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# Antimicrobial stewardship challenges: A bibliometric analysis

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*Corresponding author: E-mail:	ABSTRACT
dr.haris.spbs@gmail.com	Antimicrobial resistance (AMR) is a worldwide problem that presents a substantial risk to the healthcare of the general population. Antimicrobial stewardship (AMS) is essential in hospitals to optimize the use of antimicrobial agents and address the challenges of drug resistance, superinfection, and rising healthcare costs. However, there are still many obstacles in the implementation of the antimicrobial stewardship program (ASP) in hospitals and healthcare, so the decline in AMR to date is still not in line with expectations. The purpose of this study is to analyze antimicrobial stewardship research trends and to determine the progress of antimicrobial stewardship research in hospitals or healthcare. This study is qualitative research with a literature study approach. Taken from the Scopus database in the last five years, 534 articles were obtained to be analyzed using Mapchart, VOSviewer, and Rstudio-Biblioshiny. The results show that implementation, and the factors that contribute to the running of the AMS program. The findings also show authors, countries that publish the most, journals that are most cited, topics that are rarely published, and themes that can be developed in the future. The conclusion of this study is to determine the development of AMS research and to gain a better understanding of AMP implementation.
	Keywords: Antimicrobial stewardship, antibiotic stewardship, hospital, healthcare

## Introduction

Antimicrobial resistance is a worldwide problem that presents a substantial danger to the health of the general population. Antimicrobial resistance is the phenomenon in which microorganisms, including bacteria, viruses, fungi, and parasites, develop the ability to withstand the effects of medications that were previously able to eliminate them (Prestinaci et al., 2015). This resistance makes it difficult to treat common infections and increases the risk of severe complications and death (Friedman et al., 2016). In addition, antimicrobial resistance undermines the effectiveness of modern medicine and jeopardizes advances in health care, including surgery, chemotherapy, and organ transplants (Roope et al., 2019).

To reduce the threat of antimicrobial resistance, it is necessary to improve infection control practices, rational use of antibiotics, and invest in research and development of new antimicrobial agents (Ayukekbong et al., 2017). Antimicrobial stewardship programs are essential in hospitals to optimize the use of antimicrobial agents and address the challenges of drug resistance, superinfection, and rising healthcare costs. These programs aim to improve patient outcomes by ensuring proper use

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of antimicrobial agents, reducing the risk of side effects, and promoting cost-effectiveness (Kim et al.,2015).

The Infectious Diseases Society of America (IDSA) introduced the notion of AMS in 2007. The original definition of antimicrobial stewardship involved the organized intervention to enhance the selection of appropriate drugs, accurate dosing, administration route, and treatment length, all while prioritizing patient outcomes (Majumder et al., 2020). In 2014, the Centres for Disease Control and Prevention (CDC) urged all hospitals in the United States to establish antibiotic stewardship programmes and published the Core Elements of Hospital Antibiotic Stewardship Programmes (Core Elements) as a guide to assist hospitals in accomplishing this objective. Core Elements delineates the fundamental structural and procedural constituents linked to a prosperous stewardship programme (Pollack & Srinivasan, 2014). The United Kingdom implemented a five-year national policy in 2013 to address the issue of antibiotic resistance. The primary objective of this strategy is to impede the progression and dissemination of antibiotic resistance (Johnson et al., 2015). In Indonesia, AMS has been regulated by the Minister of Health Regulation No. 28 of 2021 regarding the rational use of antibiotics to reduce the impact on resistant germs. AMS aims to improve patient outcomes by improving the quality of antibiotic use which includes selection of antibiotic dose type, interval, route, and duration of administration. AMS regulates the use of antibiotics by grouping them into three categories of AWaRe: Access, Watch, and Reserve (Kementerian Kesehatan RI, 2021). The Antimicrobial Stewardship Program (ASP) needs to be carried out jointly by all countries so that the reduction in germ resistance rates can be realized immediately.

Antimicrobial stewardship plays a crucial role in restricting the spread of antimicrobial resistance, as well as reducing mortality rates, hospital stays, and healthcare expenses (Demir et al., 2021; Cercenado, 20233). Overuse of antibiotics can escalate the economic cost and likelihood of acquiring strains of other multidrug-resistant pathogens during extended hospital stays (Bhatti et al., 2023). The introduction of ASP has demonstrated its ability to enhance the prudent use of antibiotics and mitigate the detection of infections caused by antibiotic-resistant bacteria without causing adverse consequences for patient safety (Cheon et al., 2016; Cai et al., 2016).

