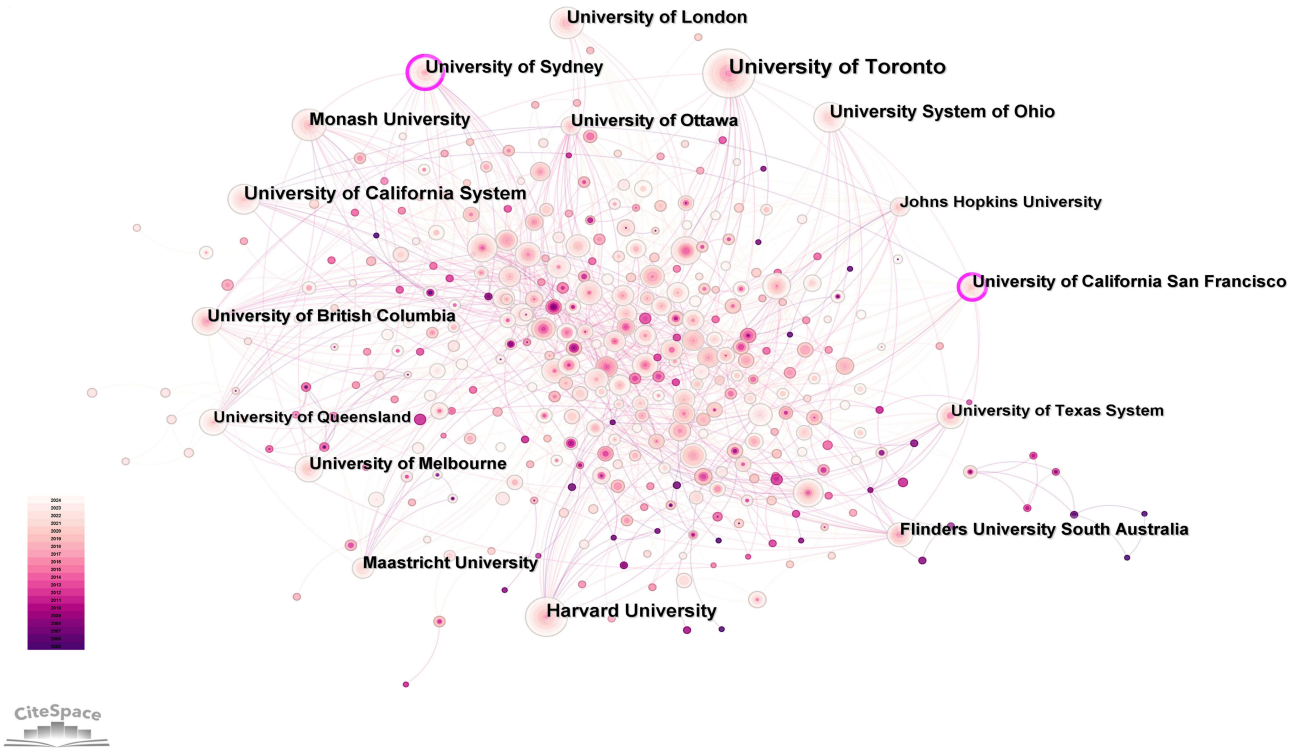

Figure 7 CiteSpace visualization of institutions engaged in the research on HPEM.

(Figure 8A). The second most productive contributor, Frank, Jason R, demonstrates strong collaborative ties with subsequent ranking scholars Holmboe, Eric S and Carraccio, Carol, suggesting the establishment of a cohesive international research alliance. The scholarly alliance primarily revolves around the trio of authors (Table 6), forming a collaborative network that coordinates research activities. This partnership structure demonstrates how intellectual cooperation manifests through coordinated efforts among key contributors, as evidenced by the organizational patterns documented in the referenced data matrix.

Figure 8B illustrates a visualized co-citation network featuring 1,028 interconnected nodes linked through 3,370 connections. This visual depiction underscores the spatial arrangement of frequently cited scholars while enabling the identification of prominent contributors in HPEM studies. Significantly, the data points corresponding to Epstein RM and Frenk J appear highlighted with purple borders and demonstrate elevated betweenness centrality scores, suggesting their crucial function as knowledge bridges that have enhanced collaborative efforts across research teams.

