

Original Research Article

Clindamycin facing stewardship challenges: A bibliometric analysis of research themes and therapeutic debate

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Abstract

Purpose: To explore the bibliometric overview of international literature on clindamycin, including publications, impactful authors and organizations, patterns of collaboration, and thematic changes in the last decades

Methods: A bibliometric search on clindamycin was performed based on records in Scopus database. Bibliometrix and VOSviewer software were used to analyze the data.

Results: Dataset included 2,651 articles based on 955 sources, with the annual growth being 7.32 % and maximum production seen in 2024. Corresponding authorship was dominated by USA, India, and China, although international collaboration was low (8.6 %). Four main thematic clusters emerged which include microbiology (methicillin-resistant *Staphylococcus aureus* (MRSA), inducible resistance (biofilm), dermatology (acne, topical formulations), pharmacology (pharmacokinetics, comparative efficacy), and women's health/pediatrics (bacterial vaginosis, pregnancy). Temporal analysis showed that there was a change in focus from chemotherapy to antimicrobial resistance, and diagnostic methods such as inducible clindamycin resistance test (D-test). The most cited work on clindamycin focused on therapeutic strengths, possible enteric side effects and resistance mechanisms.

Conclusion: The study shows that sustained evolution of clindamycin is driven by resistant challenges and growth of therapeutic applications. This study suggests strengthening international cooperation and focusing on growing trends, such as biofilms and topical dermatologic innovations.

Keywords: Clindamycin, Bibliometric analysis, Antimicrobial resistance, Scientific collaboration, Thematic evolution

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INTRODUCTION

Clindamycin is a lincosamide antibiotic, which has been used for management of several types of bacterial infections, especially those caused by Gram-positive cocci and anaerobic pathogens [1,2]. Clindamycin, since introduced in the late

1960s, has found a wide range of clinical use in skin and soft tissue infections [3], respiratory tract infections [4], and in prophylaxis of specific surgical procedures [5]. Pharmacological flexibility in terms of good tissue penetration and efficacy against biofilm-forming bacteria has made it an important agent in both community

and hospital practices [6]. Nevertheless, the rising rate of antimicrobial resistance, changes in clinical practice, and introduction of new treatment options have all influenced research trend of clindamycin [7,8]. Understanding the evolution of scientific knowledge in clindamycin studies has emerged not only for clinicians and pharmacologists, but also for policymakers and researchers intending to conduct further research. Bibliometric analysis is a structured method of mapping intellectual environment of a research field, which offers quantitative data on the dynamics of publications, influential studies, collaborative networks, and thematic progress [9]. Using such approaches, one determines nascent issues, reveal gaps in the literature, and emphasize the contributions of major institutions, authors, and countries.

Though several reviews have been conducted to determine the clinical efficacy [10], pharmacokinetics [11] and safety profile of clindamycin [12], few studies have been conducted regarding its scientific development using a bibliometric perspective. This study seeks to offer a bibliometric overview of international literature on clindamycin, including publications, impactful authors and organizations, patterns of collaboration, and thematic changes in the last decades. With the inclusion of citation analysis, co-authorship networks, and keyword co-occurrence mapping, this study aims to shed light on the organization and dynamics of clindamycin research environment.

METHODS

Study design

This study employed a bibliometric approach to quantitatively analyze global scientific output on clindamycin. The adopted methodological framework included performance analysis and science-mapping methods to identify characteristics of publication trends, key contributions in the field, emerging themes, and collaboration networks [13].

Data source and search strategy

Bibliographic records were selected from Scopus database which was chosen due to its extensive coverage of biomedical, pharmaceutical, and microbiological studies. A structured search was conducted using the following query: (TITLE (Clindamycin) AND (LIMIT-TO (LANGUAGE,"English"))) AND (LIMIT-TO (DOCTYPE,"ar")) AND (EXCLUDE (PREFNAMEAUID,"undefined")). The search

was limited to articles only. The search was on publications from inception to August 2025. Metadata fields that were obtained in the retrieved records were authors, affiliations, source titles, citations, abstracts, keywords, references, and the years of publication.

Eligibility criteria and data preparation

All document types that were indexed as "articles" in Scopus were included. They were filtered out for methodological consistency, excluding editorial, conference abstracts, book chapters, notes, letters, and errata. The data obtained was downloaded in Comma-Separated Values (CSV) format. Metadata that was stored to be analyzed included year of publication, author information, source titles, author keywords, keywords plus, document type, citation counts, references, and DOIs.