Implementing an antimicrobial stewardship program in a hospital requires several key components. First, there must be support from hospital leadership to ensure the allocation of necessary resources (Mendelson et al., 2020) and the establishment of a culture of proper antimicrobial use. Second, collaboration and cooperation between pharmacy, specialists, and clinical microbiologists in the development and implementation of effective stewardship strategies (Burton et al., 2022). The implementation of a restricted antimicrobial process involves collaboration across multiple disciplines and requires addressing various obstacles to achieve future enhancements (Burton et al., 2022). The importance of gaining approval from clinical professionals cannot be overstated when it comes to transforming the mindset around antimicrobial usage and guaranteeing the effectiveness of the programme (Broom et al., 2017).

Although AMS has been carried out in many countries, there are still many obstacles in its implementation, so many studies are conducted to evaluate, and explore the obstacles that occur during the implementation of ASP. Some of the obstacles found in the study are a lack of knowledge in the rational administration of antibiotics (Kalungia et al., 2019), wrong perception of doctors about AMS (Broom et al., 2017; Kalungia et al., 2019), so education and training are needed to support the implementation of AMP in a health service.

The purpose of bibliometric analysis in this study is to identify research trends in implementing antimicrobial stewardship in hospitals and in healthcare and to determine the development of studies related to AMS. In particular, this article discusses the development of publications, core journal publications, author contributions, number of publications referenced, geographical distribution by country, as well as analyzing research topics using keywords used and network visualization with bibliometric analysis using VOSViewer and Rstudio-Biblioshiny. Another objective is to conclude the AMS implementation review and provide recommendations for future research.

#### **Material and Methods**

This study is structured using normative legal study methods, is a study performed by examining the sources of library materials (secondary data) which are used as the basis for the study, in the form of legislation and associated study reports and the issues raised. The primary source of the constitution used is the 1945 Constitution of the Republic of Indonesia, Constitution no. 1 of 1946 regarding the Criminal.

The method in this study is qualitative method with a literature study approach. A bibliometric review was conducted to explore the publication of trends in Antimicrobial Stewardship indexed in Scopus. A comprehensive search and selection method covers all relevant matters. The source of data in this study was taken from the Scopus database in February 2024 with the keywords "antimicrobial stewardship" OR "antibiotic stewardship" AND "hospital" OR "healthcare" within the last 5 years (January 2019-December 2023).

Preliminary results of 901 articles were obtained. Screening is carried out by limiting the subject areas of Medicine, Immunology and Microbiology Pharmacology, Toxicology and Pharmaceutics, Biochemistry, Genetics and Molecular Biology, Health Professions, and Nursing. Selected Article document type and Journal source type in the English language. The final result was 534 documents. Figure 1. shows the process of identifying articles and the process of analysis.



Source: Authors Analysis (2024)

Figure 1. Article selection process

Researchers then visualize the results of the study using computer software. This process involves creating a keyword map by exporting search results from the Scopus database into CSV format and then inserting the CSV data into Mapchart, VOSviewer, and Rstudio-Biblioshin software. Mapchart is used for Distribution of publication by Country. VOSviewer is used for Network Visualization, Overlay Visualization, and Density Visualization data analysis. The unit of data analysis in network visualization is used to map concepts in a study. Overlay Visualization is used to map the progress of the study. Density Visualization is to see density in a study and bring up new themes/keywords that have not been written much. Rstudio-Biblioshiny is used to visualize Three Field Plot, Trend Topics, and Thematic Revolution. Three Field Plot is used to visualize the relationship between three variables in bibliometric analysis, to analyze the relationship between author, keyword, and publication in one intuitive visual display. Trend Topic is used to analyze trends in topics or themes that appear in scientific literature from time to time, while Thematic Revolution in Rstudio-Biblioshiny is used to analyze significant changes in research topics or themes over time so that major changes can be seen in the focus of research in a particular field of science.

### **Results and Discussion**

#### General information and annual publication output

Annual publication output refers to the number of scientific articles published by researchers or institutions in a year indexed in the Scopus database. It can give an idea of the amount of research activity and academic productivity at the level of a particular individual, research group, or research institution. This data is often used to evaluate the performance of researchers or institutions in the context of scientific research.



Source: Adopted from Scopus database (2024)

Figure. 2 shows studies on AMS implementation have increased from 2019 to 2023. There are 77 articles in 2019, 99 articles in 2020, and increasing steadily until 2023 as many as 138 articles. Several studies on AMS in 2019 discussed the successes and barriers that occur in AMP in healthcare.

