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(REVIEW ARTICLE)

Trends of research on antibiotic prophylaxis and surgical site infection: A bibliometric review based on VOS viewer by Scopus database

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Abstract

Studies on prophylactic antibiotics and surgical site infection have been widely carried out by researchers, with various focuses and approaches. However, still more needs to be done using a bibliometric study approach. The study used 711 Scopus databases and a wide variety of bibliometric indicators such as publication trends, citations, and author keywords. Bibliometric graphic visualization using VOSviewer software is also presented. The results show that there are 200 concepts divided into four research themes' the latest topics agreed to adverse events, postoperative operations, and prescriptions. Meanwhile, issues and topics still need to be addressed related to oral drug administration, clinical practice, and guideline adherence. The bibliometric study helps provide a comprehensive and in-depth view of antibiotic prophylaxis and surgical site infection-themed research to researchers interested in discovering new knowledge and topics in this field.

Keywords: Antibiotic Prophylaxis; Surgical Site Infection; Scopus; Publication Trend; VOSviewer

1. Introduction

Many researchers with various focuses and approaches have studied prophylactic antibiotics and surgical site infections. Still, a few have been carried out using a bibliometric study approach. Usually, previous studies are studied empirically through field data using qualitative and quantitative methods. Prophylactic antibiotics are antibiotics given to minimize infectious complications resulting from an infectious process [1]. The Centers for Disease Control and Prevention defines surgical site infection (SSI) as an infection that develops within 30 days of surgery or surgical wound infection surveillance performed within 90 days of surgery when implants are placed. It is categorized into three levels (superficial incision, deep incision, and organ or space infection), contributing significantly to surgical morbidity and mortality each year [2]. Prevention of surgical wound infections includes careful surgical techniques, timely administration of preoperative antibiotics, and various preventive measures to neutralize the threat of bacterial, viral, and fungal contamination by the operating staff, operating room environment, and patient environment [3]. The administration of prophylactic antibiotics to patients must be given in by the administrative rules set based on the guidelines for prophylactic antibiotic administration [4]. In a study on giving prophylactic antibiotics for an operative procedure, it was shown that prophylactic antibiotics could reduce the incidence of surgical site infection [5]. Other studies also state that prophylactic antibiotics can reduce the incidence of SSI. Antibiotics are given to 73.3% of patients, especially postoperatively (58.3%). The most frequently prescribed antibiotics were cefotaxime (80.7%), metronidazole (63.5%), cefradine (13.6%), and amoxicillin/clavulanate (11.6%) [6].

However, another study stated that the prevalence of SSI was relatively high even though most surgical patients were given prophylactic antibiotics. The presence of comorbidities, class of contaminated and dirty wound, no prophylactic

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antibiotics, administration of prophylactic antibiotics between 1 hour and 2 hours before incision, and duration of 48 hours of surgical prophylactic antibiotics were significantly associated with SSI [7]. The effectiveness of prophylactic antibiotic administration is still being debated, and more research is needed regarding its impact on its administration.

This study aims to identify and summarize relevant articles, show research trends, grow the literature, and analyze information on prophylactic antibiotics and surgical site infections. The information presented in this study provides a consistent picture of trends in antibiotic prophylaxis and surgical site infection, encouraging readers and researchers to analyze the information for their prospective studies. This study suggests that a bibliometric review approach can significantly contribute to the prophylactic use of antibiotics against surgical site infections.

2. Research Method

The data was collected from the Scopus database with the keywords “Antibiotic prophylaxis” and “Surgical site infection” (n=3993). The next step is to limit the search for publications by year, i.e., from 2017 to 2022 (n=1762). The next step is to determine the search based on the research subject area, namely medicine, nursing, health professions, multidisciplinary, and density (n=1692). Then limit the search with Open access (n=733). The final step is to restrict searches to English (n=711). The next step was to analyze the data using VOSviewer software version 1.6.18. Keywords and search restrictions in the form : (TITLE-ABS-KEY (antibiotic AND prophylaxis) AND TITLE-ABS-KEY (surgical AND site AND infection)) AND PUBYEAR > 2016 AND (LIMIT-TO (SUBJAREA , "MEDI") OR LIMIT-TO (SUBJAREA , "NURS") OR LIMIT-TO (SUBJAREA, "DENT") OR LIMIT-TO (SUBJAREA "HEAL") OR LIMIT-TO (SUBJAREA, "MULT")) AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (LANGUAGE, "English")).