Bibliometric indicators

Performance indicators used were annual scientific production, total and per-document citations, annual growth rate, document age, author productivity, total number of keywords, references, sources, and rate of international collaboration.

Science-mapping and network analyses

Science-mapping methods were utilized to investigate the intellectual and conceptual organization of the field. Co-authorship networks were used to capture patterns of collaboration among authors, institutions and countries. Keyword co-occurrence patterns were used to capture major thematic clusters and emerging trends. The three-field plots demonstrated the intersection of countries, institutions, and journals with important research topics.

Analytical tools

The analyses were performed using the bibliometrix package and its web interface Biblioshiny in R [14]. Supplementary network visualizations and thematic overlays were generated using VOSviewer (version 1.6.20) [15].

RESULTS

Dataset

The dataset was composed of 2,651 documents gotten from 955 sources from 1968 to August 2025. With the annual growth rate of 7.32 %, average age of the document was 26.5 years.

Documents have a mean of 22.38 citations, supported by 43,135 references. The data was produced by 9,635 authors, which included 168 single authored documents, having an average of 4.68 co-authors per paper and 8.56 % international collaboration. In terms of keyword indexing, 9,627 Keywords Plus and 2,633 author keywords were retrieved.

Annual scientific production and leading journals

Annual publication volume on clindamycin spanned 1968–August 2025, beginning with 1 paper in 1968 and rising to an early peak of 88 in 1977 before stabilizing through the 1980s–1990s (range 24–57 per year). Output accelerated again after 2018, with consecutive modern highs in 2020 (72), 2021 (73), 2022 (75), and 2024 (77), reflecting sustained late-phase growth. The most productive five-year block was 2020–2024,

exceeding the best five-year block of the 1970s (Figure 1).

The publications were led by Antimicrobial Agents and Chemotherapy (154 articles) and Journal of Antimicrobial Chemotherapy (100 articles). Additional prominent outlets were Chemotherapy (72 articles), Journal of Infectious Diseases (52 articles), Journal of Drugs in Dermatology (35 articles), and the Japanese Journal of Antibiotics (35 articles; Figure 2).

Influential authors and top contributing institutions

Top authors by total items were JR (21), NORD CE (20), APPELBAUM PC (16), GORBACH SL (15), TALLY FP (15), BALDWIN H (14), BROOK I (14), DEL ROSSO JQ (14), and KREMSNER PG (14; Figure 3).

