

Global Trends in Influenza and Meningitis Research: A Comprehensive Bibliometric and Visualization Analysis (1980–2024)

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Background: Influenza and meningitis are interconnected through shared epidemiological patterns and complications, with influenza often leading to bacterial meningitis by compromising host immunity. This study conducted a bibliometric analysis to explore global research trends on influenza and meningitis.

Methods: A comprehensive search was performed for publications on influenza and meningitis from 1980 to 2024 using the Web of Science Core Collection (WoSCC) database. Bibliometric analysis and visualization were conducted using the “bibliometrix” R package, VOSviewer, and CiteSpace.

Results: A total of 397 articles were analyzed, accumulating 12,829 citations. The USA led in productivity, followed by Japan and China, with the University of California System as the top institution. Vaccine emerged as the leading journal, while Kawashima Hisashi, Oana Shingo, and Yamanaka Gaku were identified as the most influential authors. Keyword cluster analysis identified five primary research areas: epidemiology and resistance, diagnostic methods, pediatric implications, vaccination and immunization, and pathogen interactions in influenza and meningitis. Notably, the increasing prominence of the keyword “burden” in recent years reflects a growing focus on the global epidemiological impact and healthcare challenges associated with these diseases. Additionally, emerging research trends include vaccine hesitancy, long-term sequelae in pediatric populations, and integrated approaches to prevention and management.

Conclusion: This study provides a bibliometric analysis of influenza and meningitis research, highlighting emerging trends, influential publications, and global collaborations. Despite the use of a single major database, the findings offer valuable insights; however, future global reviews may benefit from including multiple databases to maximize recall and minimize bias. Future research should prioritize advancements in vaccine development, diagnostic innovation, and integrated management strategies to address evolving public health challenges and improve outcomes in influenza and meningitis.

Keywords: influenza, meningitis, bibliometric analysis, VOSviewer, CiteSpace

Introduction

Influenza is an acute respiratory illness caused by influenza viruses A, B, and C, with A and B types being the most clinically significant.¹ While influenza is primarily a viral disease, its complications can involve both viral and secondary bacterial processes, especially in vulnerable populations. Globally, seasonal influenza causes approximately 290,000 to 650,000 respiratory deaths annually, according to World Health Organization (WHO) estimates, impacting up to 10% of the population each year.² Its clinical presentation includes fever, cough, sore throat, muscle aches, and fatigue, which can escalate into severe complications in vulnerable populations such as children, the elderly, and individuals with pre-existing conditions.³ Influenza-associated complications encompass not only respiratory system issues but also those affecting other



systems, such as the central nervous system. Among these, meningitis stands out as a severe complication with significant health consequences, including a high mortality rate and long-term neurological impairments, particularly when the virus invades the central nervous system.⁴ This dual burden of direct morbidity and severe complications underscores influenza's critical role as a public health concern, necessitating continued research into its epidemiology and clinical management.

Meningitis is a severe inflammatory condition of the meninges, the protective membranes surrounding the brain and spinal cord, often resulting from bacterial, viral, or fungal infections. It is important to note the distinction between viral meningitis—commonly caused by enteroviruses or influenza viruses—and bacterial meningitis, which is typically more severe and associated with different pathogens such as *Streptococcus pneumoniae* and *Haemophilus influenzae*.⁵ The prognosis, treatment, and long-term outcomes differ significantly between these etiologies, despite some overlapping clinical presentations.⁶ Clinically, meningitis presents with headache, fever, neck stiffness, and altered mental status.⁷ Influenza can act as a precursor to meningitis, primarily by disrupting the respiratory epithelium and compromising host immunity, which facilitates secondary bacterial infections like pneumococcal or haemophilus influenzae meningitis.⁸ Globally, viral meningitis caused by influenza viruses has been increasingly recognized in outbreaks, with influenza-associated meningitis cases reported across diverse geographic regions.⁹ For example, a study tracking influenza-related complications identified neurological manifestations, including meningitis, as significant contributors to morbidity.¹⁰ Despite treatment advancements, the condition carries a high burden, with survivors often facing long-term neurological sequelae such as hearing loss, cognitive impairment, and motor deficits.¹¹ However, the current state of research on influenza and meningitis lacks a comprehensive and integrated analysis, highlighting the need to systematically evaluate advancements and gaps in understanding their interplay.¹²

Bibliometric analysis, which employs quantitative and statistical methods to identify research trends, emerging fields, and key collaborations, serves as a valuable tool for strategic planning and resource allocation in research institutions, facilitating more informed decision-making. In recent years, bibliometric analyses have been increasingly used in the field of infectious diseases and central nervous system disorders to map research trends, collaborations, and knowledge gaps.^{13,14} For example, previous studies have focused on the epidemiology of influenza itself and on broader inflammatory or immune responses in the CNS.^{15,16} However, to the best of our knowledge, a comprehensive bibliometric analysis specifically addressing the intersection of influenza and meningitis remains unavailable. This study aims to address this gap by conducting a comprehensive bibliometric analysis of existing research on influenza and meningitis.

Materials and Methods

Search Strategies and Data Collection

A literature search for influenza and meningitis research was conducted using the Web of Science Core Collection (WoSCC), a comprehensive and authoritative database that indexes high-quality research across various disciplines, covering publications between 1980 and 2024. The search strategy was as follows: (TS = (Influenza OR Grippe*)) AND TS = (Meningitis*).¹⁷ To avoid inconsistencies from database updates, the literature retrieval was conducted on December 26, 2024. The choice to use only WoSCC was based on its broad coverage, standardized metadata, and superior compatibility with bibliometric software. While searching multiple databases is generally recommended for systematic reviews to maximize recall and minimize bias, for bibliometric studies, merging data from different sources often introduces inconsistencies and duplicate records, and may reduce data quality and software compatibility. This approach is supported by Bramer et al, who highlight the practical and methodological challenges of merging records from multiple databases for bibliometric analysis.¹⁸

The inclusion criteria were: 1. Original articles and research papers related to both influenza and meningitis; 2. Publication date between 1980 and 2024; and 3. English language. The exclusion criteria included: 1. Reviews, editorial materials, letters, meeting abstracts; 2. Non-English publications; and 3. Articles unrelated to the research topic. All records retrieved from WoSCC were directly exported in plain text format. Duplicate entries were automatically detected and removed by CiteSpace and the R package bibliometrix during the bibliometric analysis process. As this study aimed to provide a comprehensive overview of global research output, no additional manual screening for relevance was conducted.

Consistent with standard bibliometric practice, no formal quality assessment was performed, as bibliometric analyses aim to map research output and trends rather than evaluate the methodological quality of individual studies. This is in line with recommendations in the bibliometric literature.¹⁹

Data collected included: publication counts, citation counts, article titles, author details, institutions, countries/regions, keywords, and journal names for subsequent bibliometric analysis.

Statistical Analysis

Microsoft Excel 2019, the R package “bibliometrix” (version 4.3.3), VOSviewer (version 1.6.20), and CiteSpace (version 6.3. R1) were utilized for data analysis and visualization. The R package “bibliometrics” enabled visualization of publication outputs from corresponding authors across different countries and the article count from the top ten institutions.²⁰ VOSviewer was employed to visualize collaborations among countries, institutions, and authors, co-occurrence and coupling networks of journals networks, as well as keyword analysis.²¹ CiteSpace was applied for keyword burst analysis, with parameters set as follows: time slicing from January 1994 to December 2024, with a slice interval of one year; node types set to keywords; and thresholds of the top five keywords per segment, employing pathfinder pruning and merged networks. These settings facilitated a visual analysis to generate a keyword timeline map for “influenza and meningitis”, offering insights into the temporal development of key research themes.

Several parameters from the WoSCC, including the h-index and g-index were employed to quantify the academic impact of individuals and journals.^{22,23} The h-index is a vital indicator for evaluating researchers’ academic contributions and predicting their future scientific achievements. The g-index enhances this evaluation by giving more weight to highly cited articles, providing a better assessment of a researcher’s impact. Journals were assessed using Impact Factor (IF) and Journal Citation Reports (JCR), which are widely recognized metrics for evaluating the academic influence, citation frequency, and overall quality of scholarly publications.²⁰

Results

An Overview of Publications

The overall selection process was presented in [Figure 1](#). The study analyzed 397 articles published between January 1980 and December 2024, spanning 246 journals and involving 2,499 authors, with a total of 930 keywords and 12,829 references. The annual article count demonstrated an average growth rate of 2.71%, with an international collaboration rate of 19.9%.