3. Results

The graph above shows the pattern of scientific publications by year. In the chart, there is an increasing trend in the number of studies from year to year; in 201,7, there were 93 studies; in 2018, there were 104 studies; in 2019 there were 115 studies; in 2020, there were 115 studies; in 2021 there were 155 studies, and in 2022 there are 129 studies. The highest number of publications was found in 2021 (155).

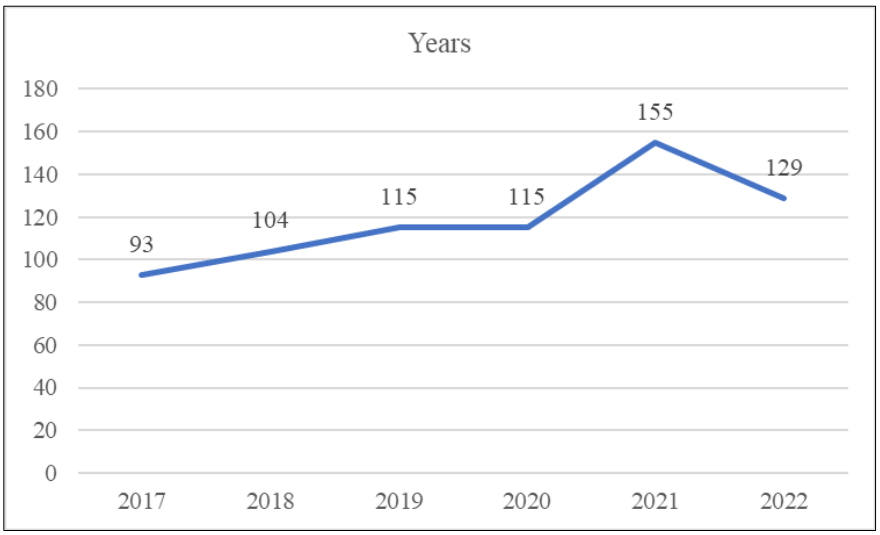

Figure 1 Number of publications by year

Figure 2 shows the distribution map where the data was taken, showing the most developed countries, including the United States with 185 studies, the United Kingdom with 69 studies, Italy with 66 studies, Switzerland with 39 studies, the Netherlands with 38 studies, China with 37 research, Australia 35 research, and so on.

In the affiliation data, there were 160 affiliations in all studies; of the 160 affiliations, there were affiliations with the highest number, including Harvard Medical School with 25 studies, Università degli Studi di Napoli Federico II 15 studies; Karolinska Institutet published 13 studies; Università degli Studi di Perugia, Azienda Ospedaliero - Universitaria di Parma, Fondazione Policlinico Universitario Agostino Gemelli IRCCS published 12 studies; Amsterdam UMC - University of Amsterdam published 11 studies related to antibiotic prophylaxis and surgical site infection.

