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Worldwide Bibliometric Analysis of Antibiotic Resistance Research Trends

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ABSTRACT

Introduction. Antibiotic resistance (AR) is a critical issue in global health, characterized by the increasing number of resistant pathogens that threaten the effectiveness of infection therapy. Although there has been a significant increase in the number of scientific publications related to AR, there are not many studies that systematically map the dynamics and direction of global research. This study aims to evaluate the global trend of antibiotic resistance research in the period 2022–2025 through a bibliometric approach. **Methods.** This is a quantitative bibliometric study with a descriptive design. Data were taken from 1,845 indexed international scientific sources, covering 18,786 documents. The analysis was carried out using *the Bibliometrix R-package* , focusing on publication growth, scientific collaboration, dominant keywords, and identification of the most contributing authors, institutions, and countries. **Results.** The study showed that despite a -28.01% decline in the annual publication growth rate, research volume remained high, with 27.62% cross-border collaboration and 87,959 authors involved. China and the United States dominated both in terms of publications and citations, while frequent keywords reflected a laboratory approach and focus on major pathogens. The most influential articles were published in leading journals such as *The Lancet, Gut,* and *Clinical Infectious Diseases.* **Conclusion.** This study confirms that antibiotic resistance remains a major focus of the global scientific community, characterized by extensive, collaborative, and evidence-based research activities. These findings provide an important scientific basis for designing more effective, adaptive, and sustainable AR research and policy strategies at the global level.

1. Introduction

Antibiotic resistance (AR) is one of the most serious global health threats in the 21st century.[1,2] The number of bacterial pathogens resistant to multiple antibiotics has led to decreased effectiveness of infection therapy, prolonged hospital stays, and increased mortality and health system costs.[3] The World Health Organization has declared antimicrobial resistance a major threat to global public health. This phenomenon is exacerbated by the irrational use of antibiotics, both in the medical and veterinary sectors, the lack of strict infection control policies, and the lack of new antibiotic discoveries in the last decade[4]. Thus, antibiotic resistance is not only a medical problem, but also a multidisciplinary issue that includes social, economic, and policy dimensions.[5,6]

With the increasing global attention to this issue, research on antibiotic resistance has grown rapidly in recent years.[7] Researchers from various disciplines, such as microbiology, pharmacy, public health, and biotechnology, have contributed to understanding resistance mechanisms, developing alternative therapies, and designing more effective detection and prevention strategies.[8] On the other hand, big data, bioinformatics, and machine learning-based approaches have also begun to be widely applied in antibiotic resistance research, especially to detect new resistance patterns and predict their spread.[9,10] However, despite the increasing number of publications, there are still few studies that systematically evaluate the direction, distribution, and global scientific contributions on this topic, especially after the COVID-19 pandemic that has

affected antibiotic use patterns worldwide.[11]

Bibliometric analysis is one of the effective quantitative approaches to map research trends in a scientific field as a whole.[10,12] Through this analysis, we can see the growth in the number of publications, identify the most productive authors and institutions, scientific collaboration networks, and topics that are the main focus of research.[13] In addition, bibliometric analysis can also help identify research gaps and provide guidance for policymakers and researchers in designing more strategic and data-driven future research directions. In the context of antibiotic resistance, this approach is very relevant to studying the dynamics of global research, given its high urgency and cross-country and cross-disciplinary scope.[14,15]

Therefore, this study aims to conduct an in-depth bibliometric analysis of global scientific publications on antibiotic resistance in the period 2022 to 2025. By utilizing data from reliable scientific databases and the latest bibliometric analysis software, this study will assess the growth and distribution of publications, institutional and country involvement, keyword trends, and contributions of leading scientists in this field.[16] It is hoped that the results of this study can provide a comprehensive picture of the direction of antibiotic resistance research development, as well as serve as a guide for researchers, academics, and policy makers in formulating more effective and coordinated antibiotic resistance control strategies at the global level.

