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Human Factors in the Operating Room: A Bibliometric Analysis

Ameliyathanede İnsan Faktörleri: Bibliyometrik Bir Analiz

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Abstract

This study presents a bibliometric analysis aimed at examining the scientific development, collaboration networks, and thematic trends of research on human factors in the operating room. Although research on human factors, which are crucial for improving patient safety, communication, and team performance, has increased over time, comprehensive evaluations of its growth, key contributors, and international collaboration patterns remain limited. Therefore, 467 articles addressing operating room safety and human factors within the fields of Medicine, Nursing, and Health Sciences indexed in the Scopus database between 1973, the year of the earliest available record in this field, and 2025 were retrieved on July 12, 2025, without restrictions on country or language. The analyses were conducted using the Bibliometrix R package (v4.2) and the Biblioshiny interface. The annual growth rate of publications during the study period was found to be 4.9%. Proceedings of the Human Factors and Ergonomics Society, Annals of Surgery, and British Journal of Anaesthesia were identified as the most influential journals. The United States and the United Kingdom were the most productive countries, while Canada and Belgium demonstrated strong international collaborations. The findings indicate that research on human factors in the operating room has increased steadily, gaining a more interdisciplinary and international orientation. This study provides guidance for researchers, clinicians, and policymakers to strengthen collaboration and enhance patient safety and team performance in surgical settings.

Key Words: Bibliometric analysis, human factors, operating room, patient safety

Özet

Bu çalışma, ameliyathanede insan faktörlerine ilişkin araştırmaların bilimsel gelişimini, iş birliği ağlarını ve tematik eğilimlerini incelemeyi amaçlayan bir bibliyometrik analiz sunmaktadır. Hasta güvenliği, iletişim ve ekip performansını iyileştirmede kritik öneme sahip olan insan faktörlerine yönelik araştırmalar zamanla artmış olsa da, bu alanın gelişimi, önde gelen katkı sağlayıcıları ve uluslararası iş birliği örüntülerine ilişkin kapsamlı değerlendirmeler sınırlıdır. Bu nedenle, Scopus veri tabanında bu alandaki en erken kayıtlı yayının yer aldığı 1973 yılı ile 2025 yılları arasında yayımlanmış, Tıp, Hemşirelik ve Sağlık Bilimleri alanlarında ameliyathane güvenliği ve insan faktörlerini konu alan 467 makale, 12 Temmuz 2025 tarihinde ülke veya dil sınırlaması olmaksızın derlenmiştir. Analizler Bibliometrix R paketi (v4.2) ve Biblioshiny arayüzü kullanılarak gerçekleştirilmiştir. İncelenen dönemde yayınların yıllık büyüme oranı %4,9 olarak saptanmıştır. Proceedings of the Human Factors and Ergonomics Society, Annals of Surgery ve British Journal of Anaesthesia en etkili dergiler olarak belirlenmiştir. En üretken ülkeler Amerika Birleşik Devletleri ve Birleşik Krallık olurken, Kanada ve Belçika güçlü uluslararası iş birlikleri sergilemiştir. Bulgular, ameliyathanede insan faktörlerine ilişkin araştırmaların istikrarlı biçimde arttığını ve daha disiplinler arası ile uluslararası bir yönelim kazandığını göstermektedir. Bu çalışma, cerrahi ortamlarda iş birliğini güçlendirmek ve hasta güvenliği ile ekip performansını artırmak amacıyla araştırmacılara, klinisyenlere ve politika yapıcılara yol gösterici niteliktedir.

Anahtar Kelimeler: Bibliyometrik analiz, insan faktörleri, ameliyathane, hasta güvenliği

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RESEARCH ARTICLE

1. Introduction

The operating room (OR) is a complex system where numerous personnel, equipment, and processes dynamically intersect (Hacıdursunoğlu et al., 2026). This environment necessitates the study of human factors that influence safety and performance in surgical settings (Pasquer et al., 2024). It is now widely recognized that surgical errors cannot be explained solely by individual expertise deficiencies; rather, the working conditions of the OR and broader human factors also play a decisive role (Sam et al., 2024). Human factors encompass sociotechnical elements such as team communication, workflow, stress, fatigue, and attention levels, serving as a foundation for transforming the OR into a high-reliability system (Lee et al., 2022).