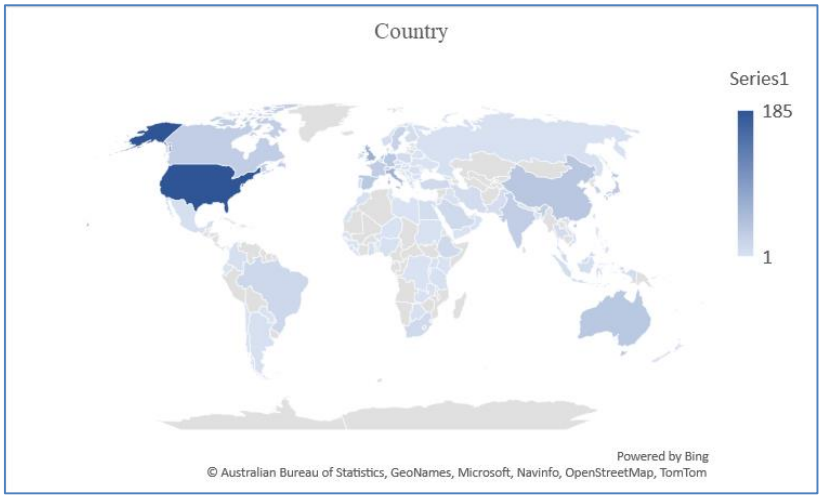

Figure 2 Distribution of publication publishing by countries

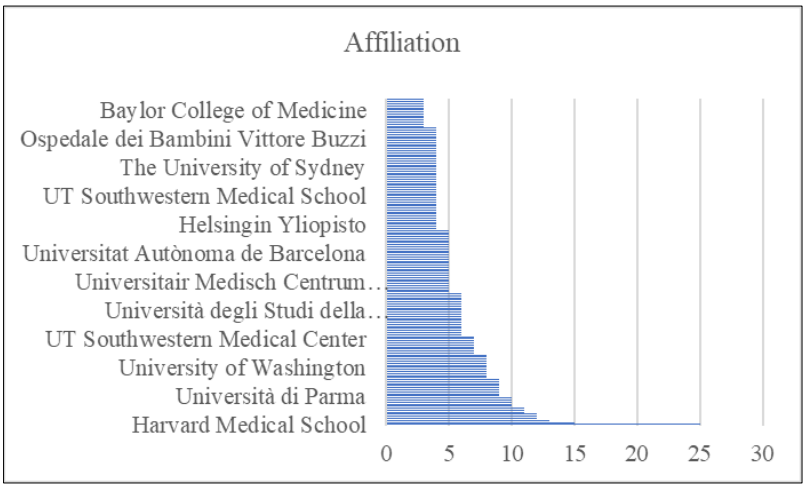

Figure 3 Research affiliation

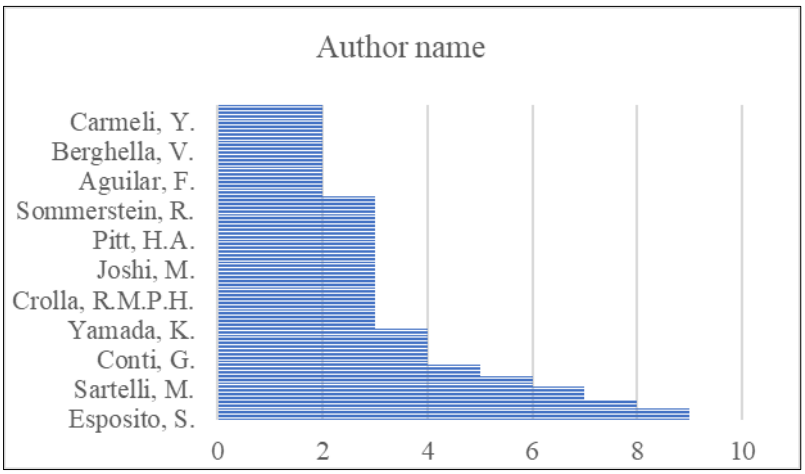

Figure 4 The most frequent researchers

In Figure 4, 159 authors contributed to the entire study. Several authors with high publication numbers related to antibiotic prophylaxis and surgical site infection, including Esposito, S; Harbarth, S; Lancella, L; Rigotti, E; Staiano, A; Venturini, E, with nine published studies. Badia, J.M; Bianchini, S; Monaco, S; Nicoletti, L with the three published studies.