2. Methods

This study uses a quantitative bibliometric study that aims to analyze global trends in antibiotic resistance research during the period 2022 to Mei 2025. With a descriptive approach, this study utilizes secondary data taken from leading international scientific databases. The focus of the analysis includes the distribution of publications, citations, scientific collaborations, keywords, and contributions from institutions, authors, and countries in this field.[17,18]

Data Source

Bibliographic data were collected from the internationally indexed Scopus database, covering scientific journals from 2022 to 2025 that are relevant to the topic of antibiotic resistance. A total of 18,786 documents from 1,845 scientific sources were successfully extracted, including scientific articles, proceedings, and other relevant publications. The data used included metadata information such as title, author name, affiliation, keywords, number of citations, DOI, and country of original of the corresponding author.[19]

Inclusion and Exclusion Criteria

Included documents were publications that explicitly discussed antibiotic resistance (including antimicrobials), using the search term "antibiotic resistance". Publications that were not directly related, such as those that only touched on bacterial infections in general without discussing resistance, were excluded from the analysis.

Analysis Process

Bibliometric analysis was performed using software such as the Bibliometrix R-package, which is capable of processing data in BibTeX or CSV format. The analysis procedure included: annual publication distribution and growth rate, average number of citations per document, international collaboration networks between authors and countries, frequency and coexistence of keywords, the most productive institutions, authors and journals, geographical distribution of scientific contributions through a global production map, and identification of the most cited publications, both in absolute and standardized terms (Normalized TC).[20]

3. Results

The results of the study show that throughout the period 2022 to 2025, 18,786 documents related to antibiotic resistance have been published from 1,845 scientific sources. Although the number of documents is quite high, the annual growth rate has decreased by -28.01%. The average age of the documents is 1.77 years, with an average of citations per document of 5,723. Collaboratively, 87,959 authors were involved in the publication, with an average of 8.38 authors per document. International collaboration shows a fairly high figure, namely 27.62%. Documents written singly only number 267 documents, indicating the dominance of collaborative research in this field. In terms of document type, publications are dominated by scientific articles with 18,597 documents, while the rest are other classification variants. In terms of content, 45,096 automatic keywords (Keywords Plus) and 27,791 keywords determined by the authors (Author's Keywords) were found, reflecting the diversity of topics and approaches in antibiotic resistance research globally (Table 1).

Keyword Analysis

Visual analysis of the frequency of keywords in publications related to antibiotic resistance during the period 2022 to 2025 produces a representation in the form of word cloud.[21] From this visualization, it can be seen that the term "antibiotic resistance" dominates as the most frequently occurring keyword, reflecting the main focus and consistency of the theme in global research on this topic (Figure 1). Other prominent keywords include "article", "anti-infective agent", "controlled study", "human", "nonhuman", as well as the names of pathogens such as "Escherichia coli", "Staphylococcus aureus", and "Klebsiella pneumoniae". In addition, terms related to laboratory methods such as "microbial sensitivity test", "minimum inhibitory concentration", and "polymerase chain reaction" are also frequently found, indicating a tendency towards experimental and laboratory-based research. Some

specific antibiotic names such as ciprofloxacin, gentamicin, amikacin, and meropenem also appeared consistently, indicating a research focus on the effectiveness of certain antibiotics against resistant bacteria. Demographic terms such as "female", "male", "adult", and "middle aged" are also present, indicating an interest in population variation in antibiotic resistance studies. Overall, this word cloud illustrates the breadth and multidisciplinary approach to antibiotic resistance research, spanning clinical, microbiological, pharmacological, and molecular aspects.

Table 1. Summary of key information of bibliometric datasets on antibiotic resistance publications for the period 2022–2025

| Description	Results
Main information about data	
Timespan	2022:2025
Sources (journals, books, etc)	1845
Documents	18786
Annual growth rate %	-28.01
Document average age	1.77
Average citations per doc	5,723
References	0
Document contents	
Keywords plus (ID)	45096
Author's keywords (DE)	27791
Authors	
Authors	87959
Authors of single-authored docs	237
Authors collaboration	
Single-authored docs	267
Co-authors per docs	8.38
International co-authorships %	27.62
Document types	
Articles	18597

Figure 1. Word cloud visualization of the most frequently used keywords in publications related to antibiotic resistance in the period 2022–2025