A study shows antibiotic treatment is considered inappropriate based on an incorrect dosage regimen, incorrect indications, or both, about two-thirds of the study population (70.3%) had

Figure 2. Global trends in publications on Antimicrobial Stewardship (2019-2023)

antimicrobials that did not match the dose, duration, and indications (Saleem et al. 2019). A separate study conducted in 2019 found that numerous emergency department doctors see several obstacles to the adoption of hospital Antimicrobial Stewardship Programmes (AMS). These barriers include uncertainty in diagnosing patients, time and resource constraints, dependence on past experiences, and limited access to expert opinions (Goulopoulos et al., 2019).

Several studies in 2019 analyzed obstacles that occur during the implementation of antimicrobial stewardship programs (ASP). The lack of adherence to policies and guidelines set by the Ministry of Health and hospital management poses a major hindrance to the adoption and implementation of ASP. Additional obstacles encompass team fragmentation, inadequate communication, insufficient recruitment or shortage of ASP team members, inadequate education and training, and absence of health information technology (Alghamdi et al., 2019). Education, decision-making support, feedback, or small rewards as rewards have a significant impact on the appropriate use of antibiotics (Malmgren et al., 2019).

In 2023, several studies on AMS discuss the existence of antimicrobial resistance which is still a big problem to overcome it. The use of antimicrobials is still not as expected. The high use of antibiotics in *hospitals* because the majority of patients treated receive antibiotics has the potential to increase antibiotic resistance so *hospital antimicrobial management* programs need to be carried out (Kamara et al., 2023). Another finding related to AMS with AMR is a study that shows that with AMS, the antimicrobial that is often used is an Access class antibiotic, but the daily dose and duration of administration are still not appropriate, so better management is needed (Negi et al., 2023). Another study writes about the limited understanding of antimicrobial resistance (AMR) by physicians and pharmacists who are not precise in prescribing and distributing antibiotics (Alam et al., 2023).

Still in 2023, a study found that there was no significant difference in AMS program compliance even though it had been running for 4 years. The majority of fundamental components in the AMS programme fall below the average level, necessitating a strong commitment from hospital leadership and joint efforts from across disciplines (Hassan et al., 2023). The other study found that overall antibiotic use was higher by about 47%. Although the AMP Policy already exists but does not seem to be followed by a high level of compliance (Jabeen et al., 2023).

### Distribution of publication by Country

Distribution of publication by Country refers to the way in which the number of scientific publications is divided among different countries around the world. It provides an overview of each country's contribution to the scientific literature in a particular field. This analysis can aid in the understanding of global research trends, and country involvement in specific areas, and can also be used to compare research performance between countries.

From the publication images of the 10 most countries, the United States ranked first, with 181 articles in the last 5 years, followed by the United Kingdom with 92 articles, and Italy with 38 articles. Writing a study from the United States in addition to conducting a study of the success and obstacles of AMS, several studies began to discuss the preparate type of antibiotic given and examined certain types of germs. Adherence to antimicrobial prophylaxis guidelines is still suboptimal, largely due to the unnecessary use of vancomycin, which can increase the risk of Acute Kidney Injury (Cabral et al., 2023). Other studies on antimicrobial preparation were the use of Carbapenem (Ferrer et al., 2021; Xu et al., 2023), Penicillin Allergy (Mabilat et al., 2022), fluoroquinolones (Jones et al., 2021).

Studies on AMS implementation also expanded by conducting research on types of bacteria Clostridioides difficile ((Jones et al., 2021; Gonzalez et al., 2022), multidrug resistance pseudomonas (Idigo et al., 2022) enterococcal bacteremia (Bhatti et al., 2023), beta-lactamase-producing *E.coli* (Raphael et al., 2021) associated with AMR in the diagnosis of certain diseases.

The second most published United Kingdom is the United Kingdom with 92 articles, one study states that only six *health* facilities (35%) have a formal organizational structure and a team responsible

for ASP. Only one facility routinely monitors antimicrobial use, so there is a significant shortage in ASP availability. This needs to be addressed urgently to reduce AMR levels in Nigeria (Fadare et al., 2019).

The challenges associated with the introduction of AMS are still extensively debated in publications in the United Kingdom. According to a study, barriers arise from a lack of coordination or breakdown in teams, inadequate communication, insufficient recruitment of ASP team members, inadequate education and training, and a dearth of health information technology (Alghamdi et al., 2019).