The annual growth rate indicated that research on influenza and meningitis steadily increased over time ([Figure 2](#)). This growth could be divided into two distinct phases. Phase one, covering the period before 2009, experienced an annual publication growth of fewer than 10 articles. Phase two demonstrated a steady increase in annual growth rates, culminating in a peak of 29 articles in 2021.

Analysis of Countries

The top publishing countries were primarily located in Asia, North America, and Europe ([Figure 3A](#) and [Table S1](#)). In the field of influenza and meningitis research, the top three contributors in terms of total publications are the USA (438), Japan (102), and China (95). The USA also has the highest total number of citations, at 2,598, followed by the UK (959) and Japan (811). However, in terms of average citations per publication, the standout countries are the UK (38.4), France (34.6), and Canada (34.1). Notably, despite its relatively high publication output, China has lower total citations (296) and average citations per publication (11).

Publications were further categorized into Single Country Publications (SCP) and Multiple Country Publications (MCP). The MCP number of USA was 20, while China and Japan only had 2 and 1 MCP, respectively. Among the 34 countries involved in international collaborations with at least one article, the USA (total link strength = 70) had the highest number of collaborations, followed by the UK (total link strength = 38) and Germany (total link strength = 30) ([Figure 3B](#)). Detailed bibliometric indicators of the high-impact journals are provided in [Table S2](#).

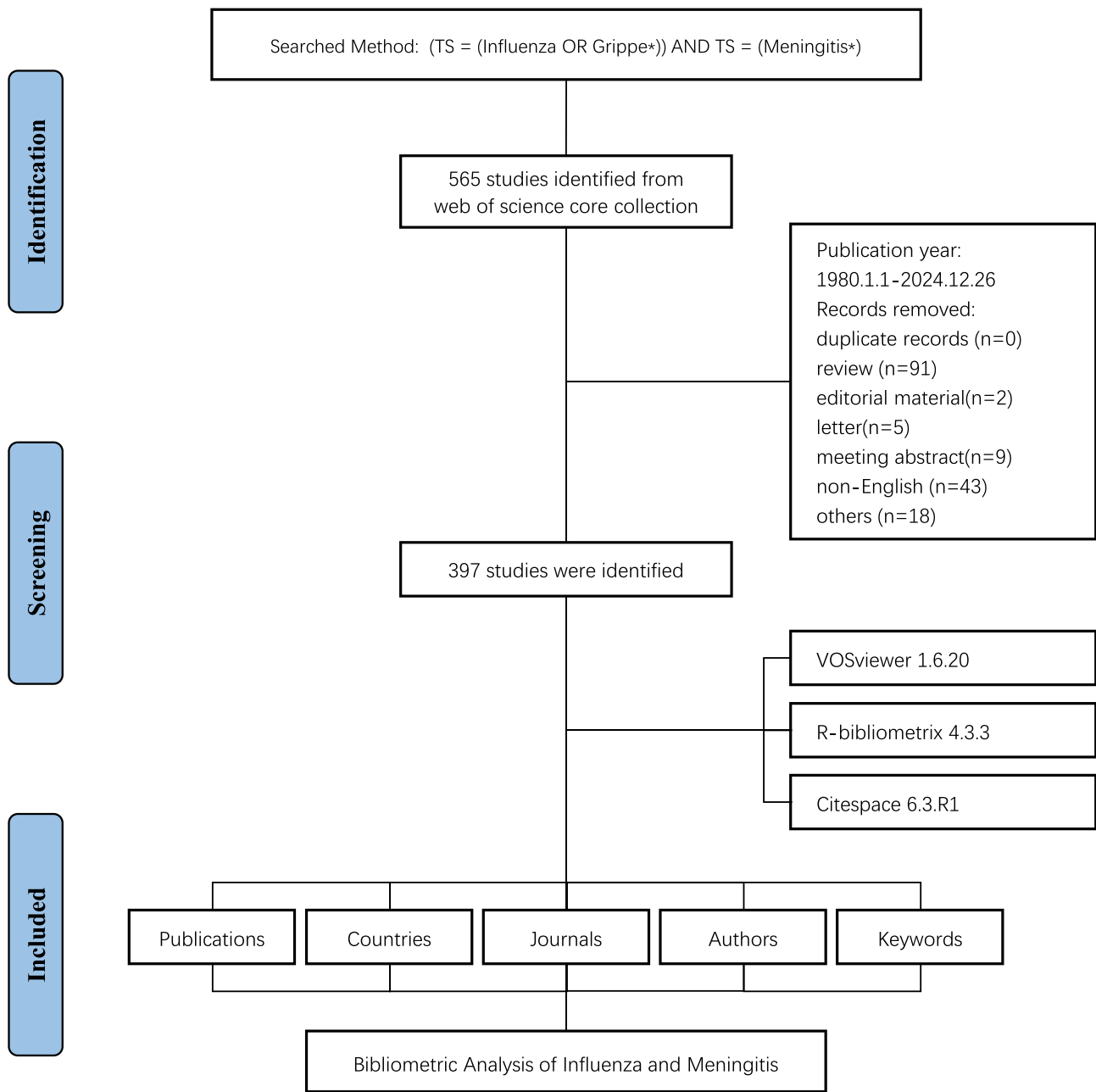


Figure 1 Flowchart of the literature screening process. Meningitis*: the asterisk (*) represents a truncation symbol used to retrieve variations of the word "meningitis".

Analysis of Institutions

The top 10 institutions contributing to the research, as shown in [Figure 4A](#), include six from the USA, two from France, and one each from the UK and Canada. The top three institutions in terms of publication volume were the University of California System (34 articles), the Centers for Disease Control and Prevention (CDC) (30 articles), and the University of Oxford (21 articles). Among the 54 institutions engaged in international collaborations with at least nine articles, Johns Hopkins University had the highest number of collaborations (total link strength of 23), followed by the Centers for Disease Control and Prevention - USA (total link strength of 15) and the University of Pittsburgh (total link strength of 13) ([Figure 4B](#)).