Most Popular Journal Sources

In this study, an analysis was conducted on the most relevant and frequently used journal sources in the field of microbiology and antibiotics.[22,23] Based on the "Most Relevant Sources" graph shown in Figure 2, it can be seen that the Antibiotics journal is the source with the largest number of documents, which is 1858 documents. This shows that the journal is the main reference and has the largest contribution to related research. Furthermore, the Frontiers in Microbiology journal is in second place with 1314 documents, followed by Microbiology Spectrum with 903 documents. Other journals such as Infection and Drug Resistance and Frontiers in Cellular and Infection Microbiology also make significant contributions with 562 and 448 documents respectively. Other sources that make lower contributions but are still relevant include the Pathogens journal (359 documents), Antimicrobial Chemotherapy Journal (341 documents), BMC Microbiology (336 documents), Antimicrobial Agents and Chemotherapy (306 documents), and Microbial Pathogenesis (306 documents) (Figure 2). These data show that research and publications in the field of microbiology and antibiotic resistance are widely distributed in several leading journals with different focuses, indicating the diversity of sources and topics that support this research.
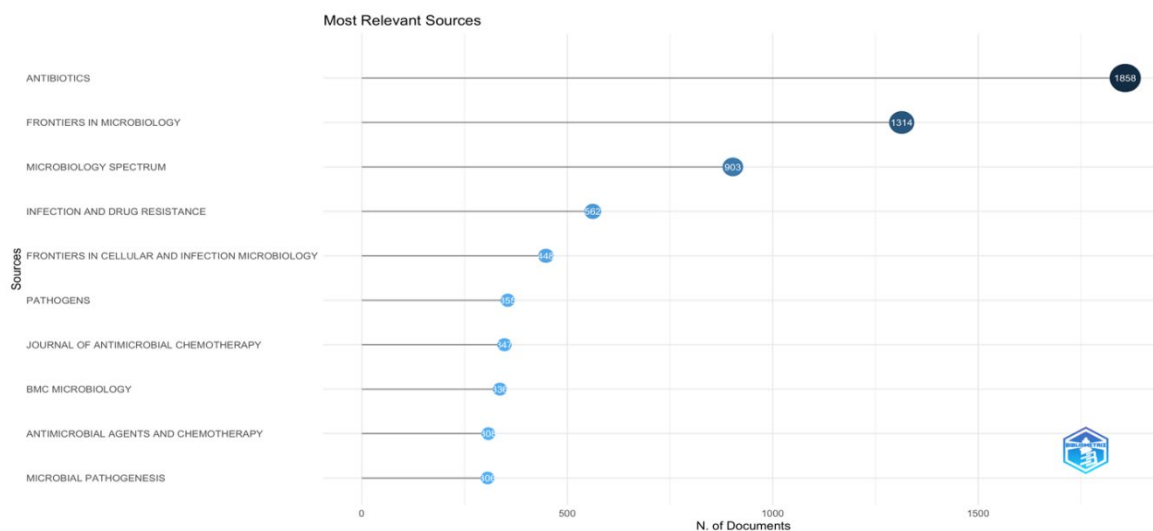
Figure 2. List of the 10 most relevant journal sources based on the number of published documents related to antibiotic resistance in the period 2022–2025
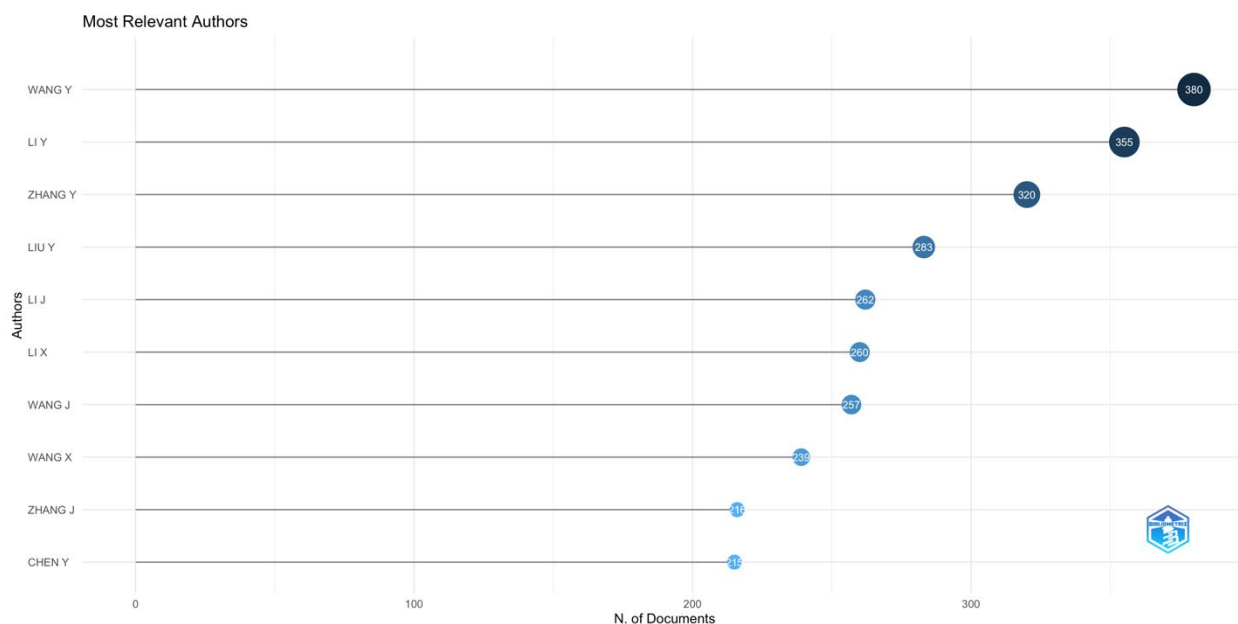
Figure 3. List of the 10 most relevant authors based on the number of published documents related to antibiotic resistance in the period 2022–2025
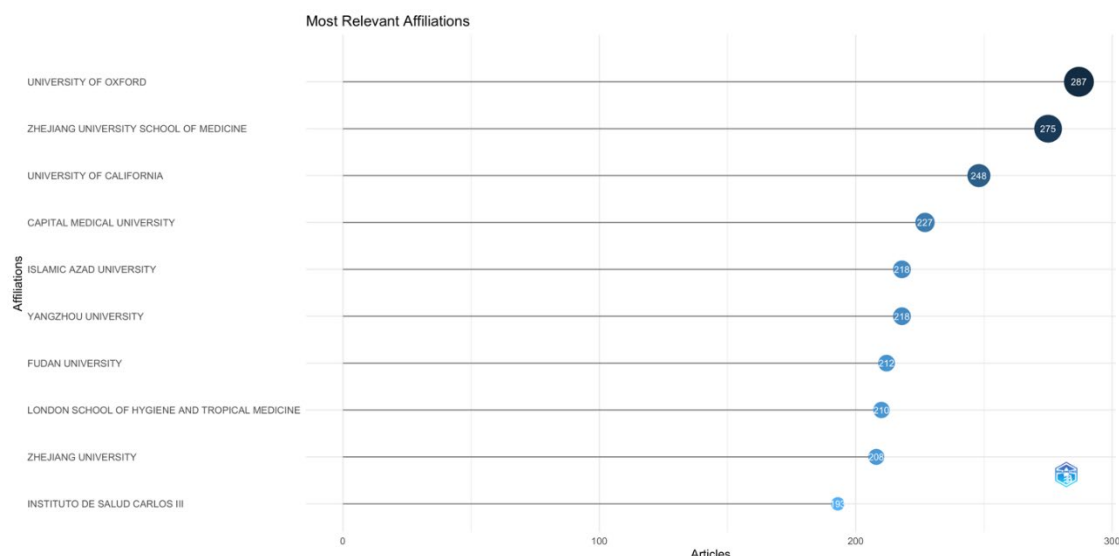
Figure 4. List of the 10 most productive institutions in scientific publications related to antibiotic resistance during the period 2022–2025