Source: Authors analysis by Mapchart (2024)

Figure 3. Publication by country

Several studies analyzed the use of antimicrobial types against antimicrobial resistance. Overprescribing of antibiotics, especially clindamycin, showed a positive association with the total incidence of Clostridioides difficile infection (CDI) (Bansal et al., 2023). Another study discussed the identification and management of antimicrobial Carbapenem resistant Gram-negative (Bedos et al., 2021). There are studies that show the results of reducing isolated Carbapenemase-producing Enterobacterales (CPE) along with reducing the use of carbapenems, at the time the AMS program is carried out (Cipko et al., 2020).

Several published studies from Italy discuss bacterial colonization. Studies from Tiri suggest that the spread of carbapenem-resistant klebsiella pneumonia colonization during the COVID-19 era is increasing (Tiri et al., 2020). Another study from Italy discussed Clostridioides difficile infection (CDI). Antibiotic administration during hospitalization is a risk factor associated with CDI (Granata et al., 2020).

### Analysis authors

The author's analysis can help in the understanding of individual contributions to the scientific literature, the dynamics of collaboration in research, and also in identifying trends or patterns in research production.

The image on Figure. 4 shows that of the 10 authors who conducted studies over the past 5 years, Godman and Haseeb had the highest number of articles, namely 9 articles. Followed by Saleem and Tarrant with 8 articles and Ashiru-Oredope with 7 articles, and authors who published 6 articles each, namely Charani, Cosgrove, Holmes, Sneddon, and Srinivasan.

Godman conducted a study on the limited understanding of doctors, pharmacists, and health professionals regarding antimicrobial resistance (AMR). It was also mentioned that the community also

self-medicates with antibiotics. This indicates a lack of awareness and knowledge regarding the proper use of antibiotics. Godman and other authors conducted research collaborations, including evaluating several types of antibiotics carried out in hospitals in the Middle East and several other countries (Saleem et al., 2019; Fadare et al., 2019; Haseeb et al., 2023; Saleem et al., 2022; Ogunleye et al., 2022). This is done to evaluate whether the writing of antibiotic prescriptions is in accordance with the AMS program carried out, as well as to see the resistance of germs to these antibiotics.



Source: Adopted from Scopus database (2024)



Another author who is most active in studying AMS is Haseeb. Three of Haseeb's studies were a joint collaboration with Godman and Saleem. Haseeb also conducted a study on the AMS Program (ASP) running in Saudi Arabian hospitals. Only 26% of hospitals report implementing ASP due to lack of knowledge, technology and staff resources to adopt and implement ASP (Alghamdi et al., 2021).

Tarrant contributed 8 articles. Three of Tarrant's studies dealt with AMS with surgical services in hospitals. A study designed interventions to encourage infection control programs (IPC) and AMS by conducting postoperative antimicrobial control and understanding of antimicrobes to patients (Ahuja et al., 2022) Another study conducted a study on the leadership style of consultants that occur in surgical wards that will affect effective communication to support AMS programs (Bonaconsa et al., 2021). Another study found that the structural foundation that allows staff to change their behaviour and participate in infection-related surgical care is lacking (Singh et al., 2021).

The fifth author who contributed the most publications was Ashiru-Oredope. One study revealed that fear of a patient's worsening condition or complications was the most frequent reason (43%) for prescribing antibiotics deemed unnecessary. Out-of-hospital prescribers may outnumber prescribers in prescribing antibiotics due to time constraints or to maintain contact with patients (Ashiru et al., 2021).

Author	Title	Source	Year	Citation
Tiri, B et al. (2020)	Antimicrobial stewardship program, COVID-19, and infection control: Spread of carbapenem-resistant klebsiella pneumoniae colonization in ICU COVID-19 patients. What did not work?	Journal of Clini- cal Medicine	2020	138
Kubin, CJ et al. (2021)	Characterization of Bacterial and Fun- gal Infections in Hospitalized Patients with Coronavirus Disease 2019 and Factors Associated with Health Care- Associated Infections	Open Forum In- fectious Dis- eases	2021	80
Friedrich, A (2019)	Control of hospital acquired infections and antimicrobial resistance in Europe: the way to go	Wiener Medizinische Wochenschrift	2019	76
Elbeddini, A et al. (2020)	Pharmacists and COVID-19	Journal of Phar- maceutical Pol- icy and Practice	2020	70
Blot, S et al. (2022)	Healthcare-associated infections in adult intensive care unit patients: Changes in epidemiology, diagnosis, prevention and contributions of new technologies	Intensive and Critical Care Nursing	2022	67