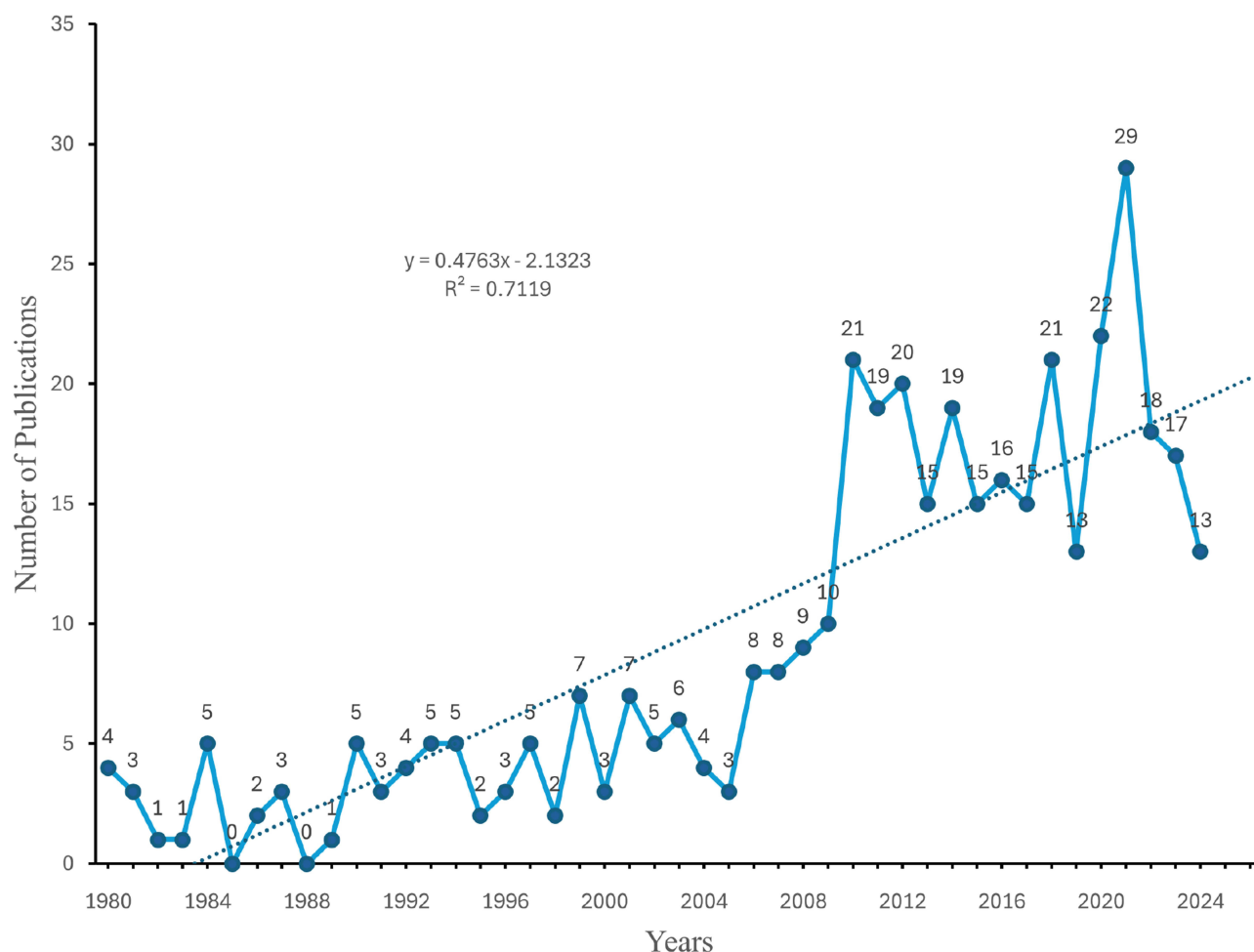


Figure 2 Annual number of publications.

Analysis of Journals

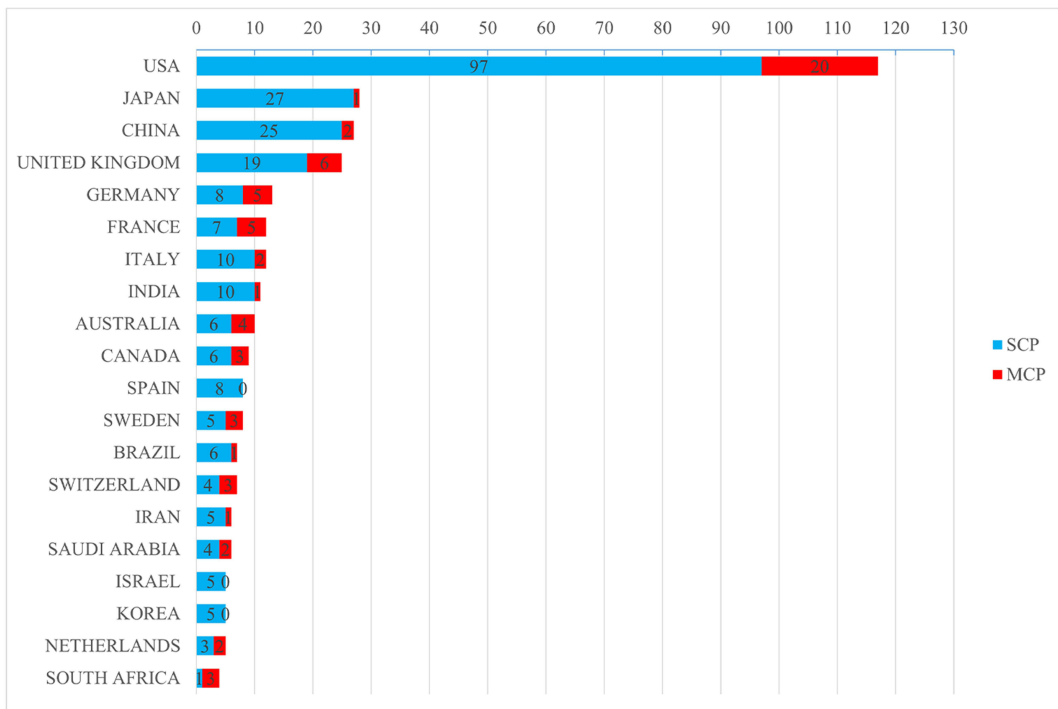
For research on influenza and meningitis, the top three journals by h-index were *Vaccine* (h-index = 13, TP = 21, TC = 414), *Pediatric Infectious Disease Journal* (h-index = 10, TP = 14, TC = 306), and *PLOS ONE* (h-index = 7, TP = 11, TC = 203). All three journals were highly influential in the field, with *Vaccine* being classified in the JCR Q2 category and *Pediatric Infectious Disease Journal* and *PLOS ONE* in JCR Q1. Among the top 10 journals by h-index, *Clinical Infectious Diseases* had the highest IF (8.2), followed by *Journal of Medical Virology* (IF = 6.8). A total of 59 journals with at least two related publications were selected for analysis. Co-occurrence networks were constructed to examine the association between publications across different journals by evaluating shared references (Figure 5A). The three key journals with the highest total link strength in co-occurrence networks were *Clinical Infectious Diseases* (9), *Pediatric Infectious Disease Journal* (4), and *Pediatrics* (4). To improve clarity, a simplified journal co-occurrence network (Figure S1) is provided, focusing on the main publication clusters.

Additionally, coupling networks were created to assess the extent of thematic or topical connections between journals based on frequent co-citation patterns (Figure 5B). High link strength in the coupling network suggested a strong intellectual relationship, demonstrating a shared research focus within the field. The same three key journals—*Pediatric Infectious Disease Journal* (137), *Vaccine* (115), and *Pediatrics* (101)—exhibited the highest total link strength in this network.

Analysis of Authors

Among the top 10 authors ranked by h-index in Table S3, Hisashi Kawashima, Anna Shinwa, and Gaku Yamauchi ranked first, second, and third, respectively, in this field, each with identical metrics (h-index = 5, g-index = 6, m-index = 0.29,

A



B

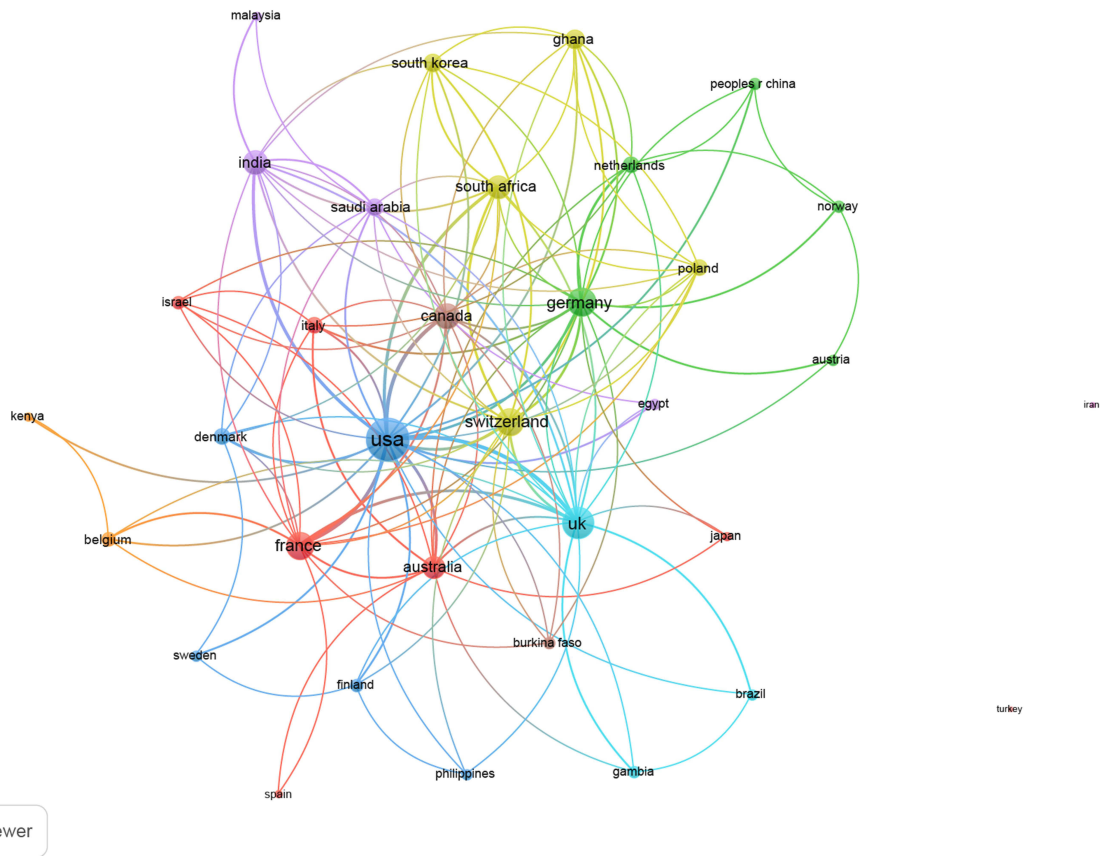


Figure 3 Global Distribution and Collaboration Network of Publications. **(A)** Distribution of corresponding author’s publications by country. **(B)** Visualization map depicting the collaboration among different countries.