Team communication and collaboration lie at the core of OR safety. Open, timely, and effective communication prevents errors and ensures continuity of patient care (An et al., 2025). Accurate information exchange between surgeons and nurses reduces technical mistakes and procedural violations, thereby improving clinical outcomes (Arad et al., 2022). Structured communication strategies such as surgical briefings, time-outs, SBAR, and TeamSTEPPS™ have been identified in the literature as effective tools for enhancing team coordination (Ghanmi et al., 2024). Conversely, stress and fatigue are critical human factors that negatively affect OR performance. Recent studies report high rates of burnout among surgical team members, leading to weakened communication, workflow interruptions, and reduced team cohesion (Madrid et al., 2025). Approximately one-third of intraoperative errors have been attributed to surgeon fatigue (Reijmerink et al., 2024). Similarly, high levels of occupational fatigue among nurses have been found to increase the risk of medical errors (Zhai et al., 2025).

Leadership and organizational structure directly influence safety culture in the OR. Supportive and communicative leadership strengthens psychological safety and encourages error reporting, whereas rigid hierarchies foster hesitation and the concealment of errors (Hao et al., 2022). Strong hierarchies have been shown to delay nurses' expression of concerns, thereby compromising patient safety (Lainidi et al., 2023).

In conclusion, human factors in the OR are critical for patient safety, surgical success, and team performance. However, the existing literature often focuses on isolated subfactors, and comprehensive analyses of scholarly output, collaboration networks, and research trends remain limited (Lee et al., 2022). This study aims to map the intellectual structure of the field by examining the evolution of research, identifying influential authors and institutions, and uncovering thematic developments. In doing so, it seeks to provide strategic direction for future research, collaboration, and policy development efforts.

2. Method

This study employed a bibliometric research design to examine the scientific development, collaboration networks, and thematic trends of studies focusing on human factors in the operating room. Bibliometric analyses have increasingly gained attention in recent years as a quantitative approach to evaluating research output, identifying influential contributors, and mapping scientific collaboration (Cheng et al., 2024). Scientific databases provide structured and comprehensive bibliometric data that enable effective access to scholarly publications (Donthu et al., 2021). Accordingly, the Scopus database, owned by Elsevier, was selected as the data source due to its extensive international coverage, rigorous content selection process, and frequent use in large-scale bibliometric and science-mapping studies (Baas et al., 2020).

2.1. Research Aim

The primary aim of this study was to conduct a comprehensive bibliometric analysis of publications addressing human factors and operating room environments. The study sought to explore scientific productivity, collaboration patterns, and thematic evolution in research focusing on human factors in surgical settings.

2.2. Research Questions

This study was guided by several key research questions aimed at understanding the evolution and structure of research on human factors in the operating room (OR). Specifically, it sought to identify the temporal trends and productivity patterns within this field, determine the most influential authors, institutions, and countries contributing to its development, and explore the major collaboration networks and thematic clusters that have emerged over time. Additionally, the study aimed to identify the core journals and publications that serve as the primary sources within this research domain.

2.3. Research Population and Sample

The research population consisted of all scientific publications indexed in the Scopus database related to human factors and the operating room. The study sample included articles and reviews classified within the subject areas of Medicine, Nursing, and Health Professions. No restrictions were applied regarding publication year, country,

or language. As a result, a total of 467 documents published between 1973 and 2025 were included in the final analysis.