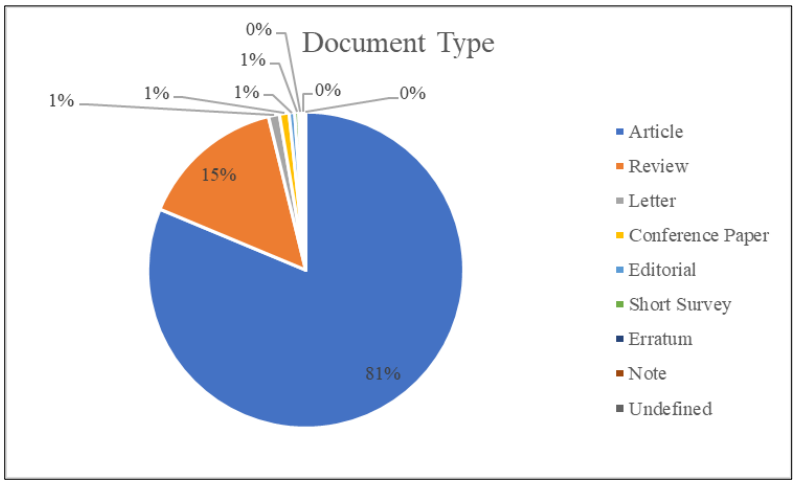

Figure 5 Distribution of document types of research publications

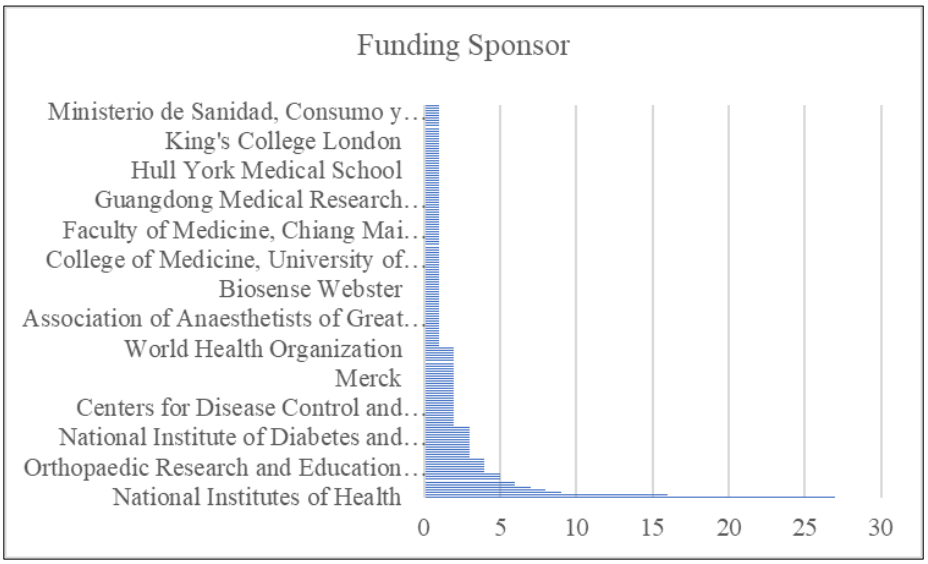

Figure 6 Distribution of research funding sponsors

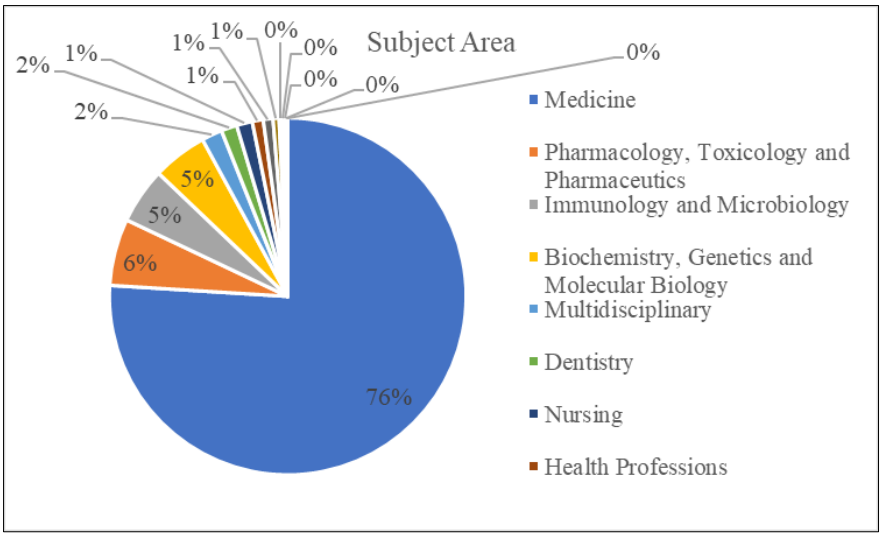

Figure 7 Distribution of research by field of research

From the data collected, it was found that there were several types of documents published by all researchers out of a total of 711, 81% (578) were of the kind of research articles, 15% (106) were of the type of research reviews, 1% (8) were of the kind of letters, conference papers, editorials, short surveys.