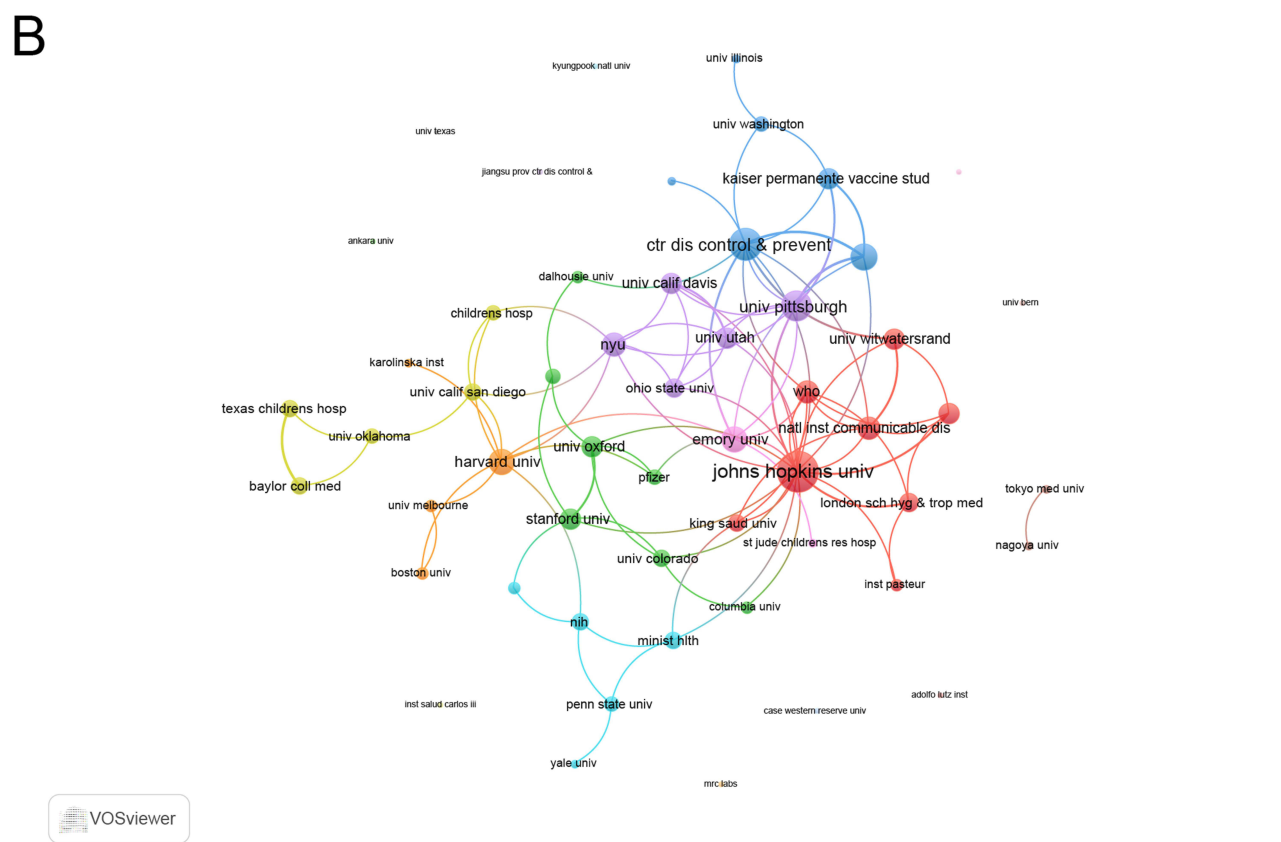
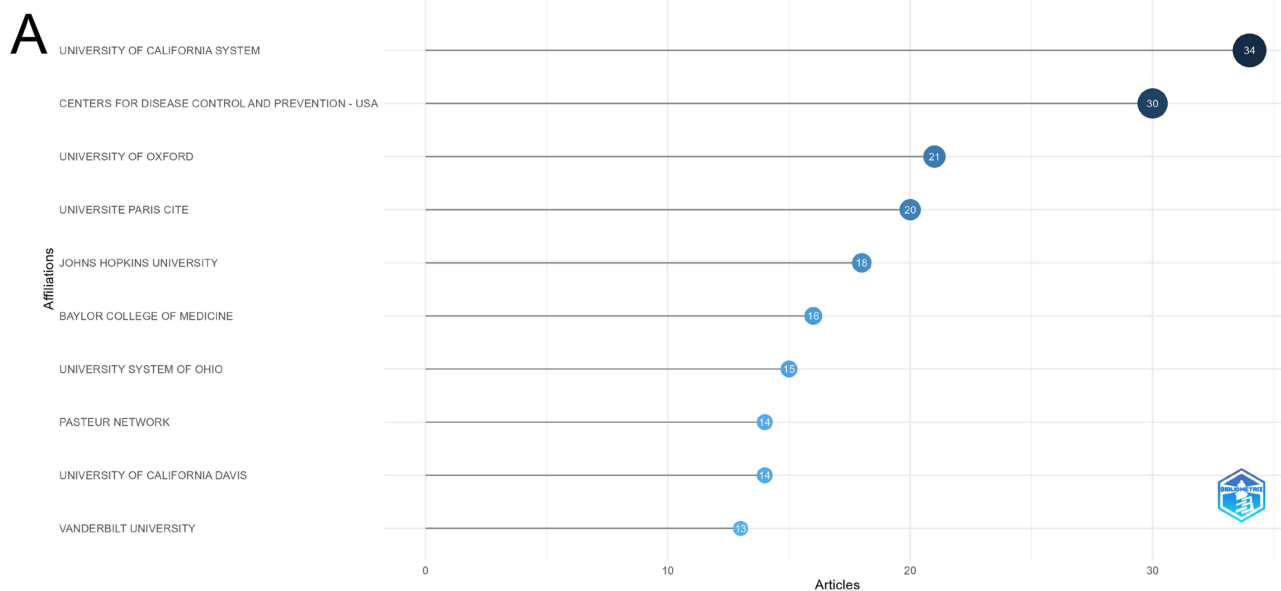


Figure 4 Institutional Contributions and Collaboration Network in Research. (A) Top ten institutions by article count and rank. (B) Visualization map depicting the collaboration among different institutions.

TP = 6, TC = 91). A collaboration network was constructed for authors with two or more publications, reflecting their interconnected contributions to advancing this critical area of research (Figure 6). Overall, authors from various institutions were classified into more than three groups based on their collaboration levels, with most of these collaborations being geographically driven. Among the 93 authors engaged in international collaborations with at least