2.4. Data Collection and Instruments

Data collection was conducted in July 2025 using the advanced search function of the Scopus database. The search query combined terms related to "human factors" and the "operating room," as follows: (("human factor*" OR "ergonomic*" OR "nontechnical skill*" OR "crew resource management" OR "human reliability" OR "system thinking" OR "cognitive workload" OR "human performance") AND ("operating room" OR "surgery" OR "surgical team" OR "perioperative" OR "operation theatre" OR "operative environment" OR "surgical safety")) AND (LIMIT-TO (SUBJAREA, "MEDI") OR LIMIT-TO (SUBJAREA, "NURS") OR LIMIT-TO (SUBJAREA, "HEAL")). The search strategy followed the PRISMA-S (Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Search Strategies) guidelines. The retrieved data were exported in BibTeX format and underwent a data-cleaning process that included removing duplicates, correcting inconsistencies in author and institutional names, and verifying missing metadata (e.g., publication year, journal title, or keywords).

2.5. Ethical Considerations

This study used only publicly available bibliographic data obtained from the Scopus database. As no human participants, experimental interventions, or personal data were involved, ethical approval was not required.

2.6. Limitations of the Study

This study was limited to publications indexed in the Scopus database and to the subject areas of Medicine, Nursing, and Health Professions. Therefore, relevant works indexed in other databases such as Web of Science or PubMed may not have been captured. Additionally, bibliometric indicators reflect citation and publication patterns rather than the intrinsic quality of research.

2.7. Data Analysis and Evaluation

Data analysis was conducted using the Bibliometrix R package (version 4.2) and its graphical web interface, Biblioshiny. The analysis comprised two main stages. The first stage, performance analysis, focused on examining publication trends, author productivity, institutional and country-level contributions, citation impact, and journal distribution. Bradford's Law was applied to identify the core journals within the field. The second stage, science mapping, explored the intellectual and collaborative structure of the research domain through author and country collaboration networks, keyword co-occurrence analysis, thematic mapping, and word cloud visualizations. Additionally, structural assessments were performed based on Lotka's Law (author productivity) and Bradford's Law (information concentration). All analyses and visualizations were executed within the R environment, following established methodological standards for bibliometric research (Aria & Cuccurullo, 2017; Donthu et al., 2021).

3. Results and Discussion

This study examined the bibliometric characteristics of scientific publications containing the terms "human factors" and "operating room." A total of 467 articles and reviews published between 1973 and 2025 were analyzed from the Scopus database. The results showed an annual growth rate of 4.9%, indicating a steady and consistent increase in academic interest in this topic.

The analyzed publications appeared in 237 different sources and involved 1,679 authors, of whom 51 were single authors. The average number of authors per document was 4.6, reflecting a high degree of interdisciplinary collaboration. Approximately 14.78% of the publications involved international co-authorship, further supporting the growing global engagement in this research domain.

Authors used a total of 929 unique keywords, suggesting substantial thematic diversity within the field. Across all publications, 13,433 references were cited, with an average document age of 10.9 years and an average citation rate of 29.19 per paper. These results indicate that the literature on human factors in the operating room demonstrates considerable scientific influence and sustained scholarly impact over time.

An examination of publication data from 1973 to 2025 revealed a marked increase in research on "human factors" and the "operating room" over time. During the 1970s and 1980s, the number of publications was very limited, with at most one or two articles per year, indicating that the field was still in its formative stage. Beginning in the mid-1990s, the number of studies gradually increased, followed by a more pronounced upward trend after 2005. By 2010, annual publication output exceeded 20 papers, reaching its highest level in 2021 with approximately 35 publications. This rise may be associated with increased awareness of operating room safety and human factors following the COVID-19 pandemic (Britton et al., 2021). Research productivity remained high during 2022–2023,

while the apparent decline in 2025 can be attributed to the data collection cutoff occurring mid-year. Overall, the findings demonstrate a substantial growth of scholarly interest in human factors and operating room safety over the past two decades.

