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Bibliometric study of PharmD involvement in antimicrobial stewardship and public health initiatives

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ABSTRACT

Background: Doctor of Pharmacy (PharmD) professionals are central to antimicrobial stewardship (AMS) and public-health interventions, yet published research on their contributions is dispersed across various clinical and public-health domains. Understanding publication trends, influential contributors, and emerging themes is essential to support evidence-based stewardship and guide future policy. This study aimed to analyze global research involving PharmD participation in AMS and public-health initiatives from 2000 to 2024, focusing on publication patterns, collaboration networks, thematic clusters, and emerging research directions.

Methods: A bibliometric approach was conducted using OpenAlex as the sole data source. A structured search identified English-language journal articles and reviews addressing PharmD or pharmacist involvement in AMS or public-health activities. After duplicate removal and standardization using OpenRefine, the data were processed through Bibliometrix for descriptive and thematic analyses and VOSviewer for visual mapping of co-authorship, institutional collaboration, and keyword co-occurrence networks. Outcomes included publication trends, core research themes, citation structures, and collaboration patterns across authors, institutions, and countries.

Results: A total of 629 publications met the inclusion criteria. Annual output increased steadily, with a sharp rise after 2015 and peak productivity between 2019 and 2023. "Antibiotic Use and Resistance" was the most prominent theme (n = 368). Keyword co-occurrence networks showed central clustering around "antibiotic stewardship," "pharmacy,""clinical pharmacy," and "antimicrobial resistance." The United States demonstrated the highest research productivity and strongest collaboration density, led by institutions such as the Veterans Health Administration and Duke University. Emerging themes included COVID-19–related stewardship, telepharmacy, diagnostic-guided prescribing, and community-level public-health interventions. Most publications were original empirical studies (n = 539), complemented by a smaller body of reviews and other document types.

Conclusion: Research on PharmD involvement in AMS and public health has expanded significantly over the past two decades. The field remains anchored in clinical stewardship while progressively incorporating diagnostic innovation, telepharmacy, and public-health responsibilities. These trends highlight the growing global role of PharmD professionals in optimizing antimicrobial use and supporting public-health preparedness.

Keywords: Antimicrobial Stewardship; Antimicrobial Resistance; Clinical Pharmacy; PharmD; Public Health.
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INTRODUCTION

Antimicrobial resistance (AMR) continues to pose a severe global health challenge, demanding coordinated efforts across healthcare disciplines to promote responsible antimicrobial use and protect population health. Meta-analysis by Mathu et al showed that the incidence of AMR was high (>30%) to first-line antibiotics in the Middle East region.[1] Antimicrobial stewardship (AMS) programs have emerged as a core strategy to optimize antimicrobial therapy, reduce inappropriate prescribing, and limit the spread of resistant organisms.[2,3] Pharmacists, particularly those with Doctor of Pharmacy (PharmD) training, have become central contributors to AMS implementation due to their advanced clinical competencies, medication-management expertise, and growing integration within interprofessional healthcare teams.[4–7]

Over the past decade, research has increasingly highlighted the expanding role of PharmD professionals in infectious disease management, antimicrobial guideline development, surveillance of antimicrobial consumption, and educational initiatives targeting both clinicians and the public.[8–11] Recent studies also emphasise the impact of pharmacist-led interventions in reducing antimicrobial misuse in hospital and primary care settings, particularly in countries prioritising national action plans against AMR.[12,13] Parallel to their stewardship responsibilities, PharmD practitioners have taken on broader public health functions, such as vaccination campaigns, health promotion activities, community-based awareness programs, and population-level efforts to address medication safety and prevent communicable diseases.[14–17]

Despite the increasing visibility of pharmacists' contributions, the literature on PharmD involvement in AMS and public health remains scattered across diverse journals, clinical specialties, and global contexts. Several recent reviews describe pharmacists' roles in AMS implementation, but they often focus on specific settings (e.g., hospitals, emergency care, primary care) and do not capture longitudinal trends, collaboration patterns, or thematic research evolution.[18–21] Bibliometric analysis offers a systematic approach to mapping scientific production, identifying influential authors and institutions, visualising collaboration networks, and uncovering emerging themes in the field.[21] With the availability of large and open scholarly datasets such as OpenAlex, combined with advanced tools like Bibliometrix and VOSviewer, it is now possible to examine research output at scale and understand how PharmD-led AMS and public health initiatives have developed over time.