Most Relevant Authors

The results of the bibliometric analysis show that individual contributions to publications in the field of antibiotic resistance are dominated by authors from the Asian region, especially China.[23] Based on the number of documents published during the period 2022 to 2025, Wang Y occupies the top position as the most productive writer with a total of 380 documents. Followed by Li Y which produce 365 documents, as well as Zhang Y with 320 documents. Other authors who also made significant contributions include Liu Y (283 documents), Li J (262 documents), and Li X (260 documents). Meanwhile, Wang J (257 documents), Wang X (218 documents), Zhang J (176 documents), and Chen Y (171 documents) were also listed as active authors in this field (Figure 3). This finding reflects the collaborative pattern and high research intensity in the East Asia region, and highlights the importance of global research networks in supporting the sustainable development of antibiotic resistance science.

Most Relevant Institutional Affiliations

An analysis of the most productive institutions in scientific publications on antibiotic resistance during the period 2022 to 2025 shows that global contributions in this field are fairly even, with institutions in the UK, China and the US dominating. University of Oxford recorded as the most productive institution with a total of 287 articles, followed by Zhejiang University School of Medicine with 275 articles, and University of California with 248 articles. Other institutions that also made significant contributions include: Capital Medical University (227 articles), Islamic Azad University and Yangzhou University each of which produced 218 articles, as well as Fudan University (212 articles). In addition, other renowned research and academic institutions such as London School of Hygiene and Tropical Medicine (210 articles), Zhejiang University (205 articles), and Carlos III Health Institute (198 articles) were also recorded as active in this research (Figure 4). This distribution illustrates the involvement of various leading international institutions in efforts to overcome antibiotic resistance, which reflects not only the intensity of research but also the importance of global collaboration across continents in facing this global health crisis.[24]

**Country Distribution of Corresponding Authors**

Based on the analysis of country contributions from the corresponding author, it appears that China become the country with the highest number of publications in antibiotic resistance research during the period 2022 to 2025[25]. This country dominates with a very significant number of documents, most of which are single-country publications (SCP – Single Country Publications), but also demonstrates a level of international collaboration (MCP – Multiple Country Publications) which is quite high. United States and India ranked second and third respectively, demonstrating an important role in the development of antibiotic resistance science through both domestic and collaborative research. Other countries such as United Kingdom, Italy, Iran, Spain, Japan, and France are also included in the ranks of major contributors, reflecting the active involvement of developed countries in this global issue (Figure 5). Interestingly, several developing countries such as Pakistan, Egypt, and Saudi Arabia also recorded as actively participating in scientific publications, indicating an increasing attention to the issue of antibiotic resistance globally. The high proportion Multiple Country Publications in countries such as the UK and Germany shows that cross-country collaboration is a key strategy in producing high-quality publications.

This distribution illustrates that antibiotic resistance is a transboundary issue that requires a global collaborative approach, with strong contributions from both developed and developing countries in the effort to find evidence-based solutions.
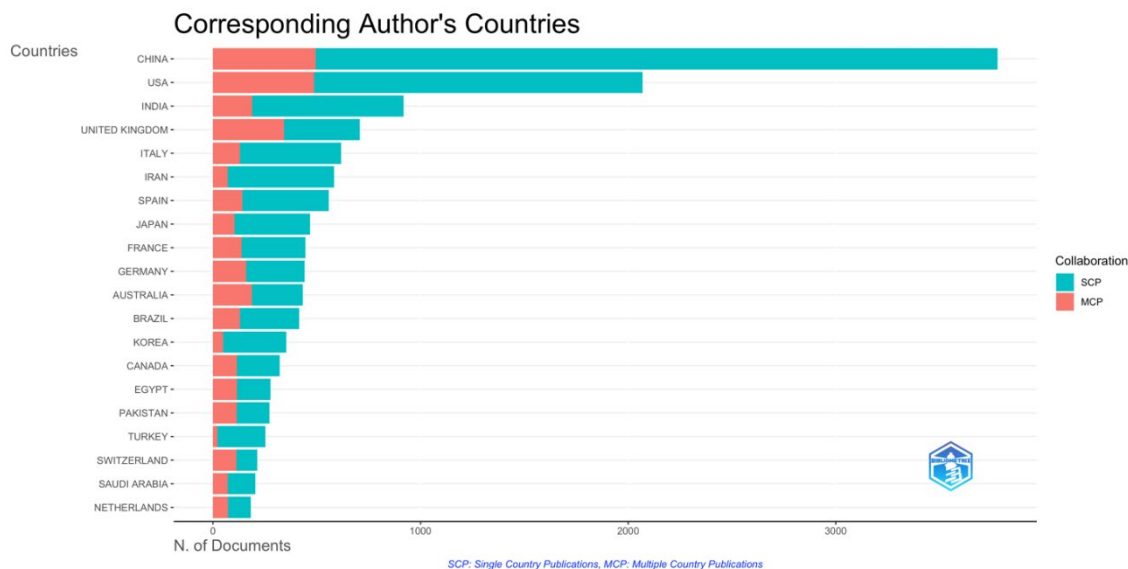
Figure 5. Distribution of country contributions of corresponding authors in publications related to antibiotic resistance in the period 2022–2025
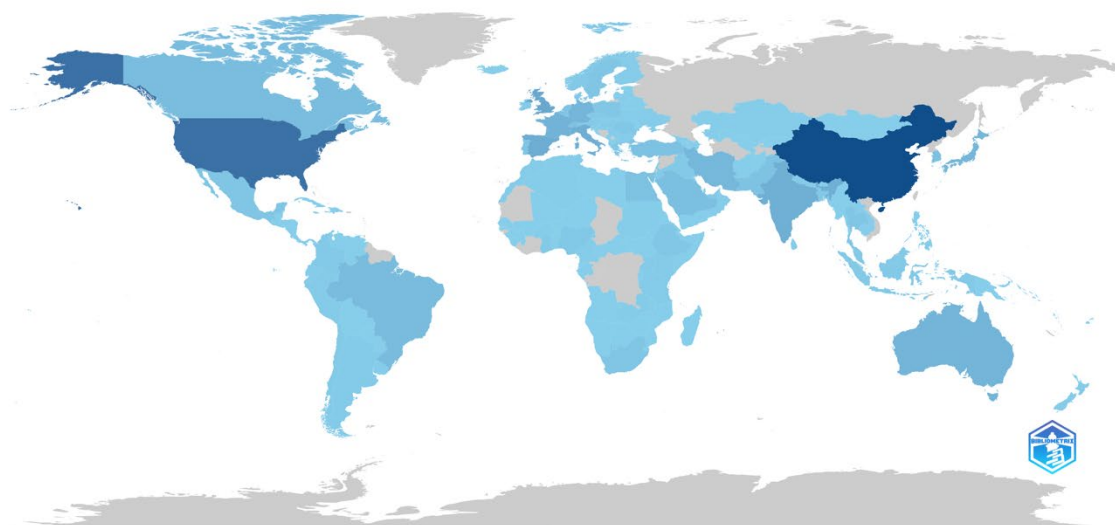