3.1. Most Productive Sources

Table 1. Top 10 Sources with the highest number of publications on "Human Factors" and "Operating Room" topics

Rank	Source Title	Number of Publications	Cumulative Publications
1	*Proceedings of the Human Factors and Ergonomics Society*	23	23
2	*Annals of Surgery*	11	34
3	*British Journal of Anaesthesia*	10	44
4	*Surgical Endoscopy*	10	54
5	*Journal of Patient Safety*	9	63
6	*Journal of Perioperative Practice*	9	72
7	*BMJ Quality and Safety*	8	80
8	*Human Factors*	8	88
9	*Surgical Innovation*	8	96
10	*Anaesthesia*	7	103

According to Bradford's Law, knowledge production tends to be concentrated within a limited number of core sources (Bradford, 1985). The data show that the Proceedings of the Human Factors and Ergonomics Society contributed the largest number of publications (n = 23), followed by the Annals of Surgery (n = 11) and the British Journal of Anaesthesia (n = 10). Together, these three journals account for 44 publications, representing a substantial portion of the literature in this field (Table 1).

The prominence of themes such as surgical safety, anesthesia, ergonomics, and patient safety within the top 10 journals reflects the multidisciplinary nature of the research domain and the growing integration of human factors approaches in healthcare. Consistent with Bradford's Law, a small number of journals exhibit a high concentration of publications, serving as core sources and key reference points for future research in this area.

3.2. Journal Impact Indicators

Table 2. Bibliometric profile of the most influential journals and authors

Journal / Author	**h-index**	**g-index**	**m-index**	**Total Citations**	**Number of Publications**	**Publications / First Publication Year**
Annals of Surgery	10	11	0.476	1655	11	2005
Surgical Endoscopy	9	10	0.300	320	10	1996
BMJ Quality and Safety	7	8	0.467	330	8	2011
British Journal of Anaesthesia	7	10	0.292	721	10	2002
Human Factors	7	8	0.350	289	8	2006
Journal of Patient Safety	7	9	0.438	160	9	2010
Anaesthesia	6	7	0.261	714	7	2003
Anesthesia and Analgesia	6	7	0.375	216	7	2003
Anesthesiology	5	5	0.139	477	5	1990
Minimally Invasive Therapy and Allied Technologies	5	6	0.167	225	6	1996
Analysis of the Index and Publication Profile of the 10 Most Influential Authors						
Catchpole K	9	14	0.750	358	14	2014
Darzi A	9	9	0.391	1086	9	2003
Wiegmann DA	8	10	0.400	374	10	2006
Cohen TN	7	11	0.700	121	12	2016
Hallbeck MS	7	10	0.389	293	10	2008
Abernathy JH	6	9	0.462	462	9	2013
Anger JT	6	8	0.600	218	8	2016
Moorthy K	6	10	0.261	743	6	2003
Shouhed D	6	6	0.500	123	6	2018
Vincent C	6	6	0.273	619	6	2004

h-index: An indicator that reflects both the productivity and citation impact of an author's publications, g-index: A metric that gives more weight to highly cited publications, emphasizing the influence of top-performing works, m-index: The ratio of the h-index to the number of years since the author's first publication, providing a time-normalized measure of research impact.

The local impact of the analyzed journals was assessed using indicators such as the h-, g-, and m-index, total citations, publication count, and year of first publication. These metrics reveal both the productivity and sustainability of scientific influence across journals. According to the results, Annals of Surgery emerged as the most influential source, with the highest h-index (10) and g-index (11), and a total of 1,655 citations. Surgical Endoscopy and BMJ Quality and Safety also demonstrated strong performance. Notably, BMJ Quality and Safety achieved 330 citations from only eight publications, reflecting a strong impact with an m-index of 0.467. Overall, certain journals stand out not only by publication volume but also by citation density and the sustained distribution of impact over time.

Lotka's Law (1926) posits that scientific productivity follows an inverse-square distribution. The findings indicate that single-publication authors (n = 1,443) represent 85.9% of all contributors, while those with two publications constitute 8.8%, three publications 2.1%, and ten or more publications only 0.2%. This pattern confirms that a small number of authors account for the majority of scientific output, consistent with Lotka's principle (Kawamura et al., 2000).