Figure 6 shows the number of publications based on sponsor funding. The publication sponsors most frequently found in the 711 publications were the National Institutes of Health (2the 7), National Center for Advancing Translational Sciences (16), National Institute for Health Research (9), Pfizer (8), Japan Society for the Promotion of Science (7). Sponsors with the least funding include Ministerstvo Zdravotnictví Ceské Republiky (1), Ministero dell'Istruzione, dell'Università e della Ricerca (1), Ministerio de Sanidad, Consumo y Bienestar Social (1) and so on.

Figure 7 shows an overview of scientific fields extensively researched about antibiotic prophylaxis and surgical site infection. The most researched subject areas are medicine (690), Pharmacology (55), Immunology (46), Biochemistry, Genetics and Molecular Biology (45), Engineering (29), and so on.

Table 1 Citations of publications by subject area

Title	**Authors and years**	**Source**	**Subject Area**	**Cited by (n)**
Centers for disease control and prevention guideline for the prevention of surgical site infection, 2017	(Berriós-Torres et al., 2017)[1]	JAMA Surgery 152(8), pp. 784-791	*Medicine*	1339
The Impact of a Reported Penicillin Allergy on Surgical Site Infection Risk	(Blumenthal et al., 2018)[2]	Clinical Infectious Diseases 66(3), pp. 329-336		185
Surgical site infection after gastrointestinal surgery in high-income, middle-income, and low-income countries: a prospective, international, multicentre cohort study	(Bhangu et al., 2018)[3]	The Lancet Infectious Diseases 18(5), pp. 516-525		177
Association of Duration and Type of Surgical Prophylaxis with Antimicrobial-Associated Adverse Events	(Branch-Elliman et al., 2019)[4]	JAMA Surgery 154(7), pp. 590-598		109
Prevention of surgical site infections: A systematic review of cost analyses in the use of prophylactic antibiotics	(Purba et al., 2018)[5]	Frontiers in Pharmacology 9(JUL),776	Pharmacology, Toxicology, and Pharmaceutics	27
Preoperative patient preparation in enhanced recovery pathways	(Iqbal et al., 2019)[6]	Journal of Anaesthesiology Clinical Pharmacology 35(5), pp. 14-23		17
Surgical site infections following instrumented stabilization of the spine	(Dapunt et al., 2017)[7]	Therapeutics and Clinical Risk Management 13, pp. 1239-1245		15
Optimizing compliance with surgical antimicrobial prophylaxis guidelines in patients undergoing gastrointestinal surgery at a referral teaching hospital in	(Mahmoudi et al., 2019)[8]	Infection and Drug Resistance 12, pp. 2437-2444		13

southern Iran: Clinical and economic impact				
Point prevalence study of antimicrobial use among hospitals across Botswana; findings and implications	(Anand Paramadhas et al., 2019)[9]	Expert Review of Anti-Infective Therapy 17(7), pp. 535-546	Immunology and Microbiology	35
Ongoing initiatives to improve the use of antibiotics in Botswana: University of Botswana symposium meeting report	(Tiroyakgosi et al., 2018)[10]	Expert Review of Anti-Infective Therapy 16(5), pp. 381-384		16
Supporting global antimicrobial stewardship: Antibiotic prophylaxis for the prevention of surgical site infection in low-and middle-income countries (LMICs): A scoping review and meta-analysis	(Cooper et al., 2020)[11]	JAC-Antimicrobial Resistance 2(3),dlaa070		14
Preoperative penicillin allergy testing in patients undergoing cardiac surgery	(Plager et al., 2020)[12]	Annals of Allergy, Asthma, and Immunology 124(6), pp. 583-588		12
Adhering to a national surgical care bundle reduces the risk of surgical site infections.	(Koek et al., 2017)[13]	PLoS ONE 12(9),e0184200	Biochemistry, Genetics, and Molecular Biology	29
Antibiotic prophylaxis for surgical site infections as a risk factor for infection with Clostridium difficile	(Balch et al., 2017)[14]	PLoS ONE 12(6),e0179117		28
Intestinal microbiota in colorectal cancer surgery	(Koliarakis et al., 2020)[15]	Cancers 12(10),3011, pp. 1-23		15
Comparison of Prophylactic Intravenous Antibiotic Regimens After Endoprosthetic Reconstruction for Lower Extremity Bone Tumors A Randomized Clinical Trial	(Alhajeri and Shah, 2019)[16]	JAMA Oncology 8(3), pp. 345-353		12

The table above is based on the most cited subject areas from medicine subjects with the Centers for disease control and prevention guidelines for the prevention of surgical site infection [1], which have been cited 1339 times, The Impact of a Reported Penicillin Allergy on Surgical Site Infection Risk which has been cited 185 times.

