Journal of Young Pharmacists, 2023; 15(3):397-405.
https://www.jyoungpharm.org

Review Article

Healthcare-Associated Infections: A Ten-Year Bibliometric Analysis

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ABSTRACT

Healthcare-Associated Infections (HCAIs) pose a significant threat to the safety of patients and Healthcare Workers (HCWs). HCAIs increase morbidity and mortality, as well as healthcare costs. Therefore, prevention is a key goal for healthcare organisations and systems. In this regard, this study aims to conduct a bibliometric analysis of research and review papers published in journals indexed in the PubMed database between 2013 and 2023 on HCAIs in order to investigate areas of concentration and developing trends in the field. There was a total of 356 core zone publications, and the number of articles published is expected to reach its high in 2020. Most of the papers were found to have been published in the journals of hospital infection and antibiotic resistance and infection control. European countries conduct the most and more collaborative scientific research in this area, followed by the United States, Australia, and China. Surveillance, infection control, hand hygiene and COVID-19 represent the leading frontiers and research hotspots for HCAIs. HCAIs and Infection Prevention and Control (IPC) also co-occurred in most of the study discussions. The analysis is expected to yield meaningful data by illuminating the overall structure and direction of previous research on HCAIs, as well as by providing important ideas for future research.

Keywords: Bibliometric analysis, Healthcare associated infection, Infection prevention and control.

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Received: 12-03-2023;
Revised: 25-03-2023;
Accepted: 02-04-2023.

INTRODUCTION

Healthcare-Associated Infections (HCAIs) are the most common type of complication experienced by patients. It includes Ventilator-Associated Infections or Events (VAE), Pneumonia (PNEU), Surgical Site Infection (SSI), Bloodstream Infection (BSI), and Urinary Tract Infection (UTI).[1,2] HCAIs continue to be a leading cause of morbidity and mortality despite advances in infection detection and control.[3-5] Along with longer hospital stays, antibiotic overuse, and the development of multidrug-resistant bacteria, which place a significant financial strain on health care systems.[6-8] The global burden of HCAIs is estimated by the World Health Organization (WHO) to be between 3.6% and 12.0% in high-income countries and between 5.4% and 19.1% in low- and middle-income countries (LMIC).[9] Infection Prevention and Control (IPC) has been acknowledged as an essential component of the healthcare system, emphasising the importance of Standard Precautions (SP) in preventing and mitigating the risk of infectious disease transmission.[3,10] The persistently high rates of HCAIs can be traced partly to the healthcare sector's failure to adhere to IPC requirements.[3,11] The global spread of COVID-19 has placed a heavy strain on the medical community and the world, introducing new challenges and potential to IPC strategies.[12,13] COVID-19 prevention attempts may have hindered or diverted IPC efforts, leading to a substantial increase in HCAI infections among COVID-19 patients.[13-15]

Bibliometrics analysis is a quantitative statistical method used to examine the evolution of research topics and the structure of existing knowledge.[16,17] It is a popular strategy used to pinpoint trends, hotspots, and developing areas in particular fields.[18,19] It utilises various analysis techniques, such as performance-based analyses by grouping publications by country, university, or author and a study of citations.[18,19] Many topics, including surgical site infections, antibiotic stewardship, and infectious disease in liver transplant patients, have been evaluated by bibliometric analyses.[16,20,21] Despite the prevalence of HCAIs, bibliometric

DOI: 10.5530/jyp.2023.15.55

Table 1: Main information of the selected articles gathered by Biblioshiny.

Description	Results
Time span	2013-2023
Documents	356
Publication sources	6
Authors	2235
Co-authors per Doc	7.8
Author's Keywords	754
Keywords Plus (ID)	677

research in this area is still limited. Currently, only one known bibliometric study focuses on HCAIs in Asia.[22] Therefore, this study aims to highlight the general structure of the literature on HCAIs by assessing and reviewing the research in English language articles core source of Bradford's law zone published in journals scanned in the PubMed database between 2013 and 2023.

MATERIALS AND METHODS

Data Sources

Relevant publications were found using the search terms "healthcare-associated infection" in PubMed, published between 2013 and 2023. With the exception of book chapters, conference proceedings, and editorials, the research covered all articles and review papers whose titles, abstracts, and keywords were related to HCAIs. Only English articles were selected. Information was identified and obtained by two reviewers independently. The bibliometric analysis was performed with the help of the R packages Bibliometrix and Biblioshiny.