To date, there is no bibliometric study that evaluate this topic. Therefore, this bibliometric study aims to analyse global research related to PharmD involvement in antimicrobial stewardship and public health initiatives from 2000 to 2024. By examining publication trends, influential contributors, thematic clusters, and emerging research topics, this work seeks to provide a comprehensive overview that can support future academic, clinical, and policy efforts to strengthen pharmacist-led stewardship and public health interventions.

METHODS

Study Design

This study used a quantitative bibliometric design to analyse global research related to PharmD involvement in antimicrobial stewardship (AMS) and public health initiatives. The approach focused on examining publication patterns, influential contributors, collaboration networks, and thematic structures within the field.

Data Source and Search Strategy

All records were retrieved exclusively from OpenAlex, an open and comprehensive scholarly database that provides detailed metadata on journal articles, authors, institutions, citations, and conceptual themes. Its broad coverage and accessibility make it suitable for large-scale bibliometric research. A structured search query was executed through the OpenAlex API to identify research discussing PharmD or pharmacist involvement in AMS or public health initiatives. The OpenAlex API Query included: title_and_abstract.search:(PharmD OR "Doctor of Pharmacy" OR pharmacist OR "clinical pharmacist" OR "pharmacist-led") AND (antimicrobial stewardship OR "antibiotic stewardship" OR AMR) AND ("public health" OR "community health" OR "health promotion"). The filters applied for that search were: 1) publication within range of years 2000–2024, 2) type of article is original article or review article, 3) article using English as main language.

Eligibility Criteria

The inclusion criteria for this study are: 1) research involving PharmD professionals, clinical pharmacists, or pharmacist-led interventions, 2) studies focusing on AMS, antimicrobial resistance, or public health activities, 3) peer-reviewed journal articles and review papers, and 4) English-language publications. While the exclusion criteria in this study are: 1) studies lacking any pharmacist involvement, 2) editorials, letters, commentaries, or non–peer-reviewed material, and 3) duplicate records retrieved via the API.

Data Extraction, Cleaning, and Standardisation Procedure

The following metadata elements were collected: Article title, Authors and affiliations, Country of the corresponding author, Year of publication, Journal/source, Author keywords, Citation counts, Referenced works, Concept categories. The data were exported in JSON and CSV formats for analysis. Data cleaning procedures included: removing duplicates, standardising author names, normalising variations in institutional names, and filtering out irrelevant records. OpenRefine (version 3.6) was used for text cleaning. Cleaned data were then imported into RStudio and converted to a bibliometric data frame using the Bibliometrix package. To minimize potential bias inherent in bibliometric analyses, several methodological safeguards were implemented. First, a comprehensive and predefined search strategy was applied using standardized keywords and Boolean operators to reduce selection bias and ensure reproducibility. Second, data retrieval was restricted to a single curated database to maintain consistency in indexing standards and citation metrics, thereby limiting database-related heterogeneity. Third, duplicate records and non-relevant documents were systematically screened and excluded through a two-stage filtering process based on titles, abstracts, and full-text metadata.

Bibliometric Analysis

The software used in this analysis are Bibliometrix (R package) for descriptive indicators, collaboration metrics, and thematic mapping. We also used VOSviewer for constructing visual networks including co-authorship, keyword co-occurrence, and co-citation patterns. The descriptive analysis included annual publication trends, leading authors, top journals, most productive countries and institutions, and citation trends. Then we continued to collaboration analysis which evaluated author collaboration networks and international research cooperation. We also conducted thematic analysis to assess keyword co-occurrence patterns, thematic clusters and evolution and identification of dominant and emerging themes. For co-citation analysis, we analyzed the most frequently co-cited authors and the

core references contributing to the field. Network visualisations were produced using VOSviewer, and tabular results were generated using Bibliometrix.

Ethical Considerations

The study relied entirely on publicly available metadata without human participants or identifiable personal information. Ethical approval was not required.

RESULTS

Annual output increased steadily from the early 2000s, followed by a marked rise after 2015, reaching its highest levels between 2019 and 2023. After selection based on the inclusion and exclusion criteria, only 629 publications met those criteria and included in the analysis. The year-by-year raw distribution is summarized in Table 1.

Two author-level collaboration structures were generated. Figure 1 presents a small-scale author-collaboration network, highlighting direct links among key contributors.