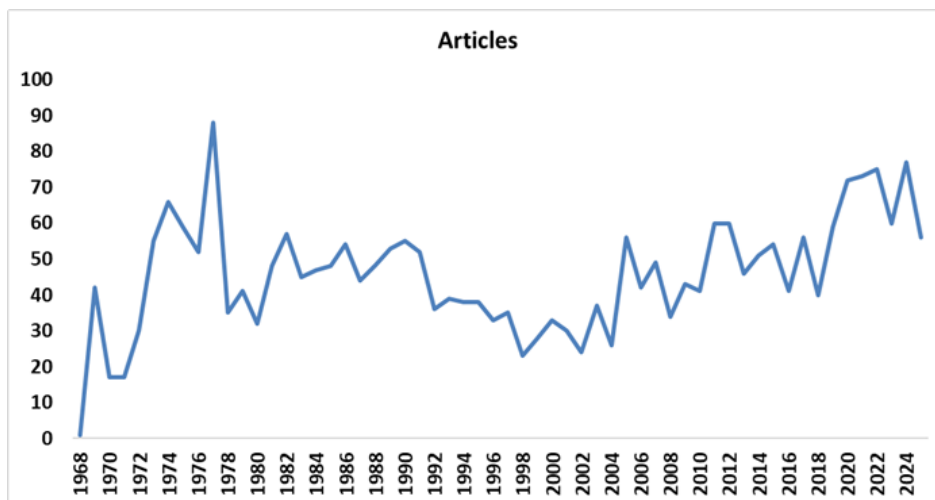


Figure 1: Annual scientific production

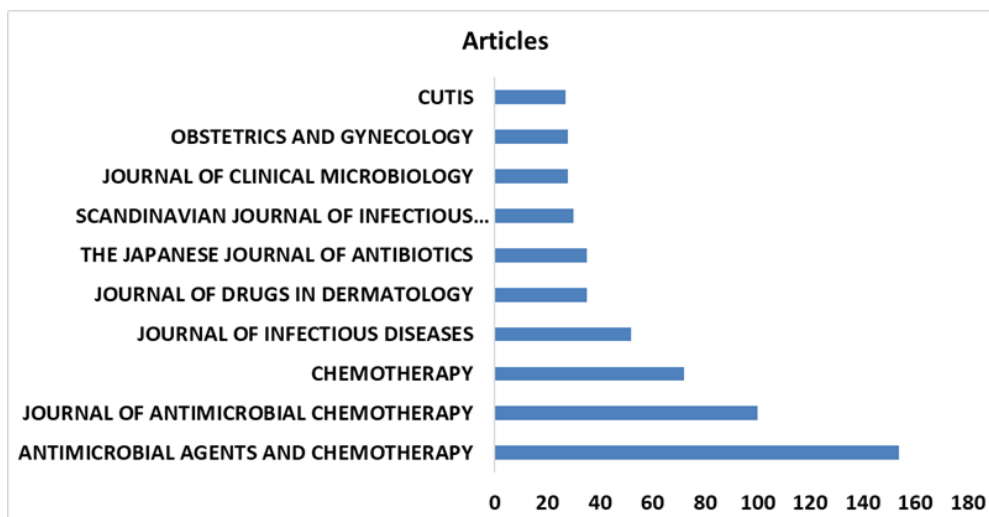


Figure 2: Most relevant sources

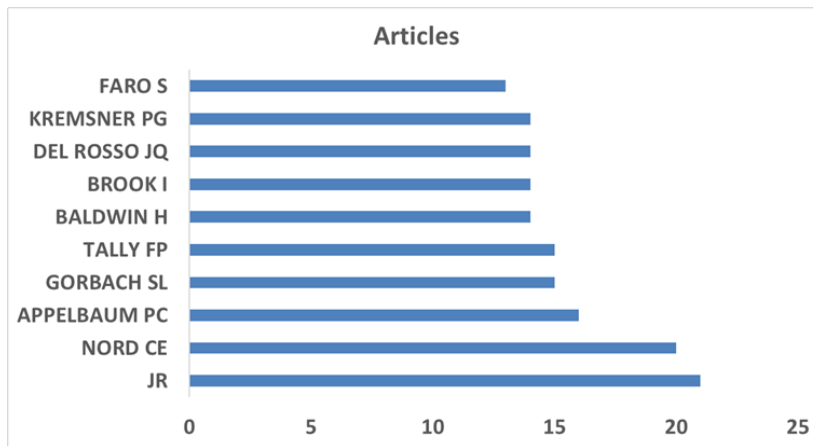


Figure 3: Most relevant authors

Countries and collaboration

Corresponding author analysis showed the United States (USA) leading (269, multi-country publications (MCP) 10 %), followed by India (96, MCP 6.3 %), China (85, MCP 7.1 %), and Iran (76, MCP 9.2 %). Australia (20; MCP 35 %) exhibited the highest international collaboration shares (Figure 4). Expanded country-level frequency of scientific production showed additional high-output nations including the USA (3,976), Japan (1,048), China (595), and India (535), United Kingdom (419), Germany (416), Iran (396), Spain (381), France (341), and Italy (265). Mid-tier contributors comprised Canada

(220), the Netherlands (181), South Korea (177), Sweden (172), Brazil (170), Egypt (167), Australia (144), Thailand (134), Denmark (125), Turkey (116), Belgium (111), Greece (110), and Poland (104; Figure 4).

Bilateral links were between USA – Canada (13), USA – United Kingdom (8), USA – Germany (7), and USA – France (7), with additional ties to Egypt (5), Belgium (4), China (4), and India (6). European hubs included Germany – Austria (6), Germany – Switzerland (6), Germany – Poland (5), Netherlands – Belgium (5), and United Kingdom – Netherlands (5; Figure 5).