Table 2. Most-cited publications in antimicrobial stewardship

Source: Adopted from Scopus database (2024)

Based on Table. 2 above shows that the study of EMR that is the main reference is the study from Tiri, about an intervention study with active surveillance to see patients with Carbapenem-Resistant Enterobacteriaceae (CRE). With the implementation of AMS and large training of all staff on infection control measures in the COVID-19 era, the incidence of CRE acquisition increased from 6.7% in 2019 (Tiri, 2020) to 50% in 2020. This shows that with AMP, AMR is difficult to control, especially during the COVID-19 era.

The second most referenced publication is shown by studies discussing antibiotic resistance that increases with the length of hospital stay, with increased vancomycin resistance in enterococcus and ceftriaxone, and carbapenem resistance in Enterobacterales. AMP is needed to limit unnecessary administration of broad-spectrum antimicrobial agents (Kubin et al., 2021).

Followed by 76 citations related to studies on the implementation of infection prevention measures that must be taken to combat AMR, especially MRSA and ESBL which are difficult to overcome (Friedrich, 2019). A further investigation of the involvement of chemists amidst the Covid-19 era. Alongside ICU nurses, physicians, and respiratory therapists, hospital pharmacists have played a crucial role in the COVID-19 response. Their responsibilities encompass the development of treatment protocols, active involvement in patient care, interpretation of COVID-19 lab results, recruitment of participants for clinical trials, investigation of new medications, provision of treatment management guidance, and AMS (Elbeddini et al., 2020).



# Linkage and clustering of themes in antimicrobial stewardship

The figure shows co-occurrence visualization. The size and color of the circles indicate the degree to which the bibliography and cluster merge, while the line length represents the strength of the connections between them.

Source: Authors analysis by VOSviewer (2024)

Figure 5. Co-occurence visualization

Of the four visible colors, there are 4 clusters in this visualization. The first cluster in red consists of the keywords hospital patient, tertiary care center, prevalence, and several keywords of the type of antimicrobial agent, such as ceftriaxone, meropenem, vancomycin, ampicillin. The second cluster in green consists of the keywords adult, hospital admission, microbiology, length of stay, hospitalization, sepsis, mortality. The third cluster in blue shows the keywords antimicrobial stewardship, antieinfective agent, antbacterial agent, antibiotic resistance, infection control, prescription, pharmacist, physician, healthcare cost, healthcare planning. The fourth cluster is yellow, consisting of child, young adult, infant. Each cluster represents a group of interrelated entities or elements in a co-occurring network based on patterns of co-occurrence in the dataset. These clusters can describe a collection of topics that are related or frequently discussed together in literature, text documents, or other datasets being analyzed.

# Relationship between references, author dan keyword in Antimicrobial Stewardship

There are 3 groups shown in the Three Field Plot figure. The left section illustrates the reference structure of the bibliographic data. Each node or branch in the tree may represent a particular category, source type, or topic relevant to the bibliographic data set being analyzed. In the middle there is the contribution of writers, the distribution of authors in certain fields, or relationships between writers, while in the right section, there are visualizations or information related to keywords used in studies.



Source: Authors analysis by Rstudio-Biblioshiny (2024)

Figure 6. Three field plot visualization

Figure 6. shows that six of the top seven authors who contributed to the topic of this study drew references from three studies. The first is an annual surveillance report issued by the United Kingdom Government containing progress against the UK's national action plan on antimicrobial resistance (UK Health Security Agency, 2023). Tong provides another citation that outlines the requirements for doing a qualitative study. The COREQ criteria is a comprehensive checklist comprising 32 items that aid researchers in accurately reporting crucial elements of their research, including the research team, research methodology, research context, findings, analysis, and interpretation (Tong et al., 2007). The most frequently cited reference is the 2015 guidelines issued by the World Health Organisation (WHO). These guidelines were designed to enhance awareness and comprehension of antimicrobial resistance, bolster knowledge through surveillance and research, decrease infection rates, and optimise the utilization of antimicrobial drugs (Organization WH, 2015).

The seven authors who contributed the most publications on AMS implementation often used the keywords antimicrobial stewardship, antimicrobial resistance, antibiotic stewardship, infection control, and antibiotics.

#### Overlay visualization themes in the development of antimicrobial stewardship

Overlay visualization is intended to see how patterns or relationships in scientific networks develop over time. This visualization can also help to see how the impact or popularity of a scientific work changes over time.