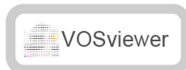
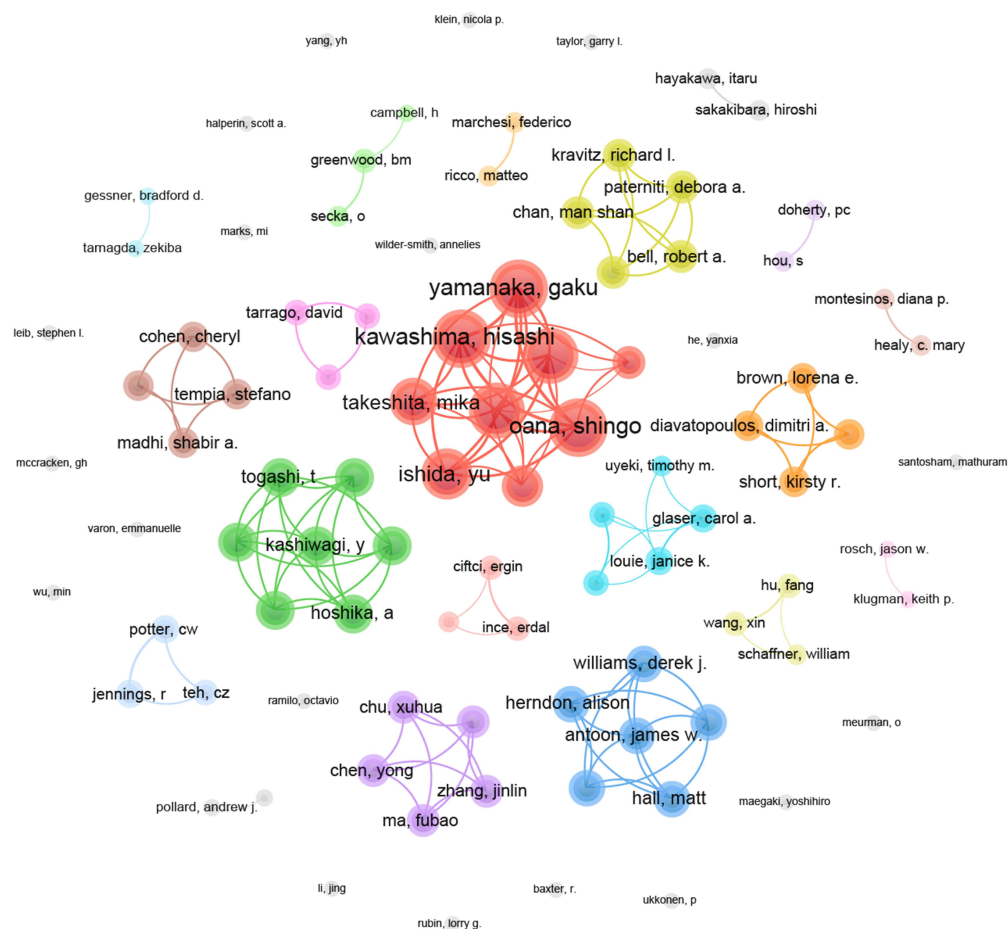


Figure 6 Visualization map depicting the collaboration among different authors.

two articles, Oana Shingo, Yamanaka Gaku, and Kawashima Hisashi each demonstrated the highest number of collaborations (total link strength of 33), highlighting robust and well-established collaborative networks among these leading researchers.

Analysis of Keyword Co-Occurrence and Burst Keyword

A total of 162 keywords with at least 3 occurrences were identified (Figure 7A), allowing the rapid identification of research hotspots within the field. The keyword cluster analysis, now visualized in a simplified network (Figure S2), identified five primary thematic areas within influenza and meningitis research. The red cluster (Epidemiology and Public Health) included terms such as “infections”, “epidemiology”, “population”, and “resistance.” The blue cluster (Diagnostics and Clinical Assessment) comprised keywords like “diagnosis”, “polymerase-chain-reaction”, “acute encephalopathy”, and “herpes-simplex encephalitis.” The purple cluster (Pediatric and Neurological Impact) contained terms such as “children”, “infants”, “encephalitis”, and “complications.” The green cluster (Vaccination and Immunization Strategies) featured keywords like “influenza vaccination”, “immunization”, and “efficacy.” Finally, the yellow cluster (Pathogen Interactions and Disease Synergy) focused on terms like “streptococcus-pneumoniae”, “influenza-virus”, “lethal synergism”, and “seasonality.” These clusters highlight the distinct research areas and recurring themes in the field of influenza and meningitis.

The change in node color reflected the variation in keyword frequency and thematic relevance over time (Figure 7B). In addition, a simplified keyword timeline network (Figure S3) visualizes the temporal evolution of research focuses. The

C

Top 20 Keywords with the Strongest Citation Bursts

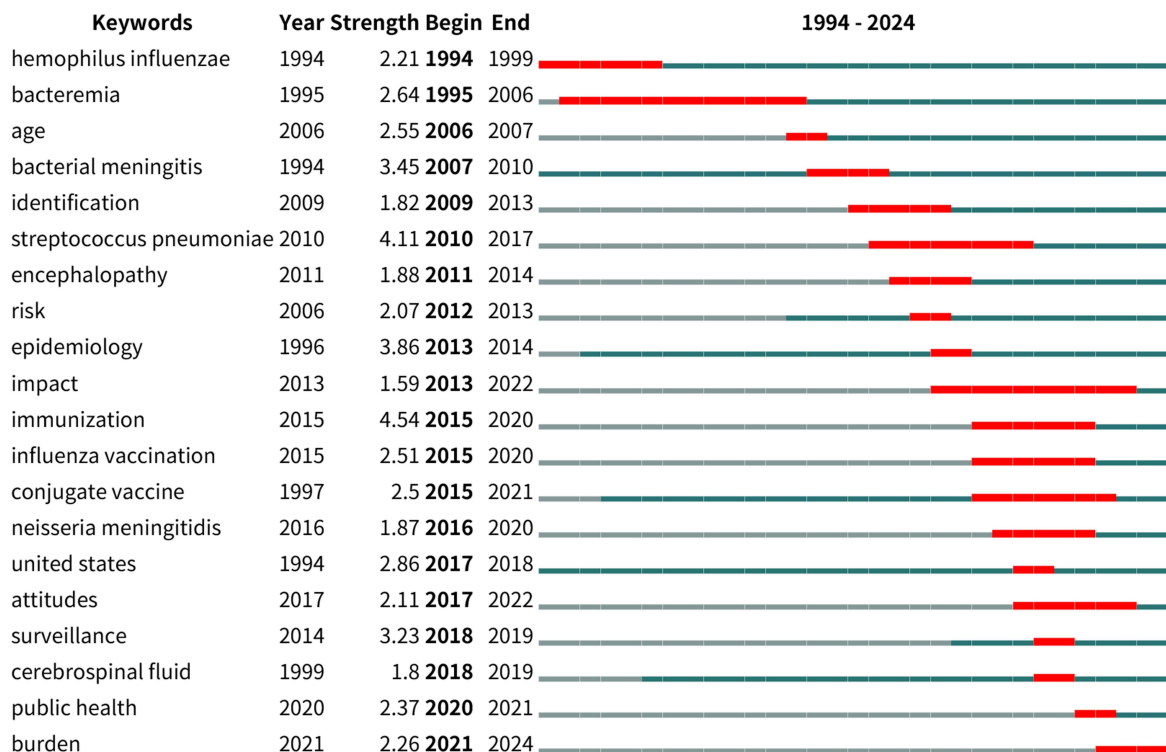


Figure 7 Keyword Co-occurrence Network, Timeline Evolution, and Burst Analysis. (A) Visual analysis of keyword co-occurrence network analysis. (B) Visual Analysis of Keyword Co-occurrence Network and Timeline Change Analysis. (C) Analysis of Burst Keywords.

analysis of keywords revealed distinct research focuses across different periods. Before 2010, frequently occurring keywords included “infections”, “children”, “infants”, and “vaccine.” By 2014, the keywords expanded to encompass terms like “immunization”, “outbreak”, “risk”, and “population.” From 2018 onward, prominent keywords included “seasonal influenza”, “manifestations”, “attitudes”, and “knowledge.”

The keyword burst analysis identified key terms with notable citation increases over specific time periods (Figure 7C). “Hemophilus influenzae” showed an early burst from 1994 to 1999 (burst strength 2.21). The strongest burst was observed for “immunization” during 2015–2020 (burst strength 4.54). More recent bursts include “public health” (2020–2021, burst strength 2.37) and “burden” (2021–2024, burst strength 2.26).

Discussion

General Information

This bibliometric study has unveiled the current state of research on influenza and meningitis, highlighting the USA as the leading contributor, followed by Japan and China, with the University of California System and the Centers for Disease Control and Prevention standing out as top institutions. Notably, Japan’s prominent contribution may be attributed to its strong tradition in pediatric infectious disease research, robust public health surveillance, and early adoption of diagnostic technologies; these factors likely explain its high research productivity relative to its population size and are worthy of further exploration in future bibliometric or qualitative research. Vaccine emerged as the most influential journal, and Kawashima Hisashi, Oana Shingo and Yamanaka Gaku were identified as the most influential authors. Keyword co-occurrence and burst analysis revealed five major research clusters in influenza and meningitis,

covering epidemiology, diagnosis, pediatric implications, vaccination, and pathogen interactions, while chronological trends indicated a shift from infection surveillance to immunization impact, with recent keyword bursts emphasizing public health burden and vaccination strategies.