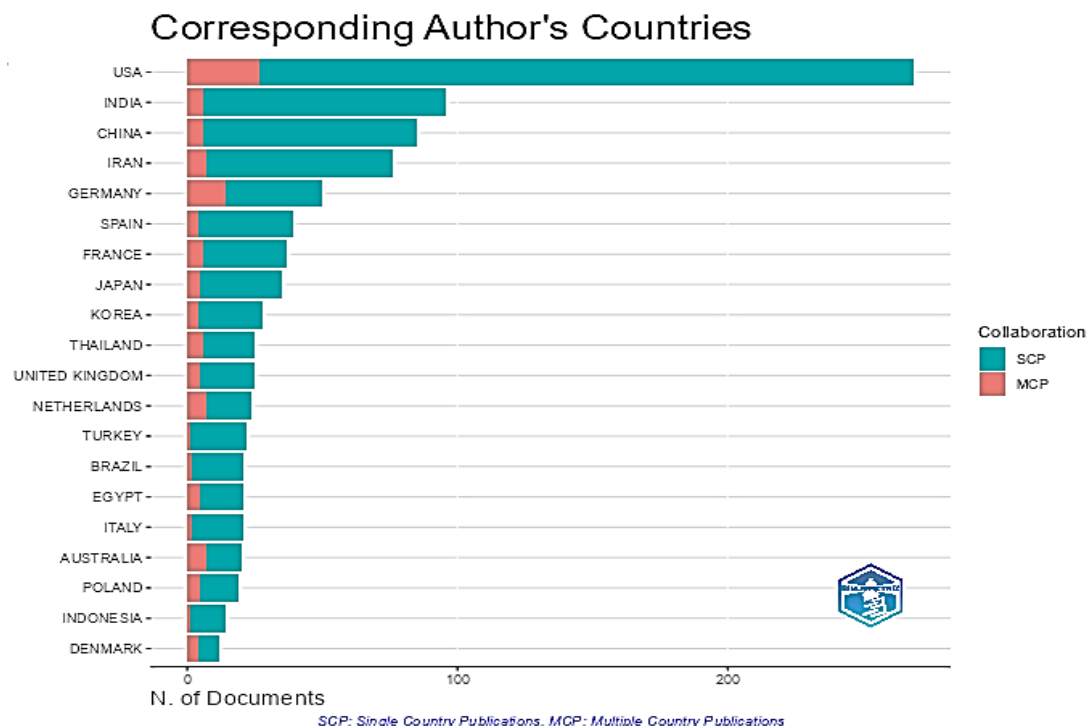


Figure 4: Corresponding Author Countries

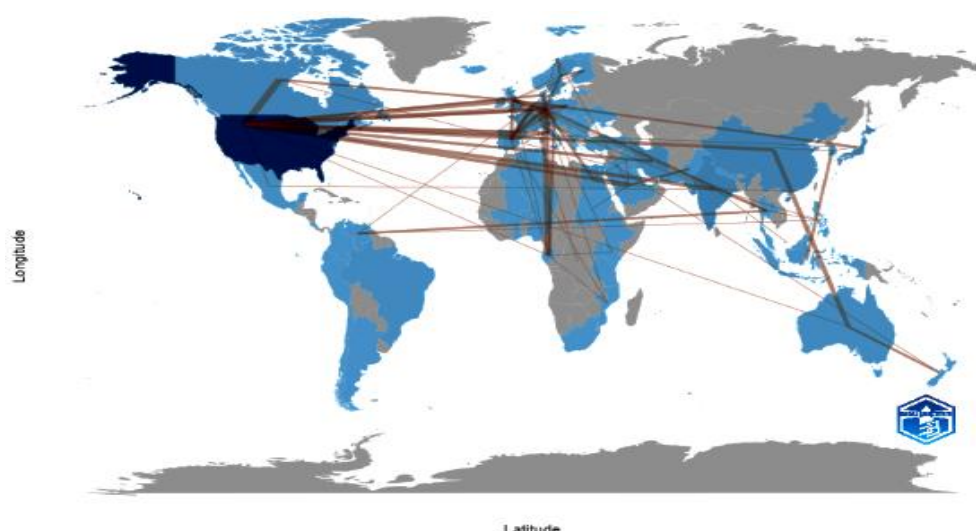


Figure 5: Country-based scientific production and collaboration world map

Table 1: Top cited papers

DOI	Total citations	TC per Year	Normalized TC	Ref
10.1128/aac.40.8.1817	606	20.2	15.50232558	[16]
10.7326/0003-4819-81-4-429	517	9.942307692	22.08543689	[17]
10.1128/IAI.05496-11	464	33.14285714	17.12177122	[18]
10.1093/infdis/158.1.23	449	11.81578947	14.73137389	[19]
10.1128/JCM.41.10.4740-4744.2003	407	17.69565217	5.785247791	[20]
10.1093/infdis/136.5.701	363	7.408163265	23.01440922	[21]