Data Analysis

The present bibliometric analysis was conducted using the biblioshiny, a shiny app for bibliometrix from the R Statistical Package (https://www.bibliometrix.org/home/index.php/layout/biblioshiny). It provides a wide range of characteristics that make conducting comprehensive bibliometric analysis possible. The Bibliometrix package was installed and loaded through R Studio (Version 2022.07.2+576). The Biblioshiny application was started by typing biblioshiny () into the R console. Scholars can undertake thorough bibliometric analysis using a variety of Bibliometrix tools.[23] The downloaded metadata were uploaded on Biblioshiny interface to be analysed. Several results are displayed in tables and graphs.[23,24] The main objective of this study is to analyse general outcomes (publication trends and collaborations), publication sources, and keywords.

RESULTS

Analysis of Publication Outputs, Growth Trends, and Scientific Collaborations.

Table 1 shows that between 2013 and 2023, a total of 356 papers were published addressing HCAIs. Six journals, mostly dedicated to scientific research, published these papers. There has been a rise in publications recently. The total number of publications published in 2020 was a record high (Figure 1). There are 2235 authors on this topic, and they come from a wide variety of nations such as Switzerland, Germany, the United States, Australia, Brazil, China, and India and the average of co-authors seven to eight. Switzerland, Portugal, Germany, Spain, and other European countries were the most common collaborators in scientific research. In addition, there was also a collaboration between USA and Australia (Figure 2).

Analysis of Publication Sources

According to bibliometric analysis, six journals with publications published between 2013 and 2023 were found. Figure 3 shows the journals that publish articles in this area of study. *The Journal of Hospital Infection* is the highest journal with 145 articles (40.7%), followed by *Antimicrobial Resistance and Infection Control Journal* with 61 articles (17.1%), *Infection Control and Hospital Epidemiology* journal with 49 articles and *American Journal of Infection Control* with 45 articles. Next are *Clinical Infectious Diseases: An Official Publica Journal* and *BMC Infectious Disease* journal with 24 and 23 articles respectively. According to the Bradford's Law of Scattering, the number of core sources with the largest number of publications is the *journal of hospital infection* (Figure 4).

Analysis of Keywords

Keywords are very useful for bibliometric analysis when looking at the most popular articles and recent developments in a given field of study. We opted for the author's keywords since they help us zoom in on the topic and issues plaguing a given area of study.[25,26] The ten most commonly used words are "healthcare-associated infection" (n=173), "infection control" (n=44), "surveillance" with occurrence 39 followed by "hand hygiene" and "Infection prevention and control" with occurrence 28,24 respectively. "Antimicrobial resistance" (n=22), "COVID-19" (n= 19) and "Infection control" (n=17). "Keywords "Healthcare-associated infection", and "epidemiology" have 16 occurrences respectively (Figure 5). As the rate of publication went up, so did the average occurrence of the keywords (Figure 5). The term "healthcare-associated infection" has increased significantly, occurring over a hundred times in the reviewed 356 papers (Figure 6).

Figure 7 presents the network of the most frequently used 50 keywords based on the analysis of their co-occurrence. A node's size reflects a keyword's frequency, while its colour represents its