Kawashima Hisashi contributed notably to pediatric neurology and infectious diseases, with one of his key works explored neurodevelopmental outcomes in children.²⁴ Oana Shingo's work, *Viral coinfections in children with invasive pneumococcal disease*, focusing on infectious diseases in pediatric populations.²⁵ Yamanaka Gaku's collaborative research significantly overlaps with these themes, further contributing to advancements in pediatric infectious disease management.²⁶

Keyword Analysis

Thematic keyword analysis revealed key areas of focus, including epidemiology, vaccination, pediatric health, diagnostics, and pathogen dynamics, reflecting the field's evolution from foundational studies to advanced preventive strategies and precision interventions aimed at improving global health outcomes.

Epidemiology and Public Health

The red cluster underscores a focus on epidemiology and population-level disease patterns. Core keywords like "infections", "epidemiology", "population", and "resistance" highlight research aimed at understanding the burden and transmission of influenza and meningitis. The epidemiological cluster demonstrated strong evidence for population-level patterns, particularly highlighting how seasonal influenza epidemics contribute to increased bacterial co-infections.²⁷ Notably, research has shown that influenza-induced inflammation significantly compromises mucosal barriers and immune responses, leading to heightened susceptibility to invasive pneumococcal infections during peak flu seasons.²⁸ At the molecular level, influenza infection upregulates the expression of host proteases such as TMPRSS2, facilitating bacterial adherence and invasion while simultaneously suppressing alveolar macrophage function, thereby exacerbating secondary infections.²⁹ However, our analysis indicates that studies from low- and middle-income countries (LMICs) remain underrepresented, likely due to language barriers, resource limitations, and publication bias, which may restrict global understanding of disease epidemiology.

Diagnostics and Clinical Assessment

The blue cluster reflects advancements in diagnostic tools and efforts to decipher clinical presentations of these diseases. Key terms such as "diagnosis", "polymerase-chain-reaction (PCR)", and "acute encephalopathy" illustrate the focus on precision diagnostics. Advances in diagnostic capabilities, particularly PCR technologies, have transformed our understanding of disease presentation and progression.³⁰ The implementation of molecular diagnostic techniques has not only improved detection sensitivity but also revealed previously unrecognized patterns in pathogen dynamics.³¹ These findings suggest that early detection through PCR-based methods may significantly improve survival outcomes in meningitis cases, though further research is needed to quantify the long-term benefits of rapid diagnosis.³² Nonetheless, there is a persistent need for rapid and affordable diagnostic tools, particularly in LMICs, as highlighted by recent shifts in global health research priorities.³³ Future research should focus not only on accuracy, but also on the affordability and accessibility of diagnostics to ensure impact in resource-limited settings.

Pediatric and Neurological Impact

The purple cluster centers on pediatric populations, with keywords such as "children", "infants", "encephalitis", and "complications." Studies have consistently reported that children are disproportionately affected by influenza and meningitis, both in terms of incidence and severity.³⁴ The high rate of long-term sequelae in pediatric cases - affecting up to 30% of survivors - underscores the critical importance of preventive strategies for this vulnerable population.³⁵ Mechanistically, children exhibit increased susceptibility due to an immature adaptive immune system, characterized by lower baseline levels of memory B and T cells and a delayed interferon response, which impairs viral and bacterial clearance.³⁶ Additionally, the underdeveloped blood-brain barrier in infants facilitates pathogen invasion, exacerbating the severity of central nervous system infections.³⁷ Despite these findings, the literature on long-term neurodevelopmental outcomes and interventions in children, especially in LMICs, remains limited and represents a notable research gap.

Vaccination and Immunization Strategies

The green cluster highlights the critical role of vaccines, with terms like “influenza vaccination”, “immunization”, and “efficacy.” Vaccination remains the cornerstone of prevention for both influenza and pneumococcal meningitis.³⁸ While meta-analyses demonstrate significant reductions in hospitalizations and disease incidence among vaccinated populations, issues of vaccine hesitancy and variable efficacy in specific demographic groups remain substantial barriers.³⁹ The emerging research on universal influenza vaccines targeting conserved viral regions may offer a promising solution to these challenges, though further clinical trials are needed to confirm their efficacy.⁴⁰ Social and behavioral research on vaccine acceptance, public attitudes, and implementation science is still insufficiently represented, particularly for marginalized and resource-limited populations.

Pathogen Interactions and Disease Synergy

The yellow cluster delves into pathogen-specific interactions and seasonal trends, with representative terms including “streptococcus-pneumoniae”, “influenza-virus”, “lethal synergism”, and “seasonality.” These studies reveal how influenza acts as a precursor to bacterial meningitis by disrupting the respiratory epithelium and facilitating secondary infections.⁴¹ Influenza virus infection compromises mucociliary clearance by impairing ciliary function and inducing epithelial cell apoptosis, allowing bacterial pathogens like *Streptococcus pneumoniae* and *Neisseria meningitidis* to colonize the upper respiratory tract more effectively.⁴² The viral infection also triggers excessive pro-inflammatory cytokine release, including IL-6 and TNF- α , which can enhance blood-brain barrier permeability, thereby facilitating bacterial invasion into the central nervous system.^{42,43} Research supports previous findings of a 25% increase in meningitis cases following peak flu activity, suggesting a clear temporal relationship between these infections.⁴⁴ Additionally, epidemiological modeling studies indicate that co-infections can significantly worsen disease severity and mortality rates, underscoring the importance of understanding host-pathogen interactions in seasonal outbreaks.⁴⁵ These insights highlight the need for integrated surveillance systems and the coordination of prevention strategies that can address both viral and bacterial pathogens, especially in regions where healthcare resources are limited.

Keyword Burst

The evolution of research on influenza and meningitis has undergone significant transitions over the past decades. Before 2010, the research focus was foundational, addressing the burden of diseases like influenza and meningitis on vulnerable populations, with keywords like “infections”, “children”, “infants”, and “vaccine” prominently featured. Studies established fundamental understanding of disease burden, particularly in vulnerable populations.²⁷ Analysis of global epidemiological data revealed striking meningitis incidence rates of 40 cases per 100,000 annually among children under five years, with mortality rates exceeding 10% despite therapeutic advances.⁴⁶ These findings were particularly significant as they established the mechanistic relationship between influenza and bacterial meningitis, demonstrating how viral infections compromise host immunity and facilitate bacterial invasions, particularly by *Streptococcus pneumoniae*.⁴⁷

On the preventive front, early investigations into vaccines began to emerge. Initial vaccine trials yielded promising results, with polysaccharide vaccines demonstrating a 25% reduction in invasive bacterial diseases among vaccinated infants.¹² However, these early interventions faced significant implementation challenges, particularly in achieving comprehensive coverage.⁴⁸ Multi-cohort analyses during this period identified premature birth as a significant risk factor for severe influenza-associated complications, highlighting the necessity for stratified preventive approaches.⁴⁹

The period from 2010 to 2014 marked a significant shift toward understanding population-level dynamics and risk assessment, highlighted by keywords like “immunization”, “outbreak”, “risk”, and “population.” Epidemiological studies demonstrated temporal correlations between influenza peaks and increased meningitis cases, attributed to co-infections and immune suppression.²⁷ The implementation of conjugate vaccine programs showed marked success in reducing meningitis incidence among vaccinated populations.⁵⁰ Mathematical modeling of outbreak dynamics revealed that delayed vaccine deployment significantly increased hospitalization rates.⁵¹ Risk stratification analyses identified age and pre-existing respiratory conditions as critical determinants of disease severity, with elderly populations showing particularly vulnerable to adverse outcomes.⁵²

Contemporary research has increasingly focused on clinical manifestations and societal factors affecting disease control. Seasonal influenza epidemics continue to demonstrate strong associations with increased meningitis hospitalizations, including keywords like “seasonal influenza”, “manifestations”, “attitudes”, and “knowledge”⁵³ Long-term follow-up studies of pediatric meningitis survivors have documented significant sequelae, including hearing impairment and developmental delays, emphasizing the critical importance of early intervention.⁵³

The emergence of vaccine hesitancy as a significant barrier to disease control has prompted increased attention to social and behavioral factors.⁴⁰ While educational interventions have shown promise in improving vaccine acceptance, significant regional variations persist. Furthermore, enhanced clinical awareness has demonstrated measurable improvements in early diagnosis and treatment outcomes, particularly in resource-constrained settings.⁵⁴ Our findings emphasize that future research should not only pursue technological advances but also address social determinants of health, implementation barriers, and health equity issues.