TC: total citations

Highly cited papers

The modal clindamycin-related studies include mechanisms of action, clinical applications, and diagnostic methods (Table 1). Sutcliffe *et al* [16] (606 citations) investigated M resistance type to macrolide–lincosamide antibiotics and not clindamycin [16]. Tedesco (517 citations) investigated the incidence of colitis and diarrhea in patients receiving clindamycin [17]. Buffie *et al* [18] (464 citations) demonstrated how antibiotics like clindamycin disrupt gut microbiota and increase susceptibility to enteric infection. Stevens *et al* [19] (449 citations) highlighted the efficacy of clindamycin in treating myositis due to *Streptococcus pyogenes*. Fiebelkorn *et al* [20] (407 citations) revised a critical method for detecting inducible clindamycin resistance in *Staphylococci aureus*. Bartlett *et al* [21] (363 citations) provided foundational evidence for clindamycin-associated colitis.

Trend topics

The trends showed first emphasis on chemotherapy, bioavailability and comparison to other antibiotic (ampicillin, aztreonam; bioavailability), to later focus on resistance, D-test, methicillin resistant *Staphylococci aureus* (MRSA) and *S. aureus* from 2004-2016 (e.g.

“MRSA” 36; 2011-2021). Terms related to dermatology increased significantly after 2010, including “acne vulgaris” (50; 2014-2021), “acne” (31; 2010-2023) and “benzoyl peroxide” (22; 2016-2023). Furthermore, women’s health topics remained consistent with articles on “bacterial vaginosis” (29; 2000-2017) and “vaginitis” (5; 1993-2008). More recent studies concerned “antibiotic resistance” (18; 2016-2022), “biofilm” (11; 2016-2022), “clinical trial” (9; 2012-2023) and “surgical site infection” (6; 2018-2024; Figure 6).

Core, niche, and emerging themes

The clindamycin thematic map revealed that centrality and high development of motor themes were represented by ‘clindamycin’, ‘*Staphylococcus aureus*’, and ‘antibiotics’, suggesting large coverage on clinical studies and pathogenic efficacies. Fundamental concepts surround the terms ‘inducible clindamycin resistance’, ‘D test’ and ‘MRSA’. The terms dermatology-centered, ‘clindamycin phosphate’, ‘acne vulgaris’ and ‘acnes’ seem to be moderately central, new areas of connectivity between formulation and therapeutic applications were identified (Figure 7).