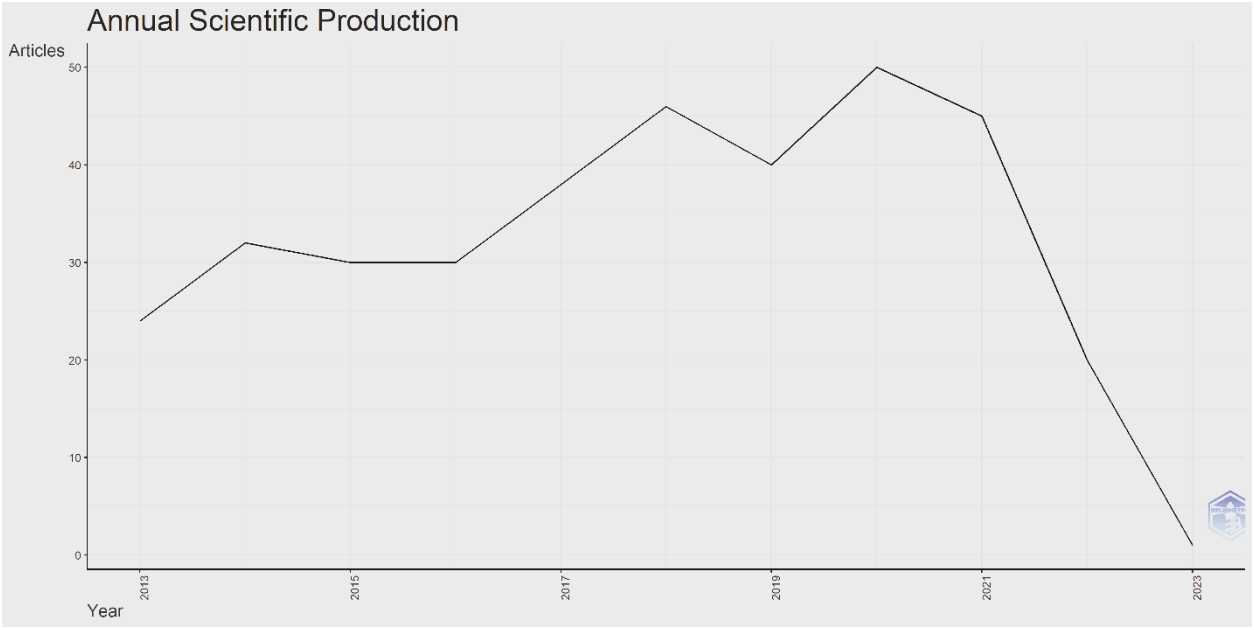

Figure 1: The total number of annual publications. The year 2020 had the most publications between 2013 and 2023, with 50 articles published.

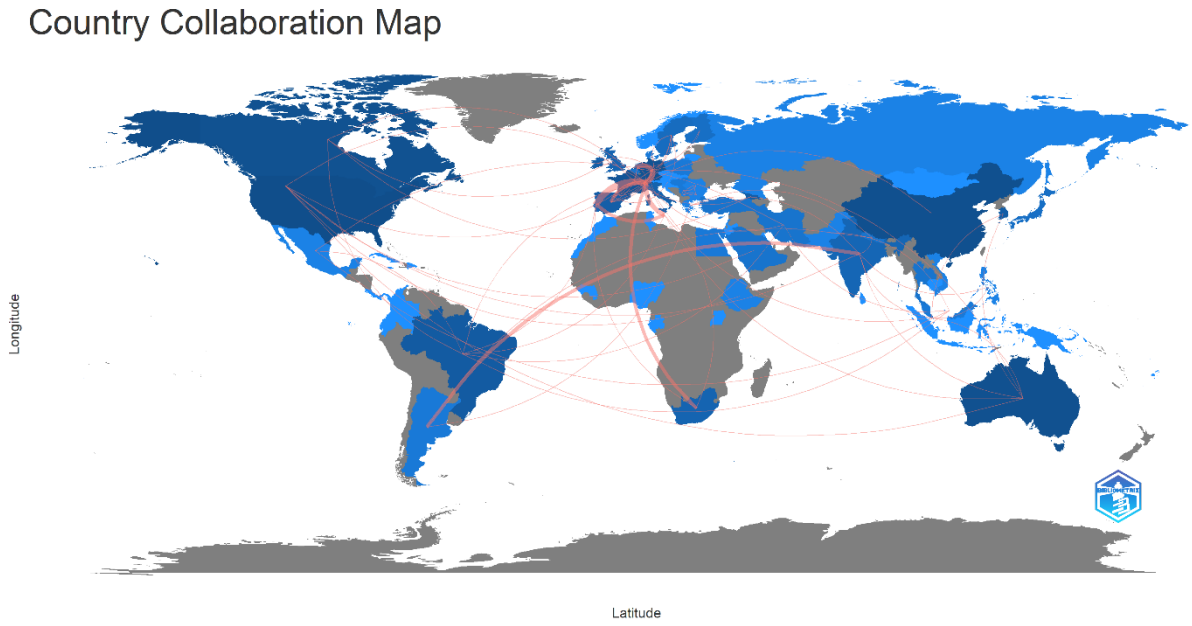

Figure 2: Scientific collaboration world map. Countries with a darker blue shade have a higher number of publications. The red line connects the two countries with the highest frequency of collaboration.

cluster and correlation with other nodes. Based on the analysis, all keywords were divided up into three distinct clusters, which were colour coded. Blue for "healthcare-associated infection, infection control, SARS-COV-2, COVID-19, *Acinetobacter baumanni* and prevention. The red for "healthcare-associated infection, surveillance, antimicrobial stewardship, surgical site infection, and bloodstream infection". Purple color for "infection prevention and control, patient safety, hand hygiene, and implementation". This keyword network map reveals that these three clusters have performed as the main driving forces behind the HCAIs research process in the last ten years (Figure 7).