Table 2 presents the most influential authors in the field of human factors in the operating room. Catchpole K and Darzi A both achieved the highest h-index (9), with Darzi A also recording the greatest citation impact (1,086 citations). Moorthy K and Vincent C, despite a limited number of publications, reached high citation ratios, indicating substantial scientific contributions. These results are valuable for identifying leading researchers and mapping the developmental trajectory of the literature in this domain.

3.3. Institutional and Country-Level Distribution

At the institutional level, Cedars-Sinai Medical Center stands out as the most productive organization, contributing a total of 75 publications. It is followed by the Medical University of South Carolina (58) and Imperial College London (31). These three institutions form the core centers of research activity in this field. Consistent with prior literature, studies are predominantly concentrated within institutions based in the United States and Canada, indicating that global scientific production on human factors and operating room safety is largely clustered around specific academic hubs (Li et al., 2024). This concentration highlights the role of leading institutions and strong research collaborations in shaping the advancement of the field.

Table 3. Country-level distribution of publications and international collaboration (MCP) data

Country	Number of Publications	Publication%	SCP (Single-Country Publications)	MCP (Multiple-Country Publications)	MCP %
United States	136	29.1%	116	20	14.7%
United Kingdom	57	12.2%	47	10	17.5%
Canada	26	5.6%	18	8	30.8%
Germany	20	4.3%	19	1	5.0%
France	16	3.4%	14	2	12.5%
Netherlands	16	3.4%	13	3	18.8%
Belgium	5	1.1%	2	3	60.0%
Iran	5	1.1%	4	1	20.0%
Italy	5	1.1%	5	0	0.0%
New Zealand	5	1.1%	3	2	40.0%

An examination of country-level publication trends on human factors and operating room research reveals that the United States is the clear leader, with a total of 136 publications (29.1%). Despite its strong research infrastructure, 85.3% of its output originates from domestic collaborations, indicating a relatively modest level of international cooperation (14.7%). The United Kingdom ranks second with 57 publications (12.2%) and a 17.5% rate of international collaboration. Although Canada accounts for a smaller share of publications (5.6%), it demonstrates a notably high level of international collaboration (30.8%). Overall, the United States and the United Kingdom emerge as dominant contributors, while countries such as Canada, Belgium, and New Zealand, despite their limited publication volume, stand out for their strong multinational partnerships. These findings underscore the growing importance of international research networks in human factors and operating room safety, suggesting that

expanding global collaborations could enhance both knowledge diversity and scientific impact in the field (Kulaksızoğlu et al., 2025).