Topic-frequency analysis identified "Antibiotic Use and Resistance" as the most represented theme, appearing in 368 publications (Table 2). Additional prominent topics included pharmaceutical care and patient outcomes, urinary-tract infection management, susceptibility testing, and drug-induced adverse reactions.

These patterns align with the keyword co-occurrence structure illustrated in Figure 2, where "medicine," "antibiotics," "pharmacy," "clinical pharmacy," and "antibiotic stewardship" appear as central, high-frequency nodes.

Institutional analysis revealed that the U.S. Department of Veterans Affairs and the Veterans Health Administration were the top contributors, each producing 27 publications (Table 3). Other major institutions included: Henry Ford Health System / Henry Ford Hospital, Duke University, University of Pittsburgh, and University of Michigan

The institutional collaboration network (Figure 3) demonstrates strong interconnectedness among major U.S. hospitals and universities, with growing participation from institutions in India, the Middle East, and Latin America.

The country collaboration mapping (Figure 4) shows that the United States serves as the central hub in global research collaboration. Strong links connect the U.S. with: United Kingdom, India, Saudi Arabia, China, Spain, Australia, and Canada. These findings are supported by the country-level data extracted from *Country_Nodes.csv* and *Country_Edges.csv*, which confirm that the U.S. has the highest publication count and collaboration density in the dataset Figure 4.

The keyword co-occurrence network (Figure 2) revealed several major knowledge clusters which is 1) Antimicrobial/Antibiotic Cluster: "antibiotics," "antibiotic stewardship," "antimicrobial," "resistance", 2) Clinical/Pharmacy Cluster: "pharmacy," "pharmacist," "clinical pharmacy," "pharmaceutical care", 3) Internal Medicine & Infectious Diseases Cluster: "internal medicine," "emergency medicine," "sepsis," "bacteremia", and 4) Public Health / Quality Improvement Cluster: "audit," "intervention," "guideline," "multidisciplinary". These clusters collectively demonstrate the strong clinical foundation of pharmacist-led antimicrobial stewardship (AMS) research and the breadth of topics connected to it (Figure 5).

The thematic map generated using Bibliometrix (Figure 3) positioned themes according to centrality and development which is: 1) motor themes: central and well-developed areas such as antibiotic stewardship and pharmacy practice, 2) basic themes: foundational fields including medicine, internal medicine, and pharmacology, 3) emerging themes: COVID-19–related ams, outbreak

Table 1. Annual Publications (2000–2025)

Year	Number of Publications (n)
2025	85
2023	71
2022	67
2021	83
2020	69
2019	56
2018	45
2017	39
2016	37
2015	33
2014	30
2013	27
2012	23
2011	18
2010	12
2009	9
2008	5
2007	3
2006	2
2005	1
2004	1
1999	1
Total	**629**

Table 2. Top Research Topics in PharmD-Led AMS Literature

Topic	Works (n)
Antibiotic Use and Resistance	368
Pharmaceutical Practices and Patient Outcomes	50
Urinary-Tract Infection Management	21
Bacterial Identification and Susceptibility Testing	21
Drug-Induced Adverse Reactions	14
Infectious Disease Diagnostics	11
Clinical Pharmacy	9
Pharmacy Practice	9
Medical Prescription Quality	8
Antimicrobial Resistance Surveillance	8

Figure 1. Micro-Level Author Collaboration Pathway in AMS Research

Table 3. Most Productive Institutions

Institution	Works (n)
United States Department of Veterans Affairs	27
Veterans Health Administration	27
Duke University	16
Henry Ford Health System	14
Henry Ford Hospital	14
University of Pittsburgh	12
Amrita Institute of Medical Sciences	10
University of Michigan	9
University of Utah	9
University of Minnesota Medical Center	8
Wayne State University	8
University of Rochester	7
University of Iowa	7
Houston Methodist	7
University of Colorado Denver	6
University of Maryland	6
Mayo Clinic	6
King Abdulaziz University	5
Ministry of Health (multiple countries)	4
Universidad Bíblica Latinoamericana	4

Figure 2. Keyword Co-Occurrence Network of Pharmacist-Led Antimicrobial Stewardship Research (VOSviewer)