Thematic evaluation

By identifying the most commonly used terms, we may further analysis the evolution trend of the theme using the author's keyword. The analysis of theme evolution is essential for showing how particular study fields have developed over time and for detecting shifts and changes in the way that research has been presented.[18,27] Figure 8 illustrates the evaluation of the HCAIs research field. The number of keywords used in each of the coloured nodes, which indicate different research areas, determines their size. The grey flow band between nodes indicates

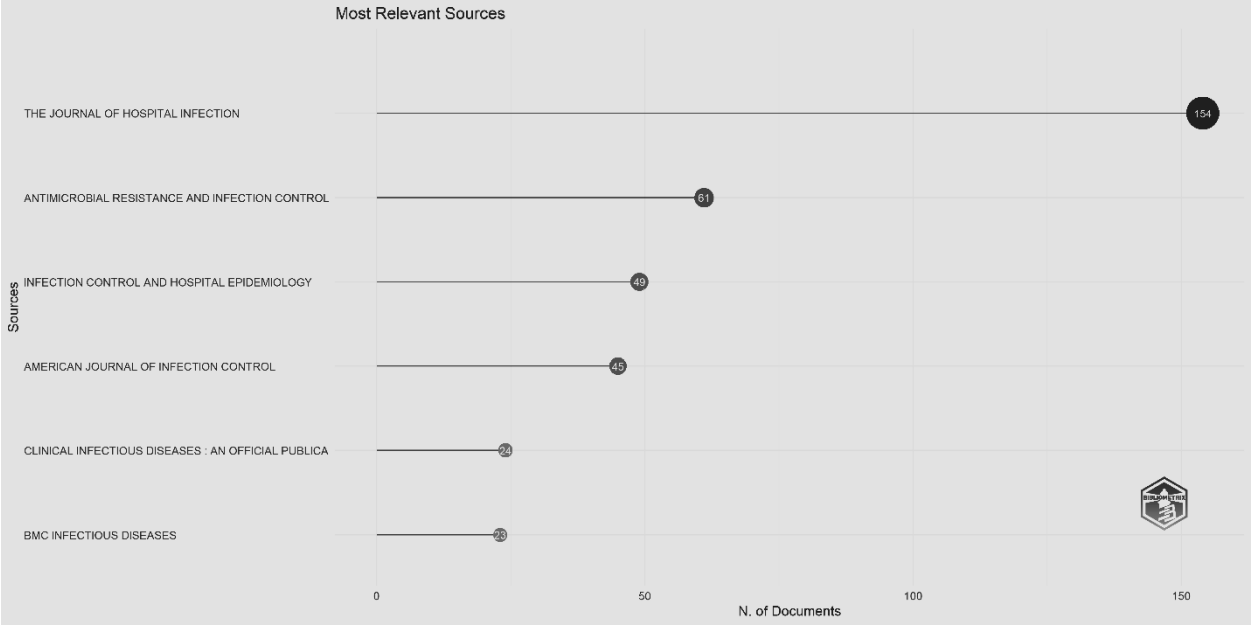

Figure 3: Top journals that published healthcare-associated infection related articles.