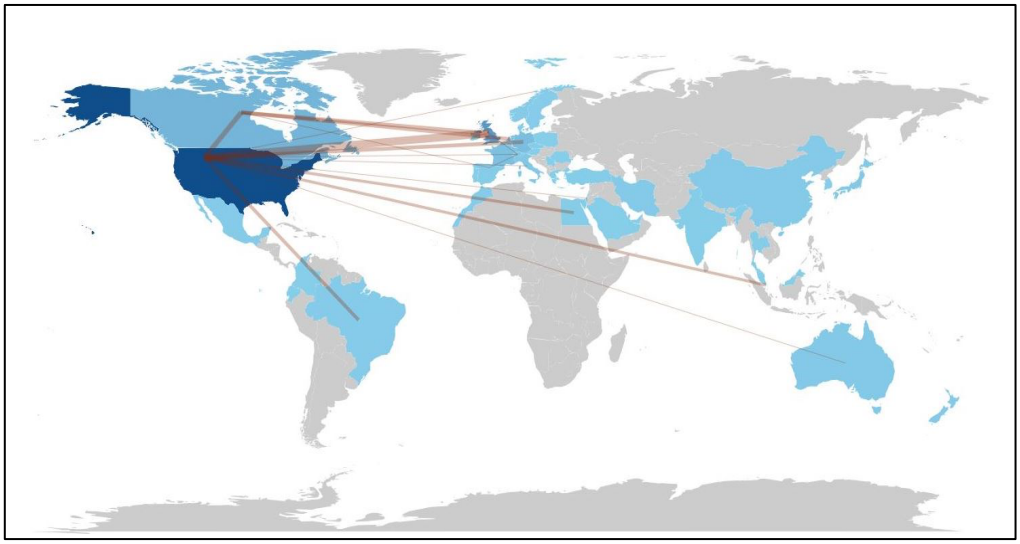

Figure 1. International collaboration map among author countries in human factors and operating room research

The global distribution of academic collaborations in operating room practices and human factors research was analyzed using the Countries' Collaboration World Map (Figure 1). The map reveals scientific networks and primary production hubs across countries. The United States stands out as both the most productive country and the one with the widest international collaboration network. Strong ties between the United States and Western European countries, such as the United Kingdom, Germany, France, and the Netherlands, illustrate the intensity of transatlantic scientific interaction. In addition, collaborations with Canada, Australia, China, Japan, India, and Brazil reinforce the central position of the United States in global academic production. Türkiye is also included in this network and maintains direct collaborations with several countries, particularly the United States. However, due to its relatively low publication volume, there remains a need to enhance Türkiye's global visibility in this field.

3.4. Citation Analysis

In the citation analysis, the United States ranks as the clear leader with a total of 4,793 citations, followed by the United Kingdom with 2,463 citations. Canada, Israel, and the Netherlands stand out for their high average citation rates despite lower total publication counts. In particular, Israel (408.00), Hong Kong (105.00), and Sweden (49.50) have produced a limited number of studies with exceptionally high impact. This finding indicates that a lower publication volume does not necessarily correspond to lower scientific influence.

3.5. Keywords and Thematic Structure

Figure 2. Most frequently used keywords (Word Cloud)

Word cloud analysis revealed that the most frequently emphasized concepts in the literature include “human,” “humans,” “operating room,” and “patient safety.” These findings indicate that research in this field predominantly centers on themes related to human factors, operating room environments, and patient safety. The frequent appearance of “human” and “humans” underscores the defining role of human-centered approaches in healthcare. The prominence of “operating room(s)” reflects a strong focus on surgical settings and safety processes. Moreover, the prevalence of terms such as “patient safety,” “medical errors,” “clinical competence,” and “risk assessment” highlights the importance of error prevention and the competency of healthcare professionals. Similarly, the frequent use of “teamwork,” “communication,” “leadership,” and “patient care team” demonstrates that effective collaboration and communication are essential components of patient safety. Finally, the presence of “anesthesia” and “anaesthesiology” indicates that anesthetic practice holds a distinct and influential position within this research domain (Figure 2).