Bibliometric Analysis of Co-Citation Network Across References

The citation network within HPEM studies encompassed 104,547 scholarly sources, featuring 929 distinct nodes interconnected through 1,476 citation relationships. The most frequently cited work emerged as Virginia Braun's seminal paper "One size fits all? What counts as quality practice in (reflexive) thematic analysis?" published in Qualitative Research in Psychology, which occupied the central position in the co-citation visualization (Figure 9A).

The co-citation network analysis revealed 18 distinct clusters, exhibiting strong structural organization (Q=0.9171) and exceptional cluster cohesion (S=0.9587), which substantiates the validity and differentiation of these groupings (Figure 9B) and Table 7 comprehensively outlines the characteristics of the ten most frequently cited references, with data indicating that the current scholarly emphasis centers around interprofessional education (Cluster #0). The chronological visualization map systematically illustrates the temporal progression and thematic development across these research domains. Figure 9C illustrates the visual representations of co-citation reference networks generated by CiteSpace. Panel A displays the interconnected network diagram of cited references, while Panel B presents the clustered

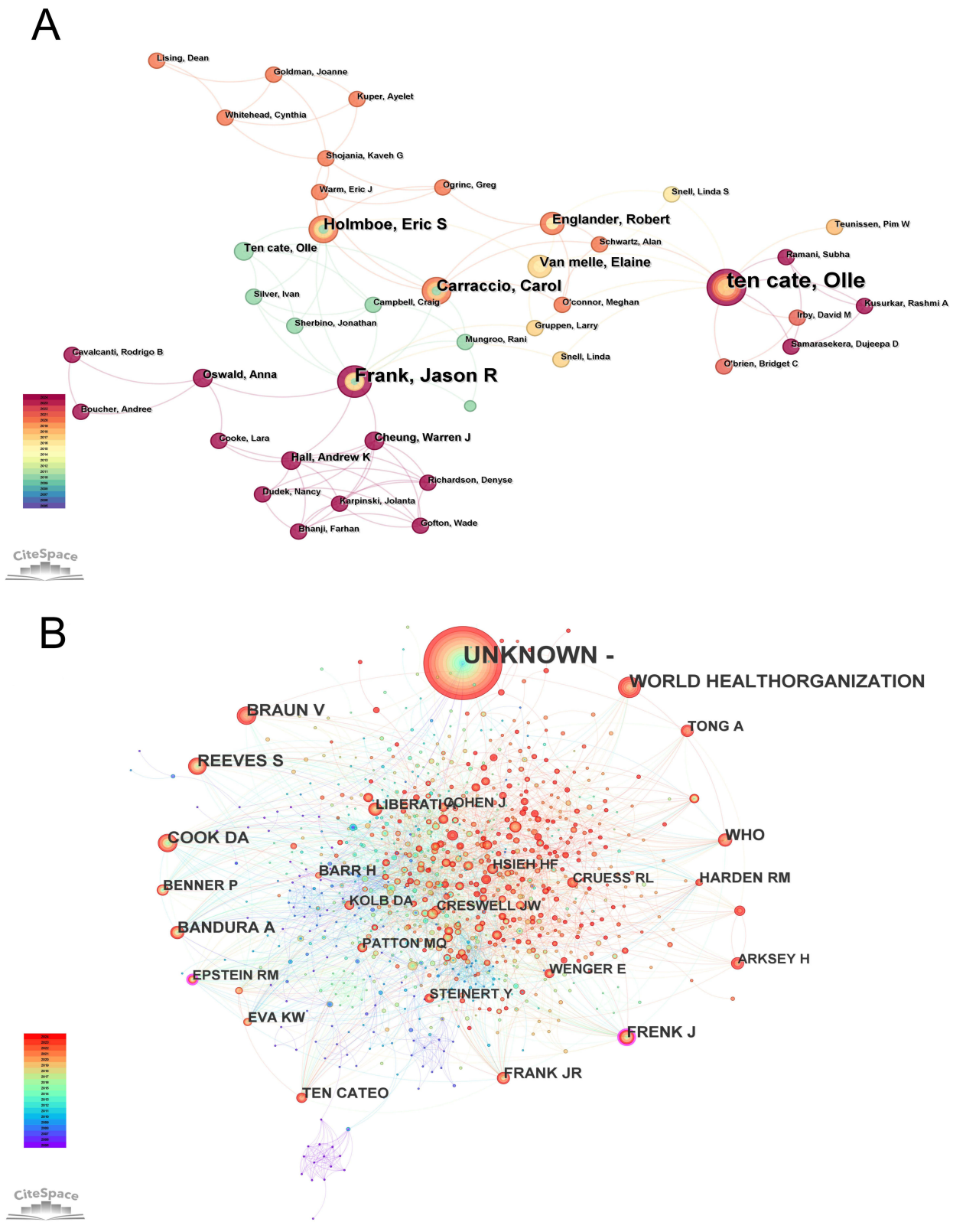

Figure 8 CiteSpace visualization of authors. (**A**) Co-authorship network. (**B**) Author co-citation network.

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Table 6 The Leading Ten Authors and Their Respective Organizations

Rank	Author	Institution, Country	Counts
1	Olle, ten Cate	University Medical Center Utrecht, Netherlands	124
2	Frank, Jason R	University of Ottawa, Canada	89
3	Holmboe, Eric S	University of Pennsylvania Graduate School of Education, United States of America	78
4	Carraccio, Carol	University of Maryland School of Medicine, United States of America	62
5	Cook, David A	Mayo Clinic, United States of America	61
6	Chan, Teresa M	University of Toronto, Canada	61
7	Englander, Robert	University of Minnesota, United States of America	60
8	Van Melle, Elaine	Queen's University, Canada	54
9	Atkins, Lou	University College London, England	49
10	Van der Vleuten, Cees	Maastricht University, Netherlands	49

grouping pattern of these references. Panel C chronologically maps the temporal development and evolutionary pathways of clustered references.

Bibliometric Analysis of Co-Citation Networks Across Journals

Researchers constructed a co-citation journal network to offer scholars critical perspectives on foundational knowledge resources and appropriate publication venues for their research (Figure 10A). From the 857 distinct journals cataloged, the three most cited publications emerged as Academic Medicine (n=966), Medical Education (n=798), and Medical Teacher (n=768). These periodicals have played a pivotal role in shaping HPEM scholarship. The most recently emerging influential journal was the International Journal of Environmental Research and Public Health, highlighting its notable impact and substantial contributions within this academic domain (Figure 10B).