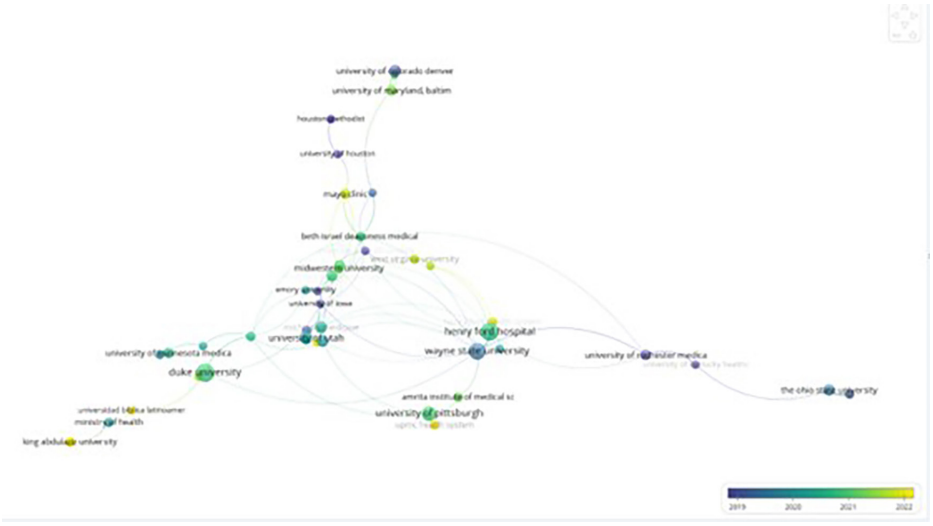

Figure 3. Institutional Collaboration Network in Pharmacist-Led Antimicrobial Stewardship Research (Time-Overlay Visualization)

preparedness, and telepharmacy, and 4) niche themes: microbiology diagnostics, susceptibility testing, and biomarker-based research. These thematic patterns confirm that pharmacist-led AMS research continues to be anchored in infectious diseases while expanding toward health-system stewardship and public-health applications Figure 6.

The dataset consisted primarily of original research articles (n = 539). Other document types included reviews, letters, book chapters, and preprints (Table 4). This distribution indicates that AMS literature is largely driven by empirical investigations supported by a smaller body of secondary or commentary works.

DISCUSSION

The findings of this bibliometric study show a steady global expansion of research focused on PharmD contributions to antimicrobial stewardship (AMS) and public-health activities. The increase in publications after 2015 coincides with rising international concern about antimicrobial resistance and the push for stronger multidisciplinary stewardship programs, as highlighted in earlier global reports and implementation studies.[2,3] Over the years, pharmacists with advanced clinical training have become deeply embedded in stewardship teams, and their impact has been documented across diverse healthcare settings. Numerous studies have shown that pharmacist-led interventions improve prescribing quality, enhance therapeutic decision-making, and reduce unnecessary antimicrobial use.[4–7]

The concentration of research around topics such as antibiotic use, resistance trends, and clinical-pharmacy services reflects the continued centrality of pharmacists in stewardship efforts. Prior evidence consistently demonstrates that pharmacists are key to developing AMS guidelines, monitoring antimicrobial consumption, and supporting prescribers through real-time clinical recommendations.[8–10] The prominence of keywords related to pharmacy practice in the co-occurrence network further confirms that stewardship activities remain strongly anchored in the clinical responsibilities of PharmD professionals.

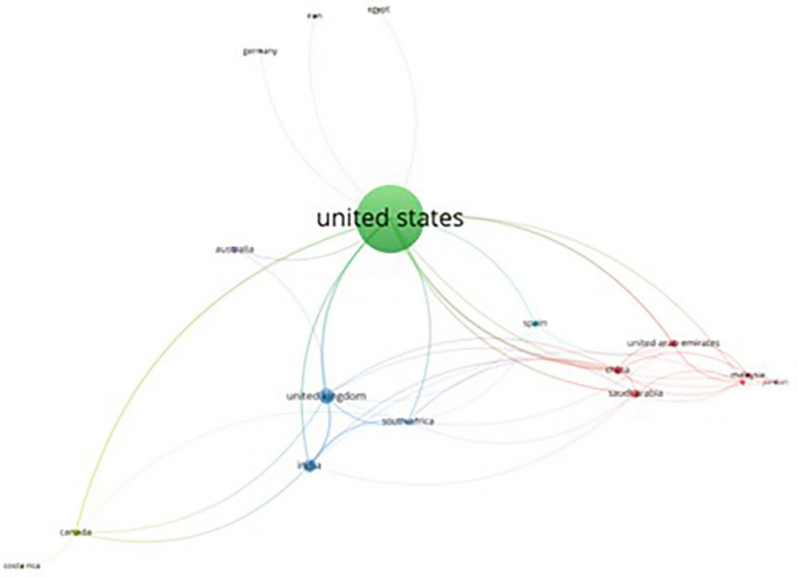

Figure 4. International Collaboration Network in Pharmacist-Led Antimicrobial Stewardship Research