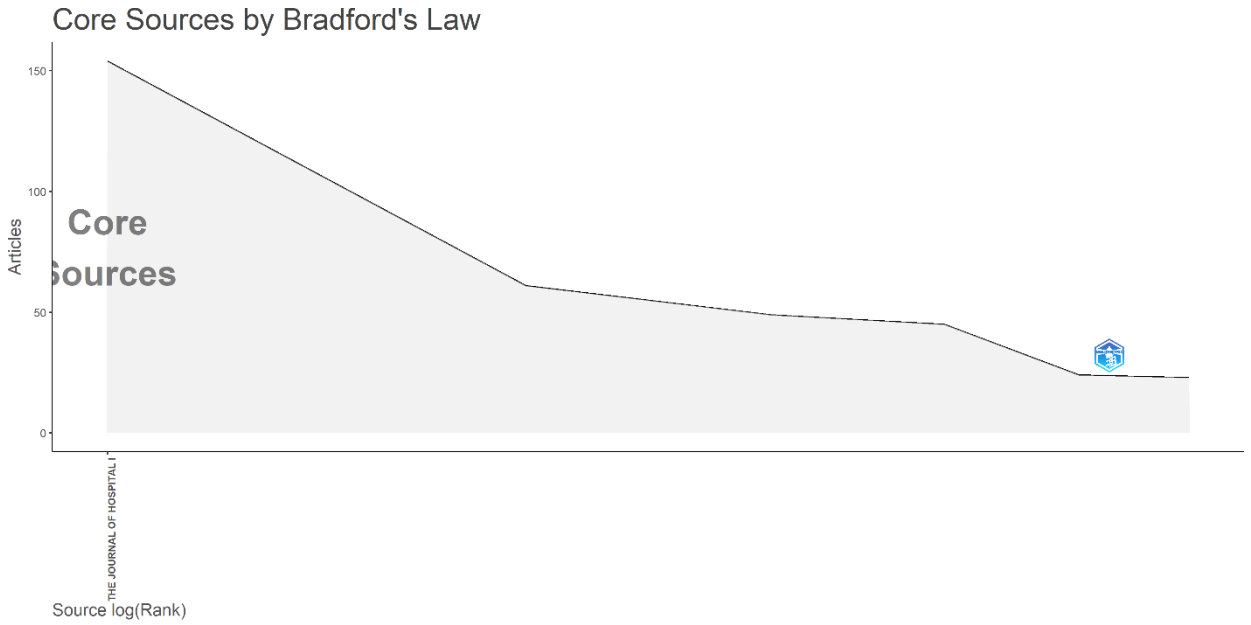

Figure 4: Core publication sources clustering through Bradford's Law.

the trend of the study topics' evolution and the consistency of time between them.

Figure 8 demonstrated an evolution timeline for the topic, from 2013 to 2023. Research on HCAIs was also divided into three distinct periods to illustrate evolving trends better. Throughout the first phase, thematic evolution between 2013 and 2017, the study topics were "healthcare associated infection," "clostridium difficile," "infection prevention and control," "surgical site infection," and "blood stream infection". This established a foundation for further investigation of the theme. Emerging themes from the second phase of research, covering the years 2018-2019, included "risk factor," "length of stay," "*Acinetobacter buamannii*," and "environment," while "healthcare-associated infection," "bloodstream infection," "clostridium difficile," and "surgical site infection" remained constant. In the third stage, which ran from 2020 to 2023, new topics about "surveillance" and "implementation" were developed (Figure 8). The changing nature of these themes shows that scientists are paying more attention to the impact of HCAIs on patients and medical staff and are looking at the efficacy of IPC measures in reducing infection rates.[4,28-31] The potential for future research and improvements in the subject of HACIs can be further explored with the help of theme evolution analysis, which can help us grasp the current state of the field and its trajectory.

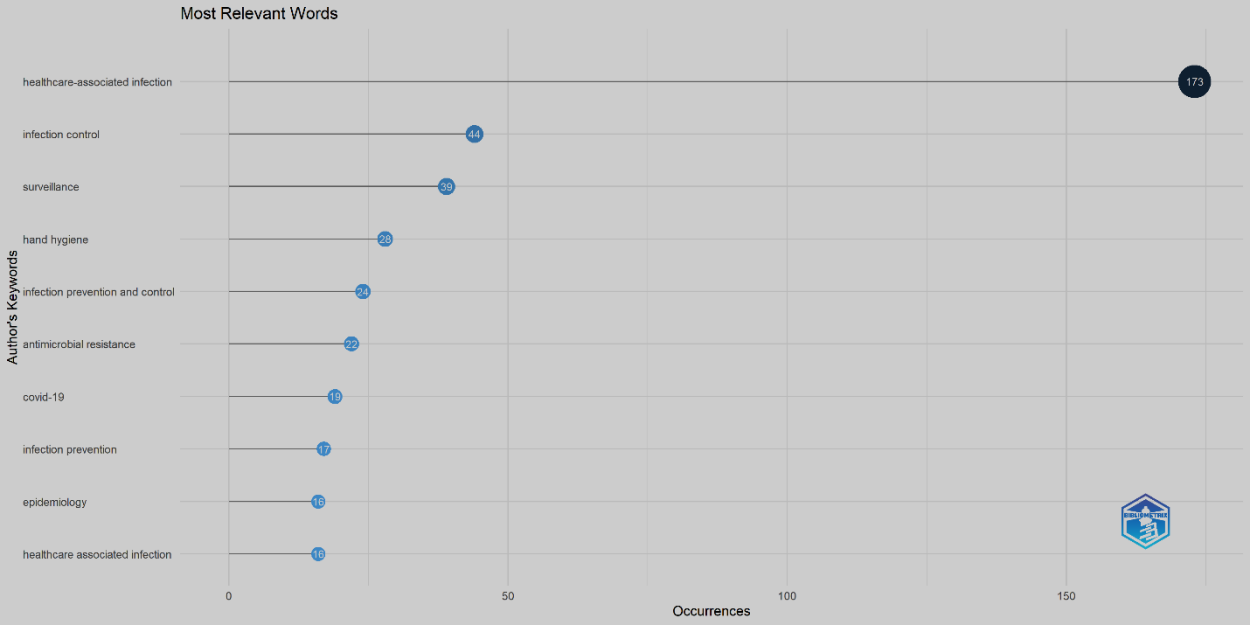

Figure 5: Top 10 most frequent author's keywords for healthcare associated infection articles.