Future Perspectives in Influenza and Meningitis Research

Future research in influenza and meningitis should prioritize the integration of advanced diagnostic technologies, such as high-throughput data chip sequencing and multimodal imaging, to surpass the limitations of PCR and enhance detection accuracy, allowing for earlier and more precise pathogen identification. Additionally, the development of rapid, affordable, and accessible diagnostic tools is urgently needed for LMICs, where disease burden is often highest and resources are scarce.⁵⁵ Expanding the development of universal vaccines targeting conserved viral and bacterial antigens offers potential for broader protection against co-infections. Enhanced surveillance systems combining real-time epidemiological data with genomic tracking could predict outbreaks more effectively. Addressing vaccine hesitancy through tailored public health campaigns and global collaboration to ensure equitable vaccine access will be essential. Emphasis on long-term patient outcomes, particularly in vulnerable populations, will drive innovations in personalized treatment and comprehensive care strategies. Moreover, future bibliometric studies should attempt to stratify analyses by pathogen (viral vs bacterial), to offer more granular insights for clinical and public health practice, as current database indexing limits such differentiation.

Strengths and Limitations

This study provides a comprehensive overview of research trends and advancements in influenza and meningitis by employing a bibliometric approach, which allows for the identification of key contributors, influential articles, and evolving research priorities. The integration of multiple analytical tools ensures robust data visualization and network mapping, facilitating a nuanced understanding of collaborative networks and thematic clusters. Furthermore, the temporal analysis of keywords offers valuable insights into the shifting focus of research, from foundational studies to contemporary challenges, enabling a strategic perspective on future directions.

In accordance with the recent BIBLIO reporting guideline for bibliometric reviews, this study adheres to minimum requirements for transparency and reproducibility. There are also some limitations, including potential publication bias, as only English-language articles were considered, which may exclude relevant studies in other languages. Furthermore, the analysis is based on available publications, and the conclusions may not fully reflect ongoing research efforts or emerging trends beyond the publication period. Additionally, the reliance on citation-based metrics may disproportionately favor older studies with more time to accumulate citations, potentially underrepresenting the impact of recent, high-quality research. Finally, differences in database indexing and journal coverage may have led to the omission of important articles not included in the WoSCC database, limiting the comprehensiveness of the analysis.

Conclusion

This comprehensive bibliometric analysis of influenza and meningitis research highlights the evolution of global research priorities, key contributors, and emerging trends in the field. The increasing prominence of keywords such as “seasonal influenza”, “knowledge”, and the recent burst of “burden” reflects a shift toward addressing vaccine efficacy, public health education, and vaccine hesitancy as central challenges. The findings underscore that research efforts are increasingly focused not only on epidemiology and clinical management, but also on societal and systemic aspects of disease control.

Implications for clinical practice and policy include the urgent need to develop rapid, affordable diagnostic tools, advance the creation of universal vaccines, and implement integrated, equitable public health strategies to reduce the burden of both influenza and meningitis worldwide. Continued global collaboration and attention to research gaps—particularly in low- and middle-income settings—will be essential to effectively mitigate the impact of these diseases in the future.

Abbreviations

WHO, World Health Organization; WoSCC, Web of Science Core Collection; IF, Impact Factor; JCR, Journal Citation Reports; PCR, Polymerase-chain-reaction.

Data Sharing Statement

All data generated or analysed during this study are included in this published article.

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Disclosure

The authors report no conflicts of interest in this work.

References

- Torres A, Loeches IM, Sligl W, Lee N. Severe flu management: a point of view. *Intensive Care Med.* 2020;46(2):153–162. doi:10.1007/s00134-019-05868-8
- Liu X, Peng Y, Chen Z, et al. Impact of non-pharmaceutical interventions during COVID-19 on future influenza trends in Mainland China. *BMC Infect Dis.* 2023;23(1):632. doi:10.1186/s12879-023-08594-1
- Nypaver C, Dehlinger C, Carter C. Influenza and influenza vaccine: a review. *J Midwifery Womens Health.* 2021;66(1):45–53. doi:10.1111/jmwh.13203
- Uyeki TM. Influenza. *Ann Intern Med.* 2021;174(11):Itc161–itc76. doi:10.7326/AITC202111160
- Al-Qahtani SM, Shati AA, Alqahtani YA, Ali AS. Etiology, clinical phenotypes, epidemiological correlates, laboratory biomarkers and diagnostic challenges of pediatric viral meningitis: descriptive review. *Front Pediatr.* 2022;10:923125. doi:10.3389/fped.2022.923125
- Liu YN, Zhang YF, Xu Q, et al. Infection and co-infection patterns of community-acquired pneumonia in patients of different ages in China from 2009 to 2020: a national surveillance study. *Lancet Microbe.* 2023;4(5):e330–e339. doi:10.1016/S2666-5247(23)00031-9
- Kohil A, Jemmeh S, Smatti MK, Yassine HM. Viral meningitis: an overview. *Arch Virol.* 2021;166(2):335–345. doi:10.1007/s00705-020-04891-1
- Mercer A. Protection against severe infectious disease in the past. *Pathog Glob Health.* 2021;115(3):151–167. doi:10.1080/20477724.2021.1878443
- Sudo RYU, Câmara MCC, Kieling SV, et al. Shorter versus longer duration of antibiotic treatment in children with bacterial meningitis: a systematic review and meta-analysis. *Eur J Pediatr.* 2024;183(1):61–71. doi:10.1007/s00431-023-05275-8
- Copelyn J, Hincks JR, Wilmshurst JM, et al. Clearance of immunodeficiency-associated vaccine-derived poliovirus infection with pocapavir. *Pediatr Infect Dis J.* 2020;39(5):435–437. doi:10.1097/INF.0000000000002584
- Zainel A, Mitchell H, Sadarangani M. Bacterial meningitis in children: neurological complications, associated risk factors, and prevention. *Microorganisms.* 2021;9(3):535. doi:10.3390/microorganisms9030535
- Hamilton JL, Evans SG, Bakshi M. Management of fever in infants and young children. *Am Fam Physician.* 2020;101(12):721–729.
- Amusa LB, Twinomurizi H, Phalane E, Phaswana-Mafuya RN. Big data and infectious disease epidemiology: bibliometric analysis and research agenda. *Interact J Med Res.* 2023;12:e42292. doi:10.2196/42292
- Islam N, Islam S, Roy PB. A bibliometric technique for analyzing trends in public health research. *Data Sci Inform.* 2025;2:1.
- Zong Y, Li H, Chang Y, et al. Global research trends in the relationship between influenza and CD4(+) T/CD8(+) T cells: a bibliometric analysis. *Hum Vaccin Immunother.* 2024;20(1):2435644. doi:10.1080/21645515.2024.2435644
- Li H, Zong Y, Li J, et al. Research trends and hotspots on global influenza and inflammatory response based on bibliometrics. *Virology.* 2024;21(1):1–13. doi:10.1186/s12985-024-02588-4
- Yang C, Liu H, Feng X, et al. Research hotspots and frontiers of neoadjuvant therapy in triple-negative breast cancer: a bibliometric analysis of publications between 2002 and 2023. *Int J Surg.* 2024;110(8):4976–4992. doi:10.1097/JS9.0000000000001586
- Bramer WM, Rethlefsen ML, Kleijnen J, Franco OH. Optimal database combinations for literature searches in systematic reviews: a prospective exploratory study. *Syst Rev.* 2017;6(1):245. doi:10.1186/s13643-017-0644-y
- Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM. How to conduct a bibliometric analysis: an overview and guidelines. *Journal of Business Research.* 2021;133:285–296. doi:10.1016/j.jbusres.2021.04.070
- Zhang L, Zheng H, Jiang ST, et al. Worldwide research trends on tumor burden and immunotherapy: a bibliometric analysis. *Int J Surg.* 2024;110(3):1699–1710. doi:10.1097/JS9.0000000000001022
- van Eck NJ, Waltman L. Software survey: vOSviewer, a computer program for bibliometric mapping. *Scientometrics.* 2010;84(2):523–538. doi:10.1007/s11192-009-0146-3
- Radford DM, Parangi S, Tu C, Silver JK. h-index and academic rank by gender among breast surgery fellowship faculty. *J Womens Health.* 2022;31(1):110–116. doi:10.1089/jwh.2020.8579