The visualization above shows that around 2020, studies on AMS were more associated with the topics and keywords antimicrobial stewardship, antibiotic resistance, microbiology, pharmacist, and prescription. In the following year, studies shifted regarding topics and keywords hospital admission, hospitalization, length of stay, anti-infective agent, anti-bacterial agent, tertiary care center, hospital patient, and sepsis.

In recent years, studies on AMS have covered topics that have largely examined the effect of antimicrobial agents on the success of ASP. Vancomycin and meropenem are the most frequently discussed antimicrobial agents associated with multidrug resistance. Other antimicrobial agents studied include carbapenem, ertapenem and methicillin resistant staphylococcus aerous. A study proves that with the guideline for methicillin resistant staphylococcus aerous (MRSA) infection prevention, adherence to hand washing increases (Kusbaryanto, 2018) Studies on types of germs such as klebsiella pneumonia and pseudomonas aeroginosa have also begun to look at antimicrobial resistance.



Source: Authors analysis by VOSviewer (2024)

Figure 7. Overlay visualization

## Visualization for trend topic in antimicrobial stewardship

"Trend topic" in Rstudio-Biblioshiny refers to a trending or popular topic or theme in the bibliographic data set being analyzed. This may include topics that get greater attention from researchers, recent publications that give rise to new topics, or trends in research and scientific literature.



Figure 8. Trend Topic in Antimicrobial Stewardship

In the Trend Topic image above, the size of the circle indicates the frequency with which the topic appears, the larger the circle, indicating the frequent use of the topic. While the horizontal line shows when the topic appeared in the last decade. It appears that the topics of antimicrobial stewardship program (ASP), surveillance, antibiotic prescribing and implementation of AMS are most often studied around 2019-2020. From 2021 to 2022, the most studies were on the topic of antimicrobial resistance, covid-19, antibiotics and infection control. In 2023, the most frequently researched studies are pharmacists, healthcare professionals, and antibiotic prophylaxis. The topic of study on antibiotic prophylaxis needs to be examined for the progress of an AMS program, whether its use is in accordance with expectations to reduce AMR. There is overwriting of antibiotic prophylaxis in vancomycin that can cause AMR to increase (Cabral, 2023). Specific interventions on surgical antibiotic prophylaxis guidelines are needed to encourage increased adherence to their use (Shrestha et al., 2023).

# Visualization for Future Research in the study of Antimicrobial Stewardship

VOSviewer can display keyword density by being indicated by density visualization. The higher the keyword density, describing the research topic in that field, has been widely studied. Conversely, if the density is small, it can be an opportunity for new research to be carried out. Density visualization describes the density of a term based on the brightness of the visible color (Ajinegara et al., 2022). Density can serve as a foundation for examining research concepts that are infrequently conducted and frequently conducted. If a term appears with a pale or indistinct colour, it indicates that there is currently limited study conducted on that term. Conversely, when a term has a more intense yellow hue, it indicates that extensive study has frequently been conducted on that topic (Ajinegara et al., 2022).



Source: Authors analysis by Rstudio-Biblioshiny (2024)

Figure 9. Future research visualization

Figure. 9 shows that research into AMS along with anti-infective agents and anti-bacterial agents is often conducted. Other research that is often discussed is the topic of hospital admission, antibiotic resistance, and prescription. The variety of antimicrobial agents located on the outside with a less bright color shows that this topic has not been done much research. Studies on topics that are still little

discussed can be developed and analyzed in future research. The topic of study on germ types, such as pseudomonas aeruginosa, klebsiella pneumonia, clostridioides difficile, as well as studies that study antimicrobial types, such as carbapenem, ertapenem, cefoxitin, amikacin, piperacillin, doxycycline, deserves to be a study of the success of an AMS program in the present and the future.

# Visualization for thematic revolution in antimicrobial stewardship

The "thematic revolution" in Rstudio-Biblioshiny refers to a major change or revolution in a theme or topic that appears in a bibliographic data set. This could include a sudden change in research focus, a new trend in the academic literature, or a paradigm shift within a field.



Source: Authors analysis by Rstudio-Biblioshiny (2024)

#### Figure 10. Thematic Revolution Visualization

As seen in figure 10. Thematic Revolution, the theme in 2019 to 2020 is about human, hospital patient and practice guidelines. The evolution of the theme in 2021 and 2023 shifts to antimicrobial stewardship, vancomycin, human and physician.