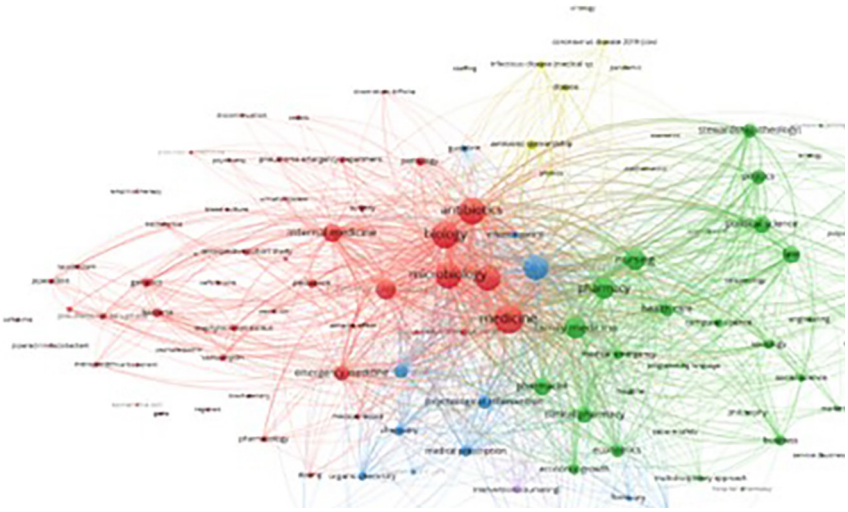

Figure 5. Full Keyword Co-Occurrence Network of Pharmacist-Led Antimicrobial Stewardship Research

Institutions in the United States, particularly the Veterans Health Administration, stood out as major contributors. This is consistent with longstanding findings that U.S. clinical-pharmacy models have enabled pharmacists to take on active, patient-facing antimicrobial-optimization roles, with several studies reporting reductions in broad-spectrum therapy, lower infection complications, and improved adherence to stewardship protocols.[11–13] However, the growing presence of institutions from India, Saudi Arabia, and Latin America reflects a broader global commitment to AMS. These regions have introduced national AMR action plans in recent years, and the increase in publications suggests measurable progress in building stewardship capacity.[14–16]

A key observation from the thematic analysis is the shift toward broader public-health functions. During the COVID-19 pandemic, pharmacists played vital roles in monitoring antimicrobial use, guiding prescribers, and mitigating inappropriate antibiotic demand, an issue frequently reported in pandemic-related prescribing literature.[17–19] Their involvement in telepharmacy, vaccination campaigns, and outbreak preparedness demonstrates how the profession continues to adapt to new public-health challenges.

Another emerging area identified through the keyword and thematic analysis relates to diagnostic stewardship. Several studies have shown that closer collaboration between pharmacists and microbiology laboratories improves the interpretation of rapid tests, supports more precise prescribing, and enhances early de-escalation of broad-spectrum antimicrobials.[20,21] This reflects a growing emphasis on aligning pharmacy practice with diagnostic technologies to promote more targeted treatment approaches.

Overall, the findings illustrate a strong and widening global evidence base supporting PharmD professionals as essential contributors to AMS and public-health initiatives. While the research landscape continues to grow, the distribution of publications across many journals and specialties suggests the need for more coordinated frameworks, shared methodologies, and multicountry comparative studies to guide future progress.

This study offers several strengths that enhance its contribution to the literature on PharmD involvement in antimicrobial stewardship (AMS) and public-health initiatives. First, it provides one of the most comprehensive bibliometric assessments to date, covering a 25-year period and analyzing global publication trends, collaboration networks, and thematic evolution using two complementary tools, Bibliometrix and VOSviewer. Second, the exclusive use of the OpenAlex database ensured broad coverage of peer-reviewed publications from diverse regions and disciplines. Third, the inclusion of multiple analytic components, descriptive indicators, co-authorship structures, institutional collaborations, keyword co-occurrence patterns, and thematic mapping, allowed for a multidimensional understanding of how PharmD-led AMS research has progressed worldwide. These strengths collectively offer a detailed overview that can inform academic planning, stewardship policy development, and future research priorities.