23. Ali MJ. Understanding the 'g-index' and the 'e-index'. *Semin Ophthalmol.* 2021;36(4):139. doi:10.1080/08820538.2021.1922975
24. Okumura A, Mizuguchi M, Kidokoro H, et al. Outcome of acute necrotizing encephalopathy in relation to treatment with corticosteroids and gammaglobulin. *Brain Dev.* 2009;31(3):221–227. doi:10.1016/j.braindev.2008.03.005
25. Techasaensiri B, Techasaensiri C, Mejias A, McCracken GH, Ramilo O. Viral coinfections in children with invasive pneumococcal disease. *Pediatr Infect Dis J.* 2010;29(6):519–523. doi:10.1097/INF.0b013e3181cdafe2
26. Morichi S, Yamanaka G, Watanabe Y, et al. High mobility group box 1 and angiogenetic growth factor levels in children with central nerve system infections. *J Infect Chemother.* 2021;27(6):840–844. doi:10.1016/j.jiac.2021.01.019
27. Wang X, Li Y, O'Brien KL, et al. Global burden of respiratory infections associated with seasonal influenza in children under 5 years in 2018: a systematic review and modelling study. *Lancet Glob Health.* 2020;8(4):e497–e510. doi:10.1016/S2214-109X(19)30545-5
28. Aguilera ER, Lenz LL. Inflammation as a modulator of host susceptibility to pulmonary influenza, pneumococcal, and co-infections. *Front Immunol.* 2020;11:105. doi:10.3389/fimmu.2020.00105
29. Mjokane N, Folorunso OS, Ogundeyi AO, Sebolai OM. The possible role of microbial proteases in facilitating SARS-CoV-2 brain invasion. *Biology.* 2021;10(10):966. doi:10.3390/biology10100966
30. Hsiao A, Yee A, Fireman B, Hansen J, Lewis N, Klein NP. Recombinant or standard-dose influenza vaccine in adults under 65 years of age. *N Engl J Med.* 2023;389(24):2245–2255. doi:10.1056/NEJMoa2302099
31. Xu H, Chen P, Guo S, Shen X, Lu Y. Progress in etiological diagnosis of viral meningitis. *Front Neurol.* 2023;14:1193834. doi:10.3389/fneur.2023.1193834
32. Lu R, Zhao X, Li J, et al. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. *Lancet.* 2020;395(10224):565–574. doi:10.1016/S0140-6736(20)30251-8
33. Heidt B, Siqueira WF, Eersels K, et al. Point of care diagnostics in resource-limited settings: a review of the present and future of poc in its most needed environment. *Biosensors.* 2020;10(10):1.
34. Wunrow HY, Bender RG, Vongpradith A, et al. Global, regional, and national burden of meningitis and its aetiologies, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Neurol.* 2023;22(8):685–711. doi:10.1016/S1474-4422(23)00195-3
35. Johansson Kostenniemi U, Karlsson L, Silfverdal SA, Mehle C. MeningiSSS: a new predictive score to support decision on invasive procedures to monitor or manage the intracerebral pressure in children with bacterial meningitis. *Neurocrit Care.* 2020;32(2):586–595. doi:10.1007/s12028-019-00792-7
36. Antoon JW, Hall M, Herndon A, et al. Prevalence, risk factors, and outcomes of influenza-associated neurologic complications in children. *J Pediatr.* 2021;239:32–8.e5. doi:10.1016/j.jpeds.2021.06.075
37. Launes C, Camacho J, Pons-Espinal M, et al. Hybrid capture shotgun sequencing detected unexpected viruses in the cerebrospinal fluid of children with acute meningitis and encephalitis. *Eur J Clin Microbiol Infect Dis.* 2024;43(5):863–873. doi:10.1007/s10096-024-04795-x
38. Wen S, Feng D, Chen D, Yang L, Xu Z. Molecular epidemiology and evolution of haemophilus influenzae. *Infect Genet Evol.* 2020;80:104205. doi:10.1016/j.meegid.2020.104205
39. Wang LM, Cravo Oliveira Hashiguchi T, Cecchini M. Impact of vaccination on carriage of and infection by antibiotic-resistant bacteria: a systematic review and meta-analysis. *Clin Exp Vaccine Res.* 2021;10(2):81–92. doi:10.7774/cevr.2021.10.2.81
40. Gobert C, Semaille P, Van der Schueren T, Verger P, Dauby N. Prevalence and determinants of vaccine hesitancy and vaccines recommendation discrepancies among general practitioners in french-speaking parts of belgium. *Vaccines.* 2021;9(7). doi:10.3390/vaccines9070771
41. Paget C, Trottein F. Mechanisms of bacterial superinfection post-influenza: a role for unconventional T cells. *Front Immunol.* 2019;10:336. doi:10.3389/fimmu.2019.00336
42. Țucureanu C, Lazăr V, Florescu SA, Lazăr DS, Caraș I. Cerebrospinal fluid cytokines and chemokines exhibit distinct profiles in bacterial meningitis and viral meningitis. *Exp Ther Med.* 2023;25(5). doi:10.3892/etm.2023.11903
43. Caragheorghieop R, Țucureanu C, Lazăr V, Caraș I. Serum cytokine and chemokine profiles of patients with confirmed bacterial and viral meningitis. *Rev Romana Med Lab.* 2023;31(4):315–324. doi:10.2478/rrlm-2023-0023
44. Kuster SP, Tuite AR, Kwong JC, McGeer A, Fisman DN. Evaluation of coseasonality of influenza and invasive pneumococcal disease: results from prospective surveillance. *PLoS Med.* 2011;8(6):e1001042. doi:10.1371/journal.pmed.1001042
45. Cleuziou P, Renaldo F, Renolleau S, et al. Mortality and neurologic sequelae in influenza-associated encephalopathy: retrospective multicenter PICU cohort in France. *Pediatr Crit Care Med.* 2021;22(11):e582–e587. doi:10.1097/PCC.0000000000002750
46. Ali M, Chang BA, Johnson KW, Morris SK. Incidence and aetiology of bacterial meningitis among children aged 1–59 months in South Asia: systematic review and meta-analysis. *Vaccine.* 2018;36(39):5846–5857. doi:10.1016/j.vaccine.2018.07.037
47. Mikušová M, Tomčíková K, Briestenská K, Kostolanský F, Varečková E. The contribution of viral proteins to the synergy of influenza and bacterial co-infection. *Viruses.* 2022;14(5):1064. doi:10.3390/v14051064
48. Aljunid SM, Mad Tahir NS, Ismail A, et al. Cost effectiveness of quadrivalent influenza vaccines in the elderly population of Malaysia. *Sci Rep.* 2023;13(1):18771. doi:10.1038/s41598-023-46079-y
49. Minozzi S, Lytras T, Gianola S, et al. Comparative efficacy and safety of vaccines to prevent seasonal influenza: a systematic review and network meta-analysis. *EClinicalMedicine.* 2022;46:101331. doi:10.1016/j.eclinm.2022.101331
50. Chen C, Cervero Licerias F, Flasche S, et al. Effect and cost-effectiveness of pneumococcal conjugate vaccination: a global modelling analysis. *Lancet Glob Health.* 2019;7(1):e58–e67. doi:10.1016/S2214-109X(18)30422-4
51. Lee K, Williams KV, Englund JA, Sullivan SG. The potential benefits of delaying seasonal influenza vaccine selections for the Northern hemisphere: a retrospective modeling study in the United States. *J Infect Dis.* 2024;230(1):131–140. doi:10.1093/infdis/jiad541
52. Yahya G, O'Keefe JB, Moore MA. Comparing a data entry tool to provider insights alone for assessment of COVID-19 hospitalization risk: pilot matched cohort comparison study. *JMIR Form Res.* 2023;7:e44250. doi:10.2196/44250
53. Radzišauskienė D, Vitkauskaitė M, Žvinytė K, Mameniškienė R. Neurological complications of pandemic A (H1N1) 2009pdm, postpandemic A (H1N1) v, and seasonal influenza A. *Brain Behav.* 2021;11(1):e01916. doi:10.1002/brb3.1916
54. Ekezie W, Connor A, Gibson E, Khunti K, Kamal A. A systematic review of behaviour change techniques within interventions to increase vaccine uptake among ethnic minority populations. *Vaccines.* 2023;11(7). doi:10.3390/vaccines11071259
55. Yimer SA, Boojj BB, Tobert G, et al. Rapid diagnostic test: a critical need for outbreak preparedness and response for high priority pathogens. *BMJ Glob Health.* 2024;9(4):e014386. doi:10.1136/bmjgh-2023-014386

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