Figure 6. Map of global scientific production in the field of antibiotic resistance for the period 2022–2025. Darker shades indicate higher scientific output, while lighter shades represent lower levels of publication. Countries not contributing significantly appear in white or very light gray

Global Scientific Production Map

Global scientific production map visualization shows the geographic distribution of country contributions to antibiotic resistance research over the period 2022 to 2025. China appears as the country with the highest intensity of scientific production, shown in the darkest blue, indicating a strong dominance in the number of publications. The United States also stands out as a major contributor, followed by countries such as India, English, German, Italy, and Iran, all of which play an important role in enriching the global literature on antibiotic resistance. Most countries in Western Europe, East Asia, and parts of South America and Oceania also show quite active scientific activity, indicated by a lighter shade of blue. However, it is also apparent that some regions in Africa and Central Asia still show limited contributions or have not been significantly involved in scientific publications on this topic. This indicates the potential for collaboration and strengthening research capacity in these countries, in order to realize a more inclusive and global approach to addressing the problem of antibiotic resistance.
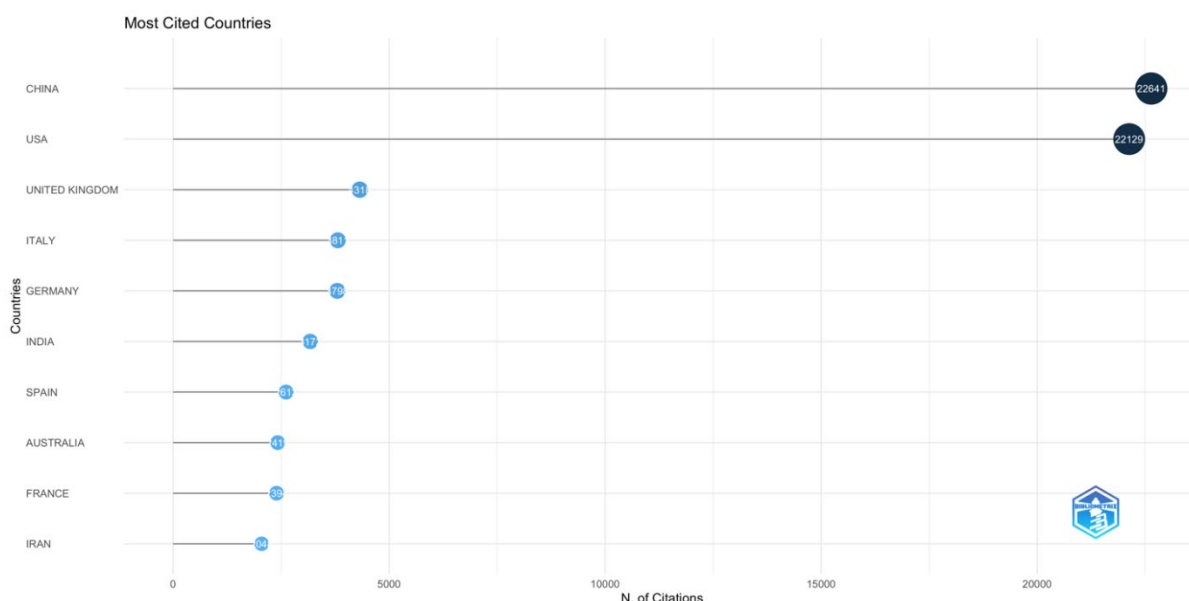
Figure 7. List of 10 countries with the highest number of citations in scientific publications related to antibiotic resistance during the period 2022–2025