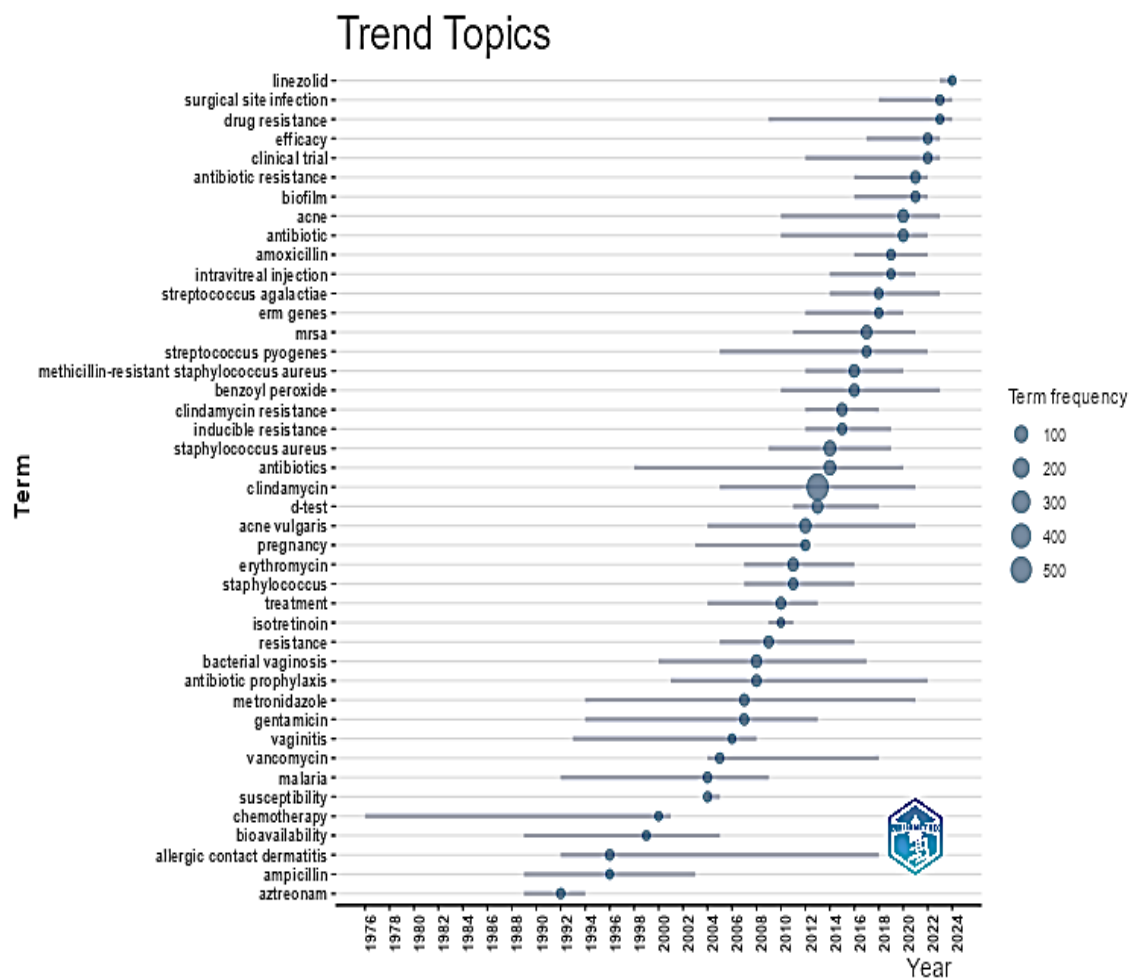


Figure 6: Trend Topics

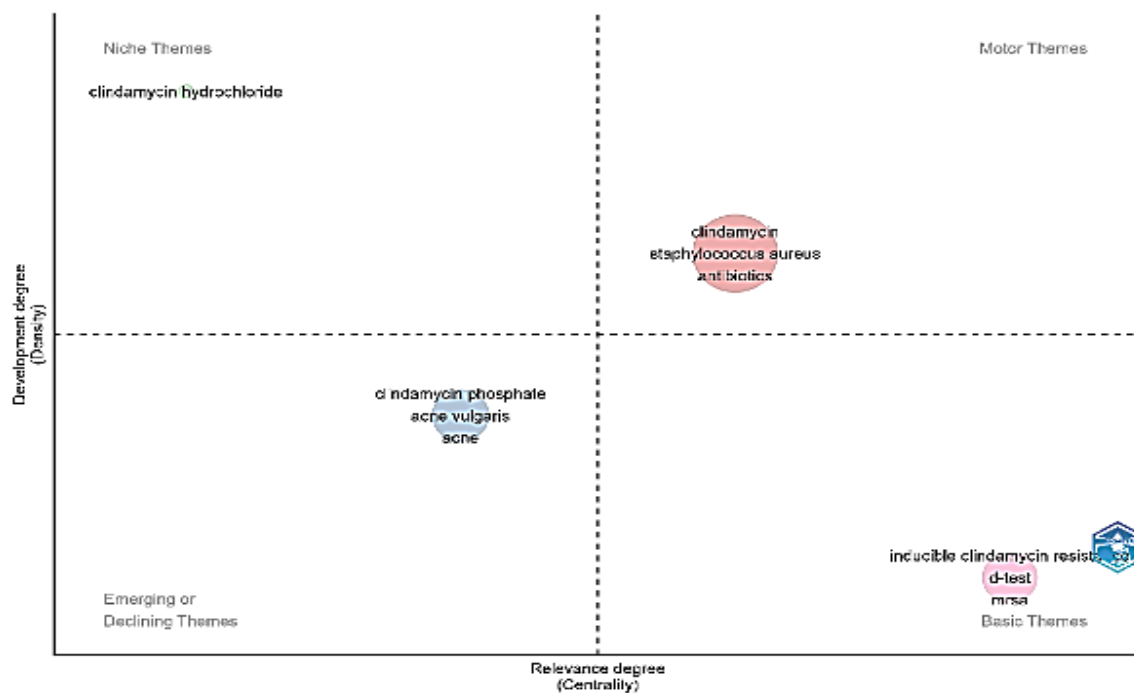


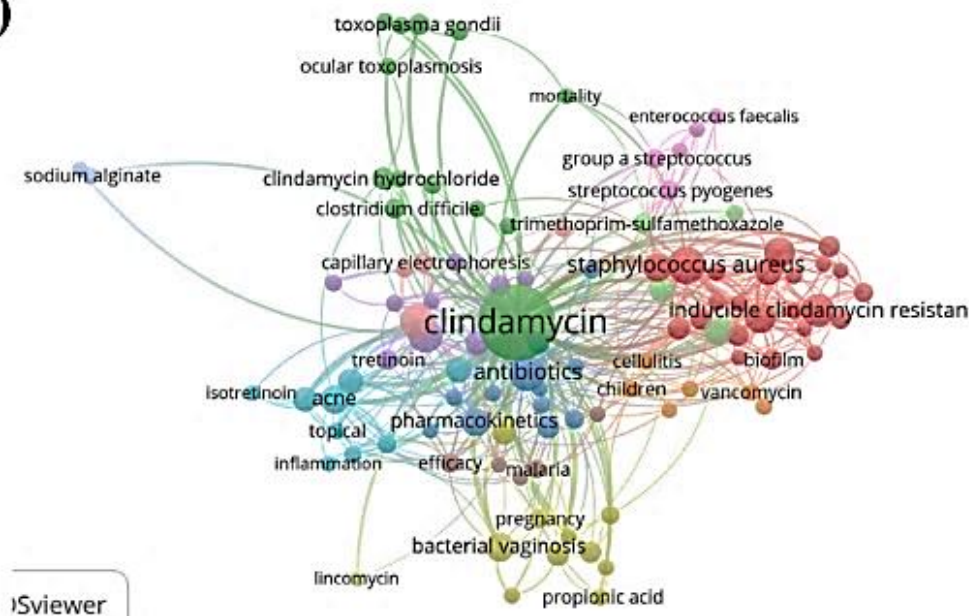
Figure 7: Core, niche, and emerging themes

Thematic clustering and evolution

Four clusters dominated clindamycin research which include a microbiology core, linking clindamycin with *S. aureus*, MRSA, inducible resistance, biofilm, and cellulitis; a dermatology node around acne, acne vulgaris, topical regimens, tretinoin, and benzoyl peroxide; a pharmacology/comparator set connecting pharmacokinetics, efficacy,

trimethoprim-sulfamethoxazole, and vancomycin; and women's health/paediatrics set including bacterial vaginosis, pregnancy, and children (Figure 8 A). Overlay visualization showed early focus on pregnancy and bacterial vaginosis transitioning through late 2000 s toward acne therapeutics, MRSA, inducible resistance, and biofilm (Figure 8 B).

(A)



(B)