Using VOSviewer, an analysis was carried out by theme (Figure 9) and year of publication (Figure 10). Identification in the form of mapping in the figure above can help researchers, especially those just starting their research from scratch. When they find an exciting topic in a particular field, they can read articles related to it with the help of this research.

After analyzing the data, 4 clusters mapped the topics of Hospital Quality and Mobile Applications. The clusters' number, theme, and color are differentiated using a network visualization from VOSviewer. Of the total themes, all clusters (200) are composed of cluster 1 (79), cluster 2 (50), cluster 3 (41), and cluster 4 (30). The clusters are loaded and described in Table 2.

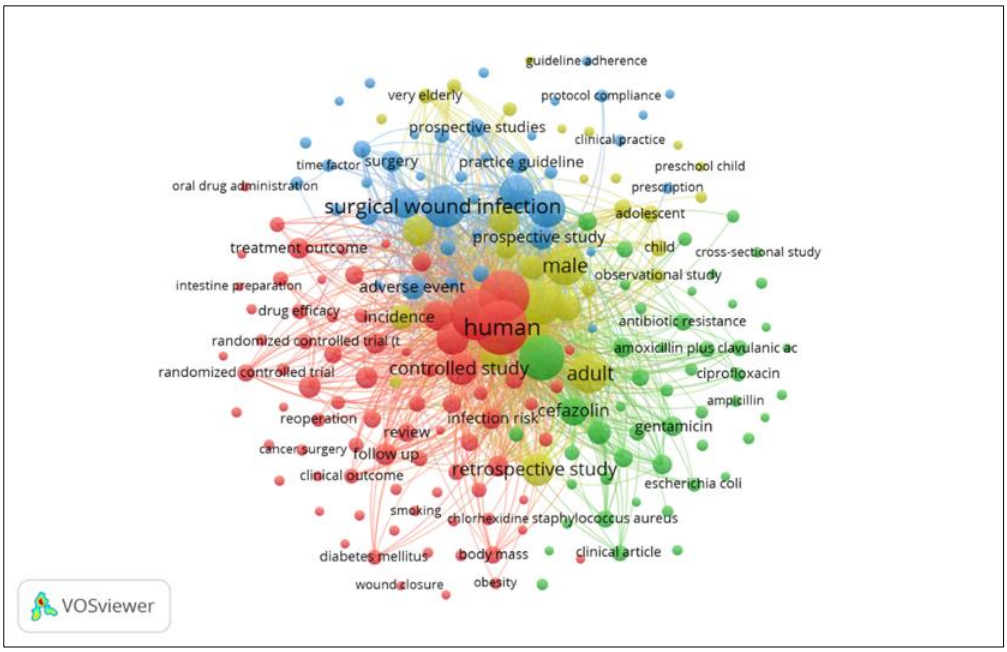

Figure 8 VOSviewer Network Visualization

Table 2 Theme cluster

Cluster	Theme	Total in % (n=300)
Cluster 1	Antibiotic prophylaxis, surgical site infection, antibiotic therapy, blood transfusion, cancer surgery, colorectal surgery, drug efficacy, human, laparoscopic surgery, laparotomy, length of stay, prevention, postoperative period, postoperative infection	79 Item
Cluster 2	Amikacin, amoxicillin, ampicillin, antibiotic resistance, antimicrobial stewardship, antibiotic sensitivity, cefazolin, cefotaxime, cefuroxime, ceftriaxone, ciprofloxacin, cotrimoxazole, meropenem	50 Item
Cluster 3	The cardiac surgical procedure, appendectomy, clinical practice, clinical trial, drug administration, multicenter study, infection control, prescription, procedure	41 Item
Cluster 4	Adolescent, adult, male, female, infant, child, middle-aged, young adult, very elderly, preschool child, incidence, retrospective study, cohort study, neurosurgery	30 Item