The study of vancomycin is widely discussed because the resistance rate to enterococcus germs is difficult to control (Bansal et al., 2023; Masoudifar et al., 2021; Abdallah et al., 2021; Fukushige et al., 2022; Tang et al., 2023). A study showed that vancomycin resistant enterococcus (VRE) did not change statistically significantly, but was the highest in 2020 compared to 2018 and 2019. The rise in broad-spectrum cephalosporin prescriptions may partly explain the increase in VRE infections (Fukushige et al., 2022). However, there are studies showing that the VRE rate dropped from 43.5% in Jan–June 2016 to 12.2% in July–Dec 2021 after AMP was implemented (Bansal et al., 2023).

The study of AMS from year to year shows an increase in the number of publications, in 2019 there will be 77 publications, in 2023 there will be 138 publications. This shows that AMS is still considered interesting to write because its implementation is still not optimal. Some studies show that with the Antimicrobial Stewardship Program (AMP) the rate of antibiotic use decreased by 12% in 30 days (Tonazzi et al., 2022). Another study revealed that with AMS, there was an improvement in the quality of handling infection cases, the use of antibiotics, and germ patterns.

However, there are several studies that show the unsuccess of an AMS program running in hospitals. A study showed that the prevalence of antimicrobial use in hospitals as a whole did not differ in the 2011 and 2015 evaluations (Magill et al., 2021). The prevalence of antimicrobial resistance is increasing across Latin America. It is crucial to comprehend the progress of antimicrobial stewardship programmes and the obstacles to successfully implementing ASP due to the scarcity of action plans or national policies to encourage ASP in the region (Lazure et al., 2022). On the other hand, AMR is increasing, but the development process of new antimicrobial drugs has slowed down (Dhingra et al.,

2020). Investing in research and development of new antimicrobial agents is critical to tackling antimicrobial resistance. This includes exploring alternative treatment options and developing new classes of antibiotics. The research conducted by Breijyeh and Karaman explores potential strategies for creating innovative types of antibiotics that can effectively combat bacterial diseases in humans, without encountering any pre-existing resistance. This is achieved through the utilization of advanced techniques such as nanotechnology and computational methodologies (Breijyeh & Karaman, 2023).

Many studies have been conducted to look at barriers to AMS implementation in hospitals and healthcare. Non-compliance of clinicians in implementing AMS is a lack of knowledge, attitudes, and practices regarding antibiotics among medical practitioners (Dhingra et al., 2020). Another study found that prescribers' confidence in their ability to use antibiotics appropriately contradicted the low level of knowledge of antibiotic use in this group of physicians (Domche Ngongang et al., 2021). Among health professionals, differences in knowledge and beliefs regarding antibiotic stewardship vary widely. These differences will affect their abilities, behaviors, and contributions to the collaboration and performance of healthcare teams (Herawati et al., 2021).

Other barriers to AMS implementation include lack of management support, competition among professionals, and poor laboratories. Infection Program Control also plays a role in supporting the implementation of AMP so that germ resistance can be reduced (Aika & Enato,2022) Another study reveals that barriers affecting AMS efficacy are a lack of human resources, reluctance to follow clinical practice guidelines, and limited availability of diagnostic microbiology laboratory services (Kotwani & Gandra, 2023).

The doctor's perspective on AMS also plays an important role in the success of ASP. Doctors have misconceptions about the rational use of antibiotics. Perceptions of antibiotic management programs remain poor (Atif et al., 2021; Alghamdi et al., 2020). antimicrobial stewardship measures (AMS) have been introduced in the UK, resulting in a reduction in antibiotic prescribing. However, there is still significant variability in antibiotic prescribing within the UK, and certain healthcare organizations continue to have high rates of antibiotic prescriptions (Borek et al., 2019). There are even studies showing that although awareness of AMS increases after implementation, many clinicians are skeptical of its benefits (Ayton et al., 2022). This further understanding of the different ASP application perspectives will provide information on possible ways to improve ASP applicability across clinical roles (Tjilos et al., 2023).

The need for education and training for professionals is critical to the success of AMP (Saleem et al., 2019; Lazure et al., 2022; Tahoon et al., 2020; Turner et al., 2023). The implemented educational program was successful in improving the knowledge, attitude, and practice of HCPs (Tahoon et al., 2020). Further incentives should be taken into account to solve perceived systemic obstacles (Lazure et al., 2022).