Discussion

This investigation carried out an extensive literature search across the Web of Science Core Collection (WoSCC) databases, examining scholarly articles on HPEM studies published from 2005 to 2024. The research team identified and examined 2,953 relevant publications through systematic retrieval. Geographical analysis revealed the United States, Australia, Canada, England, and China as the primary contributors to this field. The inclusion of China among these prominent research nations demonstrates notable progress in HPEM investigations within developing economies, highlighting the expanding global engagement in this scientific domain.

To delineate the emerging frontiers and evolutionary trajectories in HPEM research, a dual-layer scientometric analysis was conducted, encompassing both author keyword co-occurrence analysis and co-citation network analysis. This revealed three predominant thematic clusters: interprofessional education, competency-based continuing professional development, and professional student-led experiences. The initial research trend focused on interprofessional education (IPE). Interprofessional education emerges as learners across diverse disciplines engage in reciprocal learning processes involving mutual knowledge exchange and collaborative skill development, ultimately promoting synergistic teamwork and optimized patient care outcomes.[15] This pedagogical paradigm aims to cultivate interprofessional collaborative competencies (ICC) comprising domain-specific knowledge, procedural skills, and shared value systems that ultimately translate into observable team-based clinical performance metrics and interprofessional identity formation. In addition, this translational pedagogy ultimately aspires to optimize care coordination metrics through sustained implementation of evidence-based team care models that synergize discipline-specific expertise toward patient-centered outcome maximization. The global recognition of interprofessional education (IPE) as a pedagogical imperative emerged in the mid-1980s, formalized through landmark institutional initiatives. This period witnessed the establishment of The Journal of Interprofessional Care in 1986, marking the creation of the inaugural scholarly publication dedicated to advancing collaborative practice research. The academic community increasingly prioritized research in interprofessional education (IPE). A landmark event occurred in 1987 when the United Kingdom saw the emergence of the Center for the Advancement of Interprofessional Education (CAIPE), which formulated foundational models for developing