In cluster 1, the related concepts consist of Antibiotic prophylaxis, surgical site infection, antibiotic therapy, blood transfusion, cancer surgery, colorectal surgery, drug efficacy, human, laparoscopic surgery, laparotomy, length of stay, prevention, postoperative period, and postoperative infection. In cluster 2, there is more pressure on the type of antibiotics such as Amikacin, amoxicillin, ampicillin, antibiotic resistance, antimicrobial stewardship, antibiotic sensitivity, cefazolin, cefotaxime, cefuroxime, ceftriaxone, ciprofloxacin, cotrimoxazole, meropenem. Cluster 3 contains related procedures such as Cardiac surgical procedure, appendectomy, clinical practice, guideline adherence, drug administration, infection control, prescription, and procedure. Cluster 4 provides an overview of the research subjects. It consists of Adolescent, adult, male, female, infant, child, middle-aged, young adult, very elderly, preschool child, and incidence.

In cluster 1, a related study is the topic of antibiotic prophylaxis, a relevant article that can be used as a reference is a study that states that prophylactic antibiotics given to breast surgery patients are effective in reducing the incidence of infection, thereby reducing the length of stay in the hospital[17]. At the same time, research with the topic of surgical

site infection as a relevant reference is research that explains the risk factors for surgical site infection, such as wound contamination, duration of surgery, type of surgery, use of antibiotics use,d including ceftriaxone, ciprofloxacin[18].

In cluster 2, the type of antibiotic used must be tested for resistance to provide the best effectiveness[19], entitled "High rates of multi-drug resistant gram-negative organisms associated with surgical site infections in a teaching hospital in Ghana." In a study conducted in Ghana, hospitals should carry out routine antibiotic resistance tests because antibiotic resistance is rapidly increasing and developing, one of which is antibiotic resistance against gram-negative bacteria. This is relevant to the study entitled "Surgical antibiotic prophylaxis in an era of antibiotic resistance: common resistant bacteria and wider considerations for practice," which states that antibiotic resistance is increasing rapidly globally. It must be overcome by carrying out resistance tests routinely in the hospital[20].

Another study showed that 82.40% of surgical patients were given prophylactic antibiotics of different types; the most widely used antibiotics were ceftriaxone at 28.44%, metronidazole at 26.36% and the rest were other types of antibiotics[21].

In cluster 3, related to the surgical procedure performed, prophylactic antibiotics and surgical site infection are affected by the type of surgery performed [22]. In abdominal surgery, the antibiotics often given are cefotaxime, metronidazole, cefradine, and amoxicillin/clavulanate. In orthopedic surgery, the antibiotic often prescribed is amikacin[23].

Cluster 4 describes the subject of research on prophylactic antibiotics and surgical site infections. Patients with a higher age have a greater risk of playing a role in the incidence of surgical site infection[24]. A study states that there is a relationship between gender and the incidence of surgical site infection in gastric cancer surgery[25].