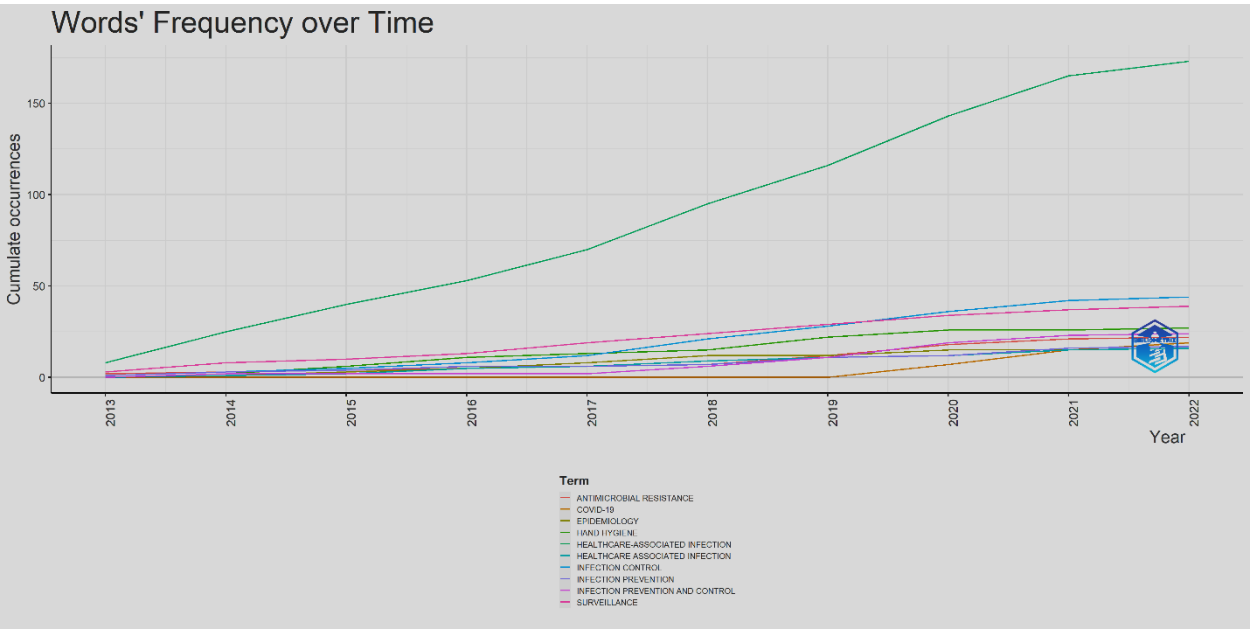

Figure 6: Cumulative authors' keyword occurrences from 2013-2023.

DISCUSSION

The prevalence of HCAIs is a major threat to the healthcare sector. HCAIs place a heavy financial strain on healthcare systems, prolonging hospital stay, and increasing morbidity.[6,8] This bibliometric analysis highlights the basic structure of the literature on HCAIs. It detects emerging article trends and patterns of cooperation which, can provide the basis for consequential advances in the field. This allows researchers to survey the subject, spot areas where more information is needed and better frame how they contribute. As far as we are aware, this is the first bibliometric evaluation of HCAIs research. The overall findings indicated that relevant publications had grown more frequently during the last ten years. The prevention, management, and evaluation of HCAIs have all been the focus of research globally.[5,8,30] From 2013, there has been an increase in the publications. In particular, from 2019 to 2020, HCAI has progressively gained greater attention in the study sector with the spread of COVID-19 that swept the world, affecting the health concerns of patients.[1,12,15,32]

Important scientific progress is made through international collaboration, emphasizing knowledge sharing and synthesis of knowledge.[33,34] While different nations may place different emphases on certain aspects of HCAI study, collaborating together might lead to resource synergy and steady progress. Our