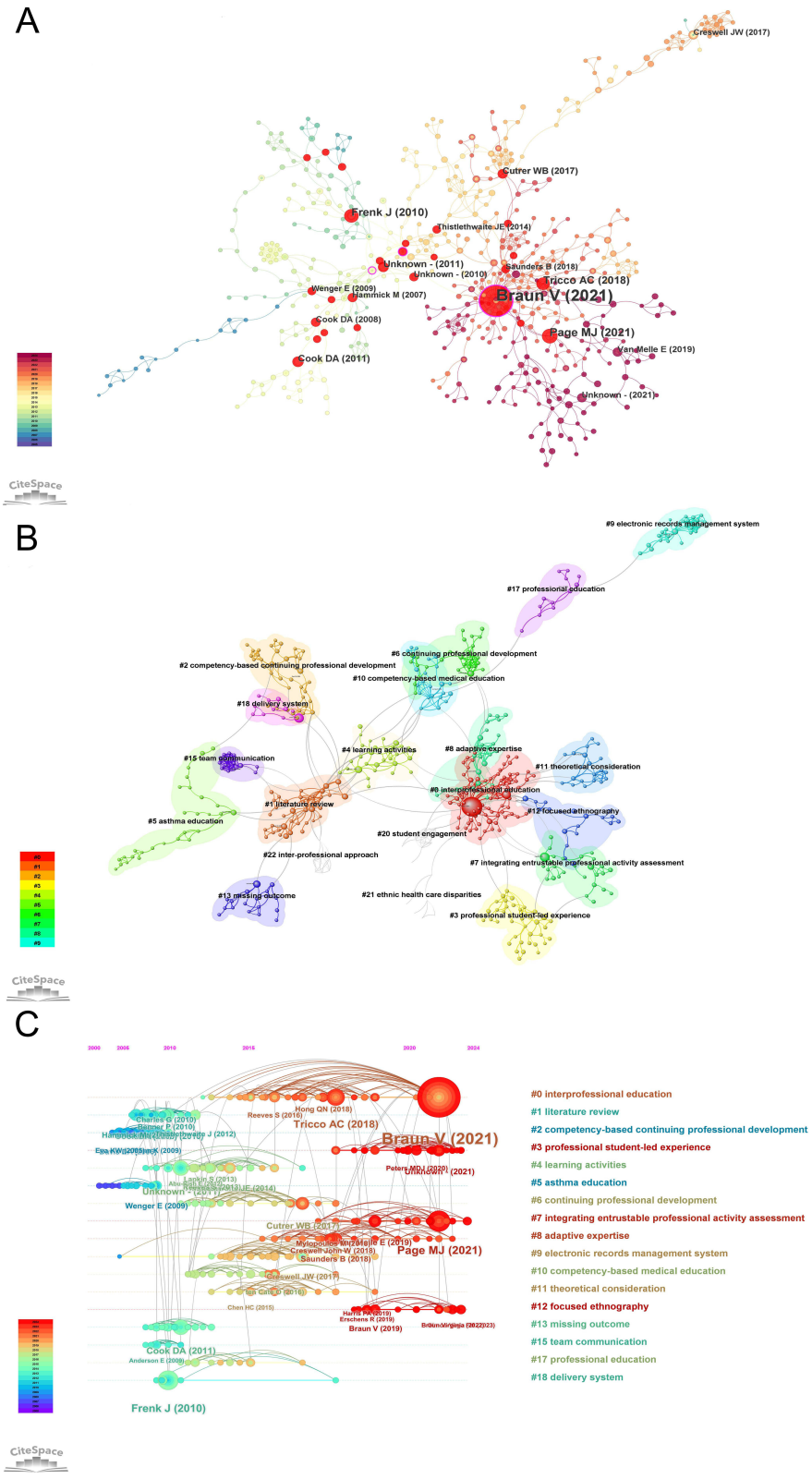

Figure 9 CiteSpace visualization of co-citation references network. (**A**) A network map of co-citation references. (**B**) Co-citation reference clusting map. (**C**) Timeline visualization of co-citation references network.