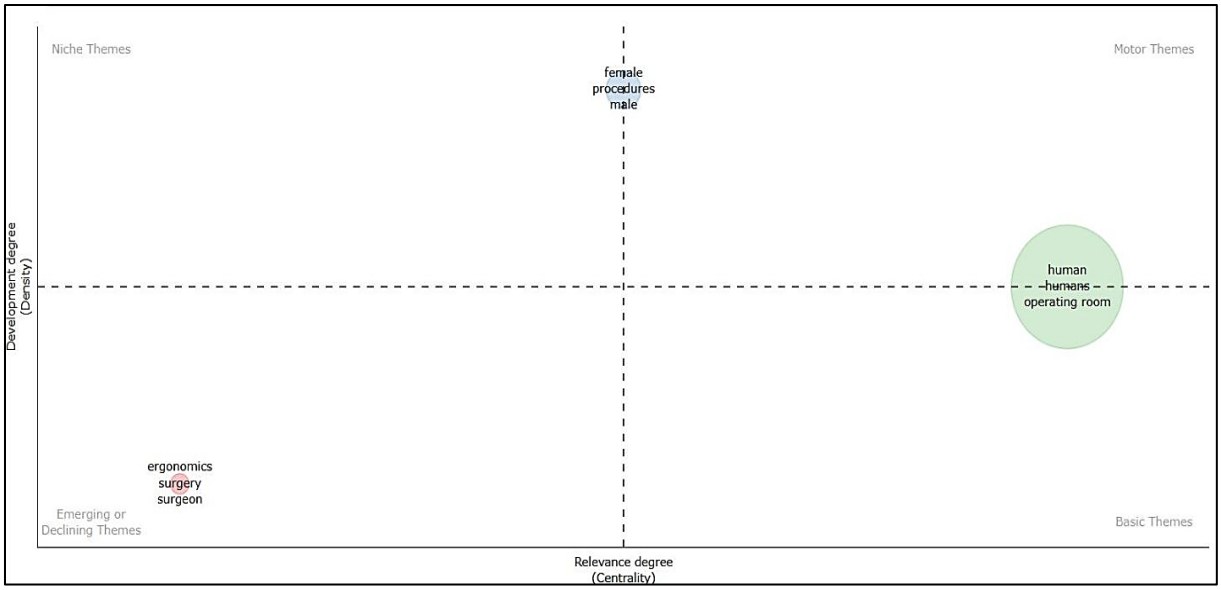

Figure 3. Thematic clustering analysis of literature

According to the thematic map analysis, the main focus of research in this field centers around the concepts of “human,” “humans,” and “operating room,” which exhibit high centrality values and represent the core, well-established themes in the literature. Themes such as “female,” “male,” and “procedures” are methodologically developed but have limited relevance to the overall structure of the field, positioning them as niche themes. In contrast, “ergonomics,” “surgery,” and “surgeon” demonstrate low centrality and density values, indicating that they are either emerging or declining themes. The absence of a distinct motor theme suggests that no single topic currently exhibits both high centrality and high development within this domain. Overall, this distribution reveals that human- and operating room–related topics dominate the field, while several emerging areas show potential for future growth and deeper exploration (Figure 3).

4. Conclusion

This bibliometric study comprehensively analyzed global scientific production on human factors and operating room safety, providing an integrated perspective on the structural characteristics of the literature. The findings revealed that publication volume in this field has steadily increased since the 1970s, gained marked momentum after 2005, and peaked following the COVID-19 pandemic. The Bradford’s law analysis indicated that core sources are concentrated in prestigious journals focusing on operating room safety, ergonomics, and patient safety. Lotka’s law demonstrated that the productivity structure follows a pattern in which a small number of authors contribute a large share of publications, suggesting that expanding the core author base could enhance scientific diversity.

Institutional and national analyses showed that research production is predominantly concentrated in institutions based in the United States and the United Kingdom. Keyword and thematic analyses revealed that “human,” “operating room,” “patient safety,” and “teamwork” are the central themes within the literature, whereas “ergonomics,” “surgery,” and “surgeon” represent emerging or developing topics. The absence of a dominant motor theme suggests substantial research potential for innovative and interdisciplinary approaches in this domain.

In conclusion, this study systematically mapped the current state of research on human factors and operating room safety and provided a guiding framework for future investigations. To advance the field, it is recommended to foster broader international collaborations, develop new research models focusing on ergonomics and human performance, and enhance the representation of low- and middle-income countries in the literature. Such integrative strategies will strengthen both scientific knowledge production and the global standards of patient safety.

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Declaration of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical Approval and Informed Consent

As this study is bibliometric in nature and does not involve human or animal participants, ethical approval and informed consent were not required.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

Conceptualization (Topic selection): M.Y.v.G., A.A.; Study design: M.Y.v.G., A.A.; Planning: M.Y.v.G., A.A.; Data collection and analysis: M.Y.v.G., A.A.; Manuscript drafting: M.Y.v.G.; Critical revision: M.Y.v.G.; Final approval: M.Y.v.G., A.A.

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