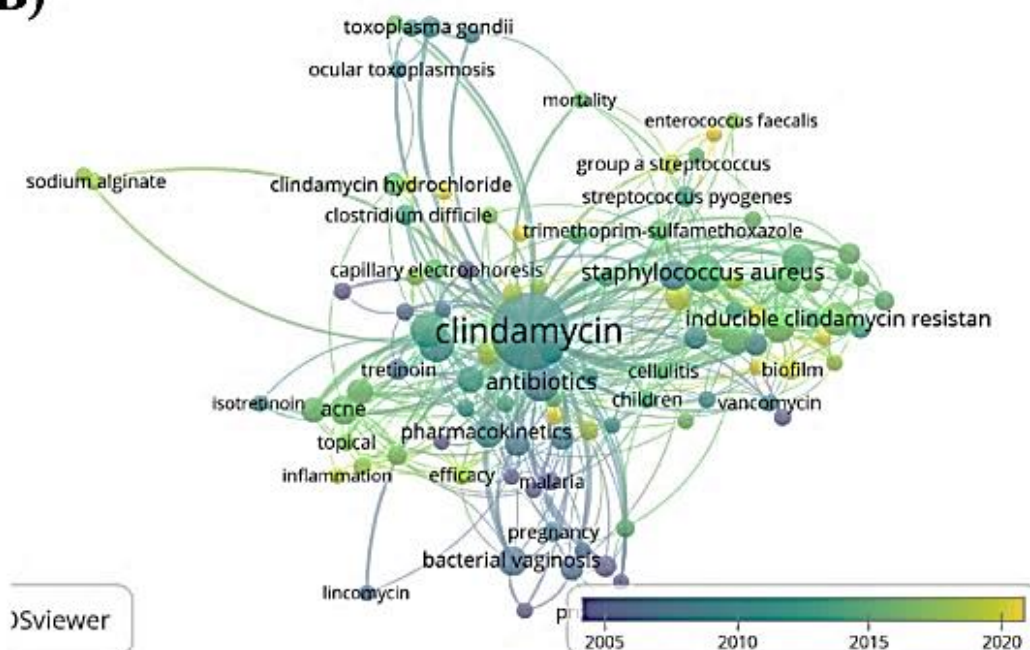


Figure 8: Thematic Clustering and Evolution

DISCUSSION

This bibliometric study represents comprehensive mapping of worldwide research on clindamycin over the course of almost 60 years. There was gradual growth in scientific activity, followed by significant increase in the mid-1970s and, subsequently, after 2010. These changes were probably a response to changing clinical priorities which include initial surge after the release of clindamycin, and subsequent re-surge by the increasing problem of MRSA, skin diseases and antimicrobial resistance [22]. Clinical uses of clindamycin are broad, and it was reflected by the thematic clusters identified which include microbiology, dermatology, pharmacology, and women's health. Emergence of concepts related to dermatology since 2010 is associated with increased use of topical preparations and interest in acne as a global disease burden [23].

In the meantime, the high citation rates around inducible resistance, D-test methods, and *Clostridium difficile* (*C. difficile*)-associated colitis highlighted the continued attention to safety and stewardship [8,24,25]. Patterns of collaboration indicated that North America, Europe and Asia are highly contributing with significant international collaboration within the USA-Europe network. Low collaboration rate (8.6 %) may be attributed to the already established position of clindamycin in clinical practice where studies have been more context dependent as opposed to multinational studies. Furthermore, the enduring centrality of resistance themes reflects the necessity to continue to focus on interventions toward overcoming this problem [26]. Emergence of more recent topics, such as biofilms, toxin, and surgical site infection prophylaxis, indicated that clindamycin is still important in the current therapeutic paradigm, especially when anti-toxin effects and tissue penetration are to be considered [7,27].

Growing focus on dermatology and the health of women draws more general conclusions about the future of outpatient care, where the widespread use of antibiotics may contribute to development of resistance [28]. These results thus provide future stewardship plans and emphasize areas where clindamycin should still be either used or reconsidered.

CONCLUSION

This bibliometric review indicates that research on clindamycin is dynamic and evolving due to resistance challenges and development of clinical indications. The publication profile,

thematic clusters and collaboration networks demonstrate the long-term effectiveness of clindamycin in the treatment of infectious diseases and its applicability in a variety of clinical indications. New topics, including biofilms, *Clostridium difficile* risk mitigation, and topical dermatologic formulations are aspects that should be investigated specifically.

DECLARATIONS

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Ethical approval

Not applicable

Use of Artificial intelligence/Large language models

The authors confirm that AI-based tools were used solely for language editing and manuscript polishing purposes (e.g., grammar, phrasing, and clarity). No AI tools were used to generate content, interpret data, or influence study design, results, or conclusions. All intellectual contributions, study analyses, and interpretations reported in the manuscript are the original work of the authors.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

No conflict of interest is associated with this work.

Contribution of authors

We declare that this work was done by the author(s) named in this article, and all liabilities pertaining to claims relating to the content of this article will be borne by the authors.

Conceptualization (MA, AA, AO, SM, YK, MK), Data curation (SM, MK), Formal analysis (MA, AA), Funding acquisition (MK), Investigation (YK), Methodology (SM, MK), Project administration (YK), Resources (MK), Software (MK), Writing - original draft (MK), Writing - review and editing. (MA, AA, AO, SM, YK).

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