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Table 7 The Top 10 Co-Citation References of HPEM Research

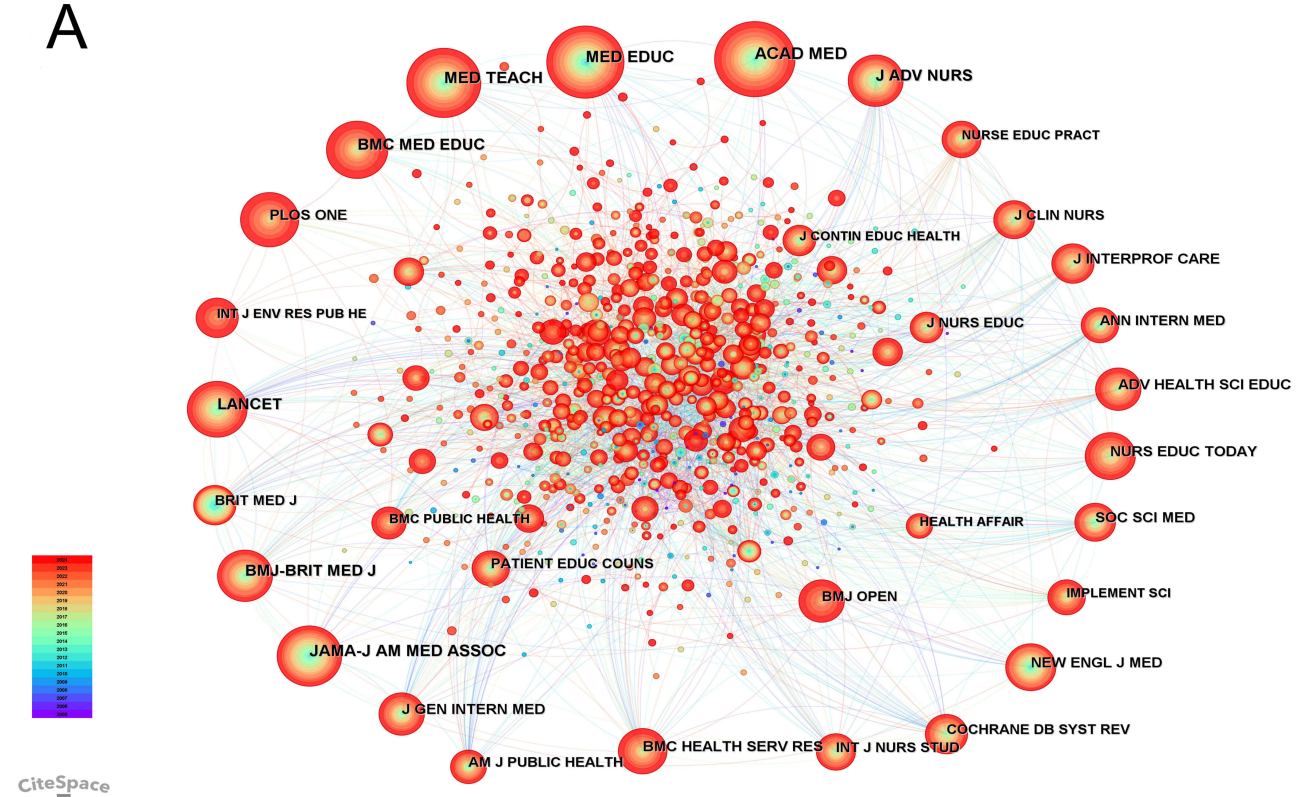
Citation Counts	Title	Source	Year	DOI	Cluster ID
120	One size fits all? What counts as quality practice in (reflexive) thematic analysis?	Qualitative Research in Psychology	2021	10.1080/14,780,887.2020.1769238	0
25	The PRISMA 2020 statement: An updated guideline for reporting systematic reviews	International Journal of Surgery	2021	10.1016/j.ijsu.2021.105906	7
23	Health professionals for a new century: transforming education to strengthen health systems in an interdependent world	Lancet	2010	10.1016/S0140-6736(10)61,854-5	18
20	PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation	Annals of Internal Medicine	2018	10.7326/M18-0850	0
14	Core competencies of interprofessional collaborative practice: report of an expert panel	Unknown	2011		4
14	Technology-enhanced simulation for health professions education	JAMA: the Journal of the American Medical Association	2011	10.1001/jama.2011.1234	13
12	Fostering the Development of Master Adaptive Learners: A Conceptual Model to Guide Skill Acquisition in Medical Education	Academic Medicine	2017	10.1097/ACM.0000000000001323	6
10	Internet-based learning in the health professions: a meta-analysis.	JAMA: Journal of the American Medical Association	2008	10.1001/jama.300.10.1181	1
10	A Core Components Framework for Evaluating Implementation of Competency-Based Medical Education Programs	Academic Medicine	2019	10.1097/ACM.0000000000002743	7
10	Framework for Action on Interprofessional Education and Collaborative Practice	WHO Report	2010		1