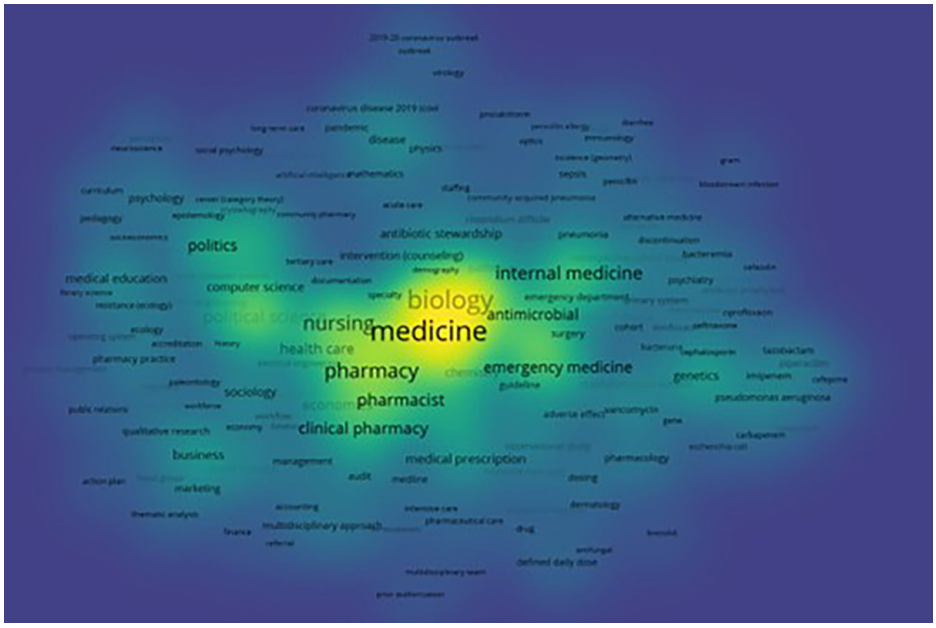

Figure 6. Keyword Density Visualization of Pharmacist-Led Antimicrobial Stewardship Research

However, the study also has limitations. The reliance on a single data source (OpenAlex) may have resulted in the omission of some publications indexed only in other databases such as Scopus or Web of Science. Variability in author name spelling, institutional labeling, and keyword assignment, common challenges in bibliometric research, may introduce classification inconsistencies despite extensive data cleaning efforts. Additionally, the analysis was limited to English-language publications, potentially underrepresenting contributions from non–English-speaking countries. Finally, bibliometric methods quantify publication patterns and thematic structures but do not evaluate the quality of individual studies or the real-world impact of pharmacist-led interventions. Future analyses combining multiple databases or incorporating systematic-review methods could address these gaps and provide deeper insight into the evidence base.

CONCLUSION

This bibliometric study highlights a robust and expanding global evidence base on PharmD involvement in antimicrobial stewardship (AMS) and public-health initiatives, with research output accelerating over the past decade alongside broader clinical scope, stronger collaboration networks, and increased urgency around antimicrobial resistance. The thematic landscape confirms AMS as the core research anchor while showing strategic diversification into emerging priorities such as telepharmacy, outbreak preparedness, and community-level prevention. By mapping key authors, institutions, thematic clusters, and collaboration linkages, the study provides actionable intelligence to guide program scaling, policy alignment, and future research roadmaps, reinforcing the critical role of pharmacists in strengthening AMS and public-health impact worldwide.

ETHICAL APPROVAL

This study did not involve human participants or identifiable personal data. All analyses were conducted using publicly available bibliometric metadata from the OpenAlex database. According to international guidelines for secondary data research, ethical approval was **not required**.

INFORMEDCONSENT

Not applicable, as the study did not involve human participants

Table 4. Document Types in the Dataset

Document Type	Count (n)
Articles	539
Reviews	37
Letters	16
Book Chapters	12
Preprints	12
Conference Papers	5
Editorials	4
Dissertations	4
Total	**629**

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest related to the design, analysis, or publication of this study.

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- **Conceptualization:** Anas Ali Alhur
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- **Supervision:** Anas Ali Alhur
- **Project Administration:** Anas Ali Alhur

All authors reviewed and approved the final version of the manuscript.

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