Table 2. List of the 10 most cited scientific publications on antibiotic resistance (2022–2025)

Paper	DOI	Total Citations (TC)	TC per Year	Normalized TC
Murray CJL, 2022, Lancet	10.1016/S0140-6736(21)02724-0	8540	2,135.00	735.66
Malfertheiner P, 2022, Gut	10.1136/gutjnl-2022-327745	780	195.00	67.19
Naghavi M, 2024, Lancet	10.1016/S0140-6736(24)01867-1	406	203.00	223.34
Malfertheiner P, 2023, Nat Rev Disease Prim	10.1038/s41572-023-00431-8	405	135.00	68.79
Florensa AF, 2022, Microb Genomics	10.1099/mgen.0.000748	357	89.25	30.75
Tamma PD, 2022, Clin Infect Dis	10.1093/cid/ciac268	344	86.00	29.63
Suh GA, 2022, Antimicrob Agents Chemother	10.1128/aac.02071-21	230	57.50	19.81
Luetkemeyer AF, 2023, New Engl J Med	10.1056/NEJMoa2211934	212	70.67	36.01
Dedrick RM, 2023, Clin Infect Dis	10.1093/cid/ciac453	199	66.33	33.80
Baker MA, 2022, Clin Infect Dis	10.1093/cid/ciab688	198	49.50	17.06

Distribution of Citations by Country

Analysis of the distribution of citations from publications on antibiotic resistance during the period 2022 to 2025 shows that China and the United States dominate globally. Based on bibliometric data, China ranks first as the country with the highest number of citations, namely 22,641 citations, followed by the United States with 22,129 citations. This figure shows that the two countries are not only active in publishing research, but also have a great influence on the international scientific community through high citations. Other countries that also show significant contributions in terms of citations include the United Kingdom (3,181 citations), Italy (3,091 citations), Germany (2,762 citations), and India (1,717 citations). Several other countries such as

Spain (1,311 citations), Australia (1,281 citations), France (1,203 citations), and Iran (1,147 citations) are also included in the top ten countries with the highest citations. The dominance of China and the United States in the number of citations reflects the central position of the two countries in the development of global antibiotic resistance science. On the other hand, the presence of developing countries such as India and Iran in the list indicates that the problem of antibiotic resistance has become a global concern that transcends geographical and economic boundaries. In addition, the high number of citations from Western European countries indicates active collaboration and strong influence of the scientific community in the region.

Most Cited Publications

Murray CJL's article published in The Lancet journal in 2022 is in the top position, with a total of 8,540 citations and an average citations per year (TC per Year) of 2,135, and a Normalized Total Citations (TC) of 735.66. This article is a main reference in the scientific community because of its broad coverage and impact in discussing the global antimicrobial resistance crisis. Other articles that also stand out are Malfertheiner P's work in the journal Gut (2022) with 780 citations, and Naghavi M's article in The Lancet in 2024 which received 406 citations , but with a very high citation rate per year of 203 and a normalized citation value of 223.34 , indicating that despite being published more recently, its influence in the scientific community is very large. Other notable publications include articles by Malfertheiner P (2023) in Nature Reviews Disease Primers with 405 citations, and Florensa AF (2022) in Microbial Genomics with 357 citations. Other authors such as Tamma PD, Suh GA, Luetkemeyer AF, Dedrick RM, and Baker MA also produced highly cited articles, most of which were published in prestigious journals such as Clinical Infectious Diseases and the New England Journal of Medicine (Table 2). The consistent high citations across these journals reflect the quality and relevance of antibiotic resistance research, as well as the importance of disseminating quality scientific evidence in supporting global health policy.