collaborative healthcare competencies. These synergistic advancements propelled IPE's transformation from isolated regional implementations into an established academic field, ultimately recognized by the World Health Organization's 1988 *Learning Together to Work Together* report as an essential pillar for reforming health professional education globally.

In 2010, the World Health Organization (WHO) officially adopted the *Framework for Action on Interprofessional Education & Collaborative Practice*,emphasizing the critical role of multidisciplinary teams in enhancing patient care standards, reducing operational expenses, and minimizing clinical errors.[16] Existing scholarship has driven significant advancements in designing collaborative learning frameworks and evaluating educational impacts across three dimensions: professional perceptions, competency development, and theoretical understanding for fostering collaborative efforts during both pre-certification and post-certification phases.[15] Our focus extended to enhancing pedagogical approaches through faculty development programs addressing instructional methodologies, educational resources, and training frameworks. Multiple studies emphasized IPE's critical function in cultivating professional competencies required for effective interdisciplinary teamwork, particularly in ensuring care quality and safeguarding patient welfare.[17] The convergence of technological innovations-epitomized by massive online courses, virtual reality (VR)-based clinical simulations, and AI-driven adaptive learning platforms-has catalyzed a paradigm shift in interprofessional education.[18,19]

The second prominent line of investigation focused on competency-based continuing professional development (CPD). Building upon the foundational principles of competency-based medical education (CBME), this instructional methodology designed to equip clinicians through targeted skill development informed by societal healthcare demands and patient care requirements.[20] This progressive CPD framework recognizes that professional proficiency evolves dynamically rather than representing static achievements. The approach rests on the understanding that medical expertise requires continuous refinement, emphasizing adaptive learning strategies that respond to evolving clinical challenges and emerging healthcare priorities throughout practitioners' careers.[20] Residents commence their clinical training with essential educational proficiencies that involve utilizing practice information, accessing various information sources,

A



B

Cited Journals	Year	Strength	Begin	End	2005 - 2024
BRIT MED J	2005	37.65	2005	2015	
JAMA-J AM MED ASSOC	2005	29.02	2005	2014	
ANN INTERN MED	2005	14.45	2005	2011	
J MED EDUC	2005	13.55	2005	2014	
MED CARE	2005	13.31	2005	2011	
AUST FAM PHYSICIAN	2005	13.04	2005	2013	
CAN MED ASSOC J	2005	11.5	2005	2013	
NEW ENGL J MED	2005	11.41	2005	2011	
CHEST	2006	15.51	2006	2018	
QUAL SAF HEALTH CARE	2007	11.82	2007	2018	
CROSSING THE QUALITY CHASM: A NEW HEALTH SYSTEM FOR THE 21ST CENTURY	2007	10.9	2007	2013	
MED J AUSTRALIA	2006	17.77	2009	2015	
FRAMEWORK FOR ACTION ON INTER-PROFESSIONAL EDUCATION AND COLLABORATIVE PRACTICE	2013	9.24	2013	2019	
AUST HEALTH REV	2014	9.18	2015	2018	
THESIS	2013	19.14	2016	2020	
INT J ENV RES PUB HE	2016	31.59	2021	2024	
FRONT PSYCHOL	2018	12.21	2021	2024	
JAMA NETW OPEN	2020	11.58	2021	2024	
BMJ OPEN	2014	16.51	2022	2024	
HEALTHCARE-BASEL	2022	12.43	2022	2024	
FRONT PSYCHIATRY	2022	11.52	2022	2024	
NURS OPEN	2022	10.61	2022	2024	
J MED EDUC CURRIC DE	2022	10	2022	2024	
SCI REP-UK	2022	9.4	2022	2024	
BMJ GLOB HEALTH	2020	9.22	2022	2024	