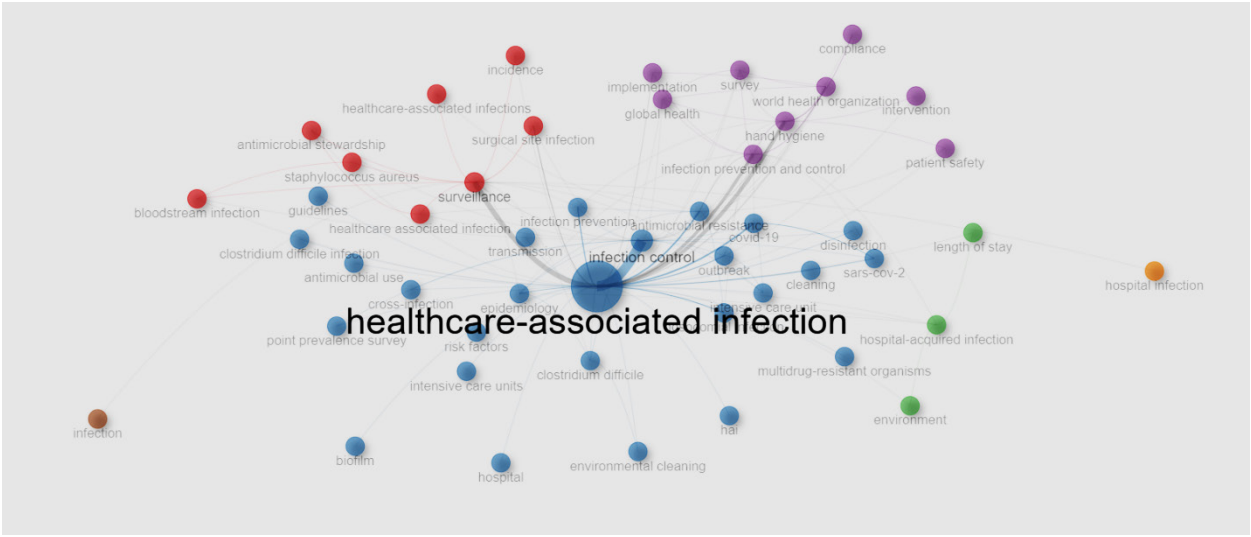

Figure 7: Co-occurrence network of the topics discussed. Nodes with the same colour indicate topics under the same cluster.

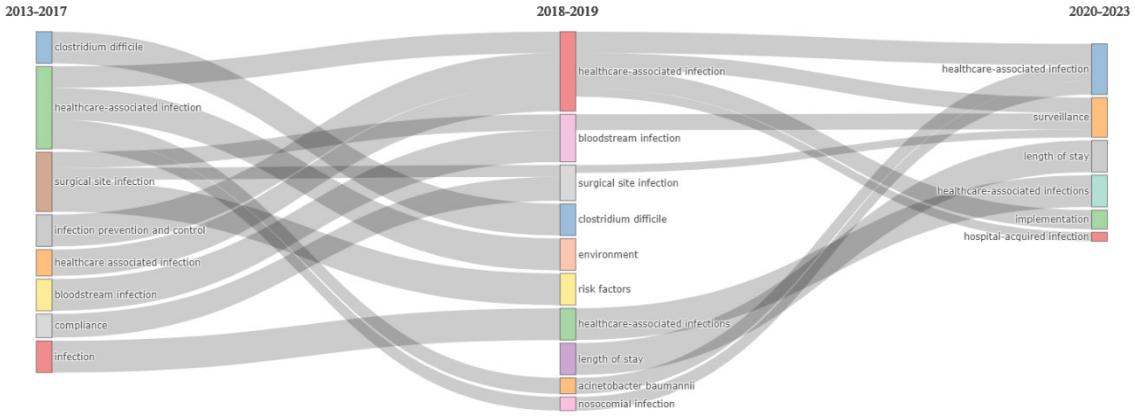

Figure 8: Thematic evolution over the decade. The figure shows the evolution of hotspots and trends of healthcare-associated infection.

analysis shows that the leading contributors to the HCAI literature are located in the United States, Germany, the United Kingdom, Switzerland, Australia, Brazil, China, and France. We discovered that less research is conducted from Low- and Middle-Income Countries (LMIC), even though HCAIs are more prevalent in these areas.[35-38] Due to a lack of documented LMIC studies, the true extent of HAI burden is unknown.[9] For this reason, it is essential to foster collaborations between scientists in countries with abundant and scarce resources and to motivate researchers to devote more time and energy to their work by providing them with technical and financial support.