In addition, policies from hospital leaders also play a major role in the success of AMP. Strengthening regulatory policies as well as leadership commitment in creating a culture that supports *antibiotic stewardship*, as well as ensuring staff are given adequate time for *antibiotic stewardship* efforts (Saleem et al., 2022; Carrico et al., 2018; Appaneal et al., 2019). Implementing crucial techniques, such as conducting proactive evaluations of management performance and providing constructive feedback, will facilitate the establishment and growth of the hospital ASP (Hayat et al., 2020).

The study that has become the most referenced is a study on increasing the number of germ resistance when handling COVID-19 patients in the ICU. Prone position, presence of personal protective equipment (PPE), and contact with health workers are thought to contribute to increased CRE colonization (Tiri et al., 2020) Another study that became the second most references also showed an increase in vancomycin, ceftriaxone, and carbamapene resistance. Factors thought to influence this resistance are prolonged hospitalization, mechanical ventilation and steroid use (Kubin et al., 2021). Understandably, both studies scored the highest citations because the researchers wanted to look at the factors that influence the unsuccess of an AMS program to control antimicrobial resistance.

Judging from the number of publications by country, the United States and the United Kingdom are two countries that are productive in writing studies on antimicrobial stewardship. This can be understood because the United States through government policy, issued regulations on antimicrobial stewardship in 2007 (Majumder et al., 2020), reaffirmed by the Centers for Disease Control and Prevention (CDC) asking all hospitals in the United States to implement AMS programs to encourage hospitals to achieve the goal of reducing antimicrobial resistance (Pollack et al., 2014). In 2013, the United Kingdom implemented a five-year national strategy to address the issue of antimicrobial resistance. The primary objective of this strategy is to impede the progression and dissemination of antibiotic resistance (Johnson et al., 2015).

Judging from the visualization of co-occurrence, overlay, and future research (VOSviewer), it appears that the topics that became studies in early 2019-2020 were studies with the keywords antimicrobial stewardship, antibiotic resistance, anti-infective agent, anti-bacterial agent, hospital admission, length of stay, infection control.

In the following years, the trend of research shifted regarding the type of antimicrobial that is resistant to certain germs. Among these vancomycin, meropenem, ceftriaxone, and others, are associated with germs such as clostridiodes difficile, klebsiella pneumoniae and pseudomonas aeruginosa. All of these topics can be recommended for future research. Future studies can focus on the discovery of novel antibiotics and treatment methods, as well as the formulation of innovative techniques to control the spread of antimicrobial resistance. Some of the newly approved antimicrobial agents include delafloxacin, lefamulin, and meropenem-vaborbactam (Stegemann & Trost, 2023).

Not much different from the trend analysis of topics and thematic revolutions in Rstudio-Biblioshin software, topics found in visualization can provide valuable insight into developments and shifts in research in a particular field over time. A topic that has not received much attention and can be used as a reference topic in the future is the topic of using prophylaxis antibiotics. Compliance from health professionals is required to prevent widespread antimicrobial resistance (Shrestha et al., 2023). Another topic that can still be used today is the role of pharmacists and health professionals in AMS implementation. Both play a major role in the success of an AMS program to reduce AMR. *Hospital pharmacists* in Europe stand ready to fight for infection prevention and contribute and promote the judicious use of antimicrobials through *antimicrobial stewardship* (AMS) (Abuhamda et al., 2023).

Steps required for intervention for an AMS success are quality improvement, multidisciplinary team involvement, auditing, development of tools for prescribing audits, providing training, and increasing staff time availability to run AMP (Borek et al., 2019). It requires the development of antibiotic use guidelines, strict laws regarding the use of antibiotics, and active participation of *health* professionals in order for an antimicrobial stewardship program to work properly (Atif et al., 2021).

#### Conclusion

The implementation of the antimicrobial stewardship program can run well in health services or hospitals if the system is also implemented properly. It requires high commitment from the government, hospital leaders, and all staff involved in it. Adequate facilities, education and training, and evaluation carried out are also important.

This study examines and summarizes the results of research in the last five years to be used as a reference topic for the implementation of antimicrobial stewardship. We conduct literature reviews to identify relevant studies and summarize the evidence. We use Vosviewer and Rstudio-Biblioshiny software programs to analyze research trends in the last five years and discuss keywords or topics that are often used as studies or that are still rarely used as research topics.

Journal readers and researchers will be more likely to develop meaningful future research on our recommended topics and topics needed for health regarding the implementation of antimicrobial stewardship to reduce widespread antimicrobial resistance.

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