Figure 10 CiteSpace visualization of co-citation journals network. (**A**) Journal co-citation network. (**B**)The top journals with the strongest citation bursts.

developing personalized knowledge organization systems, formulating questions, and employing tools to assess competence and performance. The progression of CBME paradigms into CPD represents a developmental imperative in medical pedagogy, conforming to the concept of lifelong learning. A persistent conceptual ambiguity in medical education terminology centers on the critical differentiation between competence (the demonstrated capacity to apply knowledge or skills) and performance (contextualized execution in authentic clinical settings).[21] In addition, healthcare facilities and systems consistently generate data while developing and refining teaching methodologies aimed at training CPD educators who are capable of collaborating with physician groups.[22]

The third notable research focus involves professional student-led experiences (SLEs), characterized as distinctive practice-oriented learning initiatives. Within these programs, work-based activities are undertaken by healthcare professionals as curricular placement obligations while assuming supervisory responsibilities. The core aim lies in improving current and emerging service provisions, particularly targeting recognized deficiencies within clinical environments.[23]

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Emerging evidence increasingly demonstrates the acknowledgment of the intrinsic worth of student leadership cultivated via hands-on experiential learning has prompted educational institutions to progressively incorporate student-driven projects into core competency-focused curricula.[24] Contemporary academic settings now witness the proliferation of learner-managed clinical services operating within both instructional and healthcare contexts.[23] Nevertheless, existing scholarly works addressing SLEs have primarily focused on documenting intervention strategies, implementation frameworks, learner perceptions, and operational outcomes.[25] Scholarly research has yet to sufficiently examine how leadership capabilities develop through students' educational journeys, particularly regarding the systematic approaches for nurturing these vital skills.[23]

Furthermore, this investigation incorporates an additional investigative dimension focusing on scholarly productivity and influence networks. This systematic examination seeks to map the geographical and institutional spread of academic contributions while pinpointing leading nations, collaborative teams, and prominent authors across specialized domains, thereby revealing understudied areas requiring further exploration. In terms of national contributions, the United States of America maintains a leadership position. The analysis of publication volume and citation metrics reveals that the University of Toronto emerges as a particularly influential institution in both quantitative output and scholarly impact measurements. Meanwhile, the University of California System and Harvard University secure second and third positions respectively in global rankings. This ordering highlights the nations' remarkable accomplishments in HPEM-related technological advancements and scientific exploration. Partnerships between European and American academic institutions, as well as nations, have demonstrated notable robustness. In contrast, most developing countries, apart from China, have yet to establish substantial influence through impactful research outputs in this specialized domain. Enhancing international knowledge-sharing mechanisms and fostering cross-border research initiatives should be prioritized. Advocate for enhanced research initiatives originating from regions and organizations with limited representation to facilitate deeper exploration of the dynamic relationships between sociocultural dimensions within HPEM studies.