Through the analysis of journals, the most highly published studies in the *Journal of Hospital Infection* followed by the *Antimicrobial Resistance and Infection Control Journal* with impact factor 3.35 and 5.8 respectively. According to the Bradford analysis, in the core zone the journals that are most frequently cited in the articles on any given research topic and are most likely to be of the greatest interest to those researchers who make up the core zone (Zone 1 out of 3).[39] The core sources for this research field are *journal of hospital infection;* a substantial concentration of publications contributes 40% of the published articles.

The analysis of authors' keywords may provide significant information about the trends in a certain field of study. Healthcare-associated infections and infection control were among the most frequently mentioned topics. Many studies have demonstrated that the implementation of IPC guidelines and the benefits of early detection[4,5,29,31] can reduce the prevalence of HCAIs. The healthcare pandemic directly led to an expansion of the IPC programme, which is crucial for patient and healthcare worker safety.[12,13] In particular, new terms have emerged in this field with the development of the COVID-19 pandemic, indicating a trend in studies linking HCAIs with COVID-19. Numerous studies have documented the frequency of HCAIs among COVID-19 patients.[1,14,40-42] Additionally, antimicrobial

resistance (AMR) and the widespread use of antibiotics have also been the subject of numerous studies.[6,43,44] According to the analysis the cumulative occurrences of these keywords have been increasing over time, suggesting that the related discussions are still timely and relevant. Large clusters in keyword co-occurrence networks represent active study areas. Apart from HCAIs, our findings show that features of IPC relevant to HCAI prevalence and management are the key topics of interest for most study.[46,47] One important IPC strategy that has been shown to significantly reduce the incidence of HAIs and the propagation of antibiotic resistance is increased emphasis on hand hygiene and surveillance.[28,31,48] Concerns have been raised after COVID-19 pandemic regarding the IPC rules' application to the healthcare system. Numerous studies highlighted the significance of implementing automated monitoring and automated hand hygiene that increase the quality of safety and patient care.[10,48-51] The effects of HCAIs on hospital stays and associated risk factors have been discussed elsewhere.[37,40,52] Keyword analysis by year demonstrates the centrality of themes in HCAIs research. The primary objective moving forward is to initiate additional studies connecting infection control, HCAIs, and COVID-19.[13,15,30,41]

The information offered in this article may assist researchers and scientists in focusing their attention on the most critical issues surrounding the investigation of HCAIs. Based on our findings, we suggest that future research on developing and implementing HCAI control methods should concentrate on different hospital environments. Further research is needed to decrease the prevalence of HCAIs and improve IPC policies and programmes in developing nations, such as increasing connection and cooperation across healthcare facilities.[35,38] Education, organisational and cultural hurdles, infrastructure, and financial resources are where more evidence is needed to support IPC's widespread implementation. Additionally, in healthcare settings where patient involvement is crucial to patient safety, more research is needed to highlight the importance of educating patients about nosocomial infection prevention and adopting IPC standards.[53,54] Moreover, further studies are required to evaluate healthcare students' knowledge of HCAIs and IPC to equip them with the tools they will need to succeed in the profession.

Limitations

We acknowledge that our research has some limitations. Since only the PubMed database was utilised to extract the relevant literature, there is a possibility of bias and insufficient inclusion studies. Furthermore, our search strategy may not have uncovered all relevant studies because of constraints regarding keywords, time periods, zone source and languages, which would have led to insufficient findings in our analysis. In the end, the keyword analysis in this study was based entirely on the authors' keywords.

CONCLUSION

Healthcare-Associated Infections (HCAIs) are a major cause of death and disability. We have provided a comprehensive review of the literature on HCAIs and demonstrated its potential as a growing research area. The bibliometric study of HCAIS studies over the past decade reveals a rising trend in the number of studies covering this topic. Journal of hospital infection and antimicrobial resistance and infection control journal were the most prolific publishers in this field, with the majority of researchers coming from European countries. According to the analysis of authors' keyword, we found that "healthcare-associated infection," "infection control," "surveillance," "hand hygiene," and "antimicrobial resistance" are the most frequently used terms, each of which reflects an active area of study and a possible direction for future development. It is anticipated that this study will inspire researchers to continue their work in the field of HCAIs and provide insight into current trends, research hotspots, and future research directions.

ACKNOWLEDGEMENT

This study was supported by Research Grant RMCG20-041-0041.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

HCAIs: Healthcare-Associated Infections; **SP**: Standard Precautions; **IPC:** Infection prevention and control.

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Cite this article: Ismaeil R, Nahas ARF, Kamarudin NB, Nor MBM, Abubakar U, Mohamed MHN. Healthcare-Associated Infections: A Ten-Year Bibliometric Analysis. J Young Pharm. 2023;15(3):397-405.