4. Discussion

This bibliometric study reveals critical insights into the global research landscape on antibiotic resistance between 2022 and 2025. While the annual publication growth rate declined by -28.01%, the overall scientific activity remains robust. This apparent decline may reflect post-pandemic shifts in research funding priorities, rather than a decreased interest in antibiotic resistance itself.[24] Compared to prior bibliometric studies such as Dagli et al. (2024), our findings reinforce that antibiotic resistance continues to attract significant global attention, but with evolving patterns in geographic leadership, collaborative structures, and research themes.[26] China and the United States remain dominant in both publication volume and citations, suggesting continued investment and leadership in antibiotic resistance research. However, the growing contributions from India, Iran, and other developing countries highlight an encouraging trend toward global inclusivity. The high rate of international collaboration (27.62%) also suggests a shared understanding that antibiotic resistance is a transboundary challenge requiring coordinated global action.[26]

One of the key findings concerns the recurring focus on specific bacterial species, particularly *Escherichia coli*, *Staphylococcus aureus*, and *Klebsiella pneumoniae.* These organisms are among the top contributors to multidrug-resistant infections globally, and are classified by the WHO as high-priority pathogens.[27,28] Their frequent appearance in author keywords and Keywords Plus reflects both their clinical relevance and the urgent need to develop effective diagnostics, surveillance, and therapeutics targeting these organisms. However, while laboratory-based research (e.g., on minimum inhibitory concentration or PCR diagnostics) dominates current output, the broader integration with public health, policy, and behavioral science remains underrepresented. This gap presents an opportunity for future interdisciplinary research to better address antimicrobial stewardship in real-world contexts. This study contributes significant added value by presenting the most recent bibliometric mapping post-COVID-19, covering publications up to 2025. Unlike previous reviews that typically end at 2020 or 2021, our analysis offers a timely snapshot of how scientific focus has shifted in response to global events. The inclusion of institutional and geographic trends further supports strategic planning for capacity-building, especially in low- and middle-income countries that remain underrepresented in global outputs. Despite these strengths, this study is not without limitations. First, only Scopus-indexed publications were included, which may have excluded relevant research from other databases like Web of Science or PubMed. Second, the use of a single keyword ("antibiotic resistance") may have overlooked studies using alternative terms such as "antimicrobial resistance" or pathogen-specific resistance terminology. Third, bibliometric analysis cannot capture the quality, novelty, or real-world impact of individual studies.[29]

To guide future research and policymaking, we recommend: (1) expanding cross-disciplinary collaboration between microbiology, epidemiology, data science, and behavioral health; (2) enhancing research infrastructure in low-output countries through international partnerships; and (3) prioritizing studies that evaluate the implementation and effectiveness of antibiotic stewardship programs in diverse healthcare systems.[30] Furthermore, policymakers can use the current findings to identify leading research centers and institutions for strategic partnerships, especially on critical pathogens such as *E. coli* and *S. aureus* that continue to drive global resistance burdens.[31] Ultimately, we hope this study serves not only as a descriptive analysis, but also as a practical guide for researchers, funders, and health authorities to optimize their contributions to the global fight against antibiotic resistance.

5. Conclusion

Bibliometric analysis of 18,786 global publications from 2022–2025 shows that antibiotic resistance remains a priority issue despite a decline in annual growth (-28.01%). China and the United States dominate in terms of publications and citations, with major contributions from institutions

such as the University of Oxford and Zhejiang University. International collaboration is high (27.62%), reflecting the importance of cross-border cooperation. Keyword analysis reflects the focus of research on resistant pathogens, modern laboratory methods, and specific antibiotic use. The most influential publications are published in leading journals such as *The Lancet*, *Gut*, *Nature Reviews Disease Primers*, and *Clinical Infectious Diseases*. These findings underscore the importance of a multidisciplinary and collaborative approach to addressing the global challenge of antibiotic resistance.

6. Author Contribution

D.P.A. and R.I.P. carried out the bibliometric analysis. D.P.A. wrote the manuscript with support from S.K. N.F.N., E. and A.I.N. collected and curated the data. F.L and R.P helped supervise the project. A.N. and M.A. conceived the original idea. M.A. supervised the overall project.

7. Acknowledgements

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