Additionally, the co-citation analysis highlights the pivotal role of Olle ten Cate in advancing HPEM research, particularly through his investigations into educational frameworks and specialized domains like Competency-Based Education (CBE). He is affiliated with the University Medical Center Utrecht. Although the quantitative data derived from the collaborative network of co-authors may not fully encapsulate their influence, it allows for the identification of scholars who have made significant advancements in HPEM through an analysis of highly cited and transformative literature.[25] The WoSCC search reveals that the current analysis comprises 3,476 papers published in 857 distinct journals over the past two decades, specifically since 2005. Bibliometrics online analysis was employed to evaluate the influence of these journals. The ten most cited journals are presented in Table 8, among them, four publishers are based in the United States, while six are located in the United Kingdom. Notably, Academic Medicine exhibited the highest total citation count (966) and an impact factor of 5.3, thereby ranking first within the research domain of HPEM.

The international cooperation network has had a revolutionary, multi-faceted, and systematic impact on the dissemination of HPEM. This process is no longer a mere "copy-paste" approach, instead, it has evolved into a complex endeavor that encompasses absorption, adaptation, localization, and re-innovation. International

Table 8 The Top 10 Co-Citation Journals of HPEM Research

Rank	Journal	Counts	Impact Factor in 2023
1	Academic Medicine	966	5.3
2	Medical Education	798	4.9
3	Medical Teacher	768	3.3
4	JAMA: Journal of the American Medical Association	711	63.5
5	Lancet	581	98.4
6	Journal of advanced nursing	525	3.8
7	BMC medical education	523	2.7
8	BMJ-British Medical Journal	516	93.7
9	Nurse education Today	463	3.6
10	PLOS ONE	452	2.9

organizations such as the World Federation for Medical Education (WFME), the World Health Organization (WHO), and the Association of American Medical Colleges (AAMC) have actively promoted best practices and international standards in medical education through their global networks of cooperation.[26] Many medical schools across various countries seek international accreditation from recognized bodies, such as those in the UK, Australia, and China.[27] To successfully achieve this accreditation, institutions must align their programs with established international standards.[28] This necessitates the proactive introduction and adoption of well-established curriculum designs, pedagogical approaches, and evaluation systems utilized globally.[29] Many leading universities collaborate to offer joint MD/PhD programs,[30] global health master's programs, and similar initiatives.[31] These programs serve as "experimental fields" and "showcases" for innovative educational models. The curricula and pedagogical approaches developed within these frameworks are subsequently adopted by participating institutions and integrated into their mainstream academic offerings. In light of cross-border challenges such as the infectious disease pandemic (exemplified by COVID-19) and the repercussions of climate change on public health,[32] there has emerged a universal demand for "global health" education within the international cooperation network.[33,34] Medical schools have started to integrate global health perspectives, comparative analyses of health systems, and principles of health equity into their curricula.[35] Additionally, they are fostering the development of the global health discipline.

Limitations

This investigation presents certain constraints that warrant acknowledgment. Primarily, the dataset was exclusively sourced from SCIE and SSCI-indexed publications within the WOSCC database, which may have restricted the overall volume of article available for analysis. Notably, other significant repositories including PubMed and Embase renowned for their extensive full-text archives and detailed citation indices were not incorporated into the investigation. Secondly, although employing CiteSpace for visual representation aligns with standard bibliometric methodologies, this singular analytical framework might overlook complementary insights achievable through alternative visualization tools. Subsequent research endeavors could benefit from integrating supplementary bibliometric analytical instruments, including VOSViewer or Bibliometrix, to simultaneously improve the scope and trustworthiness of their investigative outcomes. Thirdly, due to language constraints, the articles selected for this study were restricted to those published in English.

Conclusions

The scholarly landscape in this domain has demonstrated sustained growth across twenty years, with publication volumes projected to reach their zenith by 2024. Our study identifies key contributors to the discipline, including prominent countries, institutions, authors, and journals. Additionally, it highlights significant research hot topics and emerging trends such as interprofessional education, competency-based continuing professional development, and student-led professional experiences. The results underscore the necessity for enhanced collaboration among academic and clinical institutions across European nations, the United States of America, and China, especially those led by prominent scholars. This investigation offers critical insights for healthcare professionals and scientific investigators to track evolving patterns and identify emerging priorities within HPEM research, informing both clinical practice and scientific inquiry.

Data Sharing Statement

The data utilized in this study are publicly available and can be downloaded from the Web of Science Core Collection.

Ethics Approval

This research did not involve humans or animals.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

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