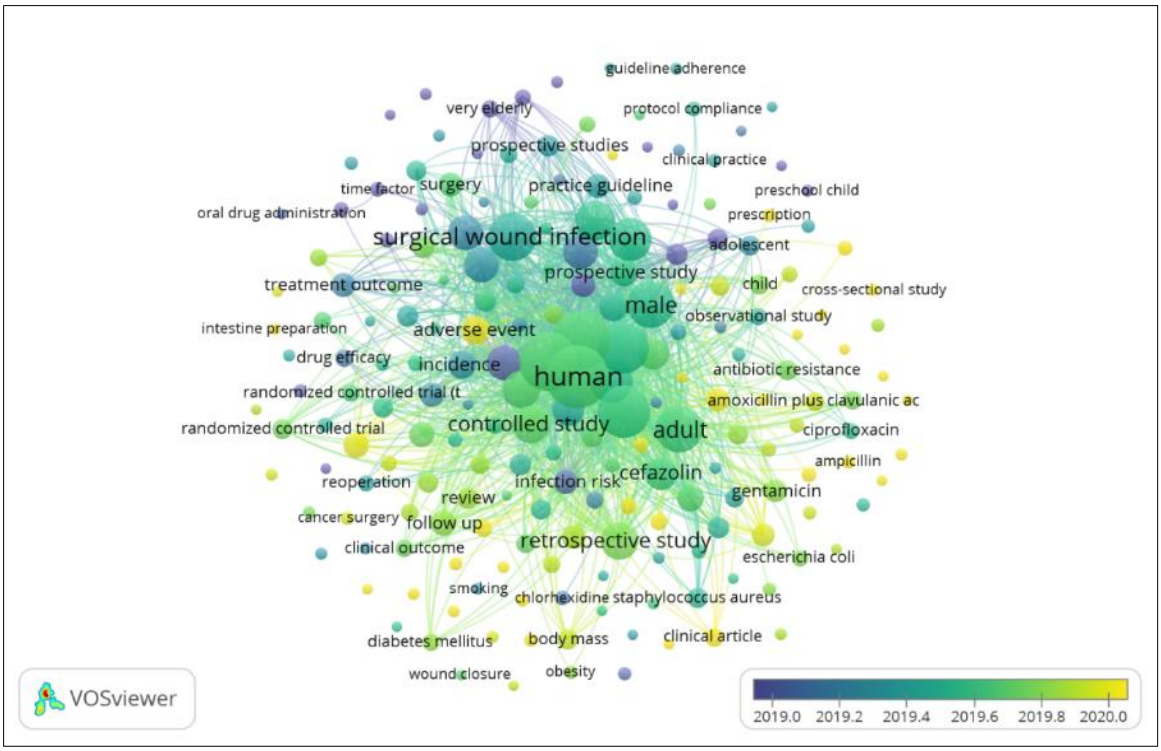

Figure 9 VOSiewer Overlay Visualization

Figure 9 shows a visualization of the publication theme used by year. The publication themes that tend to be new are adverse events, postoperative operations, prescriptions, treatment outcomes, antimicrobial stewardship, and hospitalization. In connection with the topic of adverse events mentioned in a research study regarding the side effects of prophylactic antibiotics, side effects that occur when prophylactic antibiotics are given not according to the time specified in the guidelines include the incidence of surgical site infection, acute kidney injury, clostridium difficile infection [4].

Meanwhile, themes studied for a long time include antibiotic prophylaxis, microbiology, infection risk, chlorhexidine, young adults, and risk reduction.

Figure 10 VOSviewer Density Visualization

Figure 10 is the Density Visualization of all publications with themes often found in the 711 publications. The analysis results show that themes such as human, adult, controlled study, surgical wound infection, prospective study, and incidence are often raised as research themes. In comparison, the themes that are rarely raised include oral drug administration, clinical practice, adherence to guidelines, protocol compliance, and clinical practice.

Table 3 Publication with the highest citation

Document Title	Author and Years	Source	Cited by (n)
Centers for disease control and prevention guideline for the prevention of surgical site infection, 2017	(Keely Boyle, Rachala, and Nodzo, 2018)[26]	JAMA Surgery 152(8), pp. 784-791	1339
The Impact of a Reported Penicillin Allergy on Surgical Site Infection Risk	(Blumenthal et al., 2018)[2]	Clinical Infectious Diseases 66(3), pp. 329-336	185
Surgical site infection after gastrointestinal surgery in high-income, middle-income, and low-income countries: a prospective, international, multicentre cohort study	(Bhangu et al., 2018)[3]	The Lancet Infectious Diseases 18(5), pp. 516-525	177
Association of Duration and Type of Surgical Prophylaxis with Antimicrobial-Associated Adverse Events	(Branch-Elliman et al., 2019)[4]	JAMA Surgery 154(7), pp. 590-598	109
Prevention of periprosthetic joint infection	(Parvizi, Shohat and Gehrke, 2017)[27]	Bone and Joint Journal 99B(4), pp. 3-10	94
Timing of preoperative antibiotic prophylaxis in 54,552 patients and the risk of surgical site infection	(De Jonge et al., 2017)[28]	Medicine (United States) 96(29),e6903	78
The Role of Oral Antibiotic Preparation in Elective Colorectal Surgery: A Meta-analysis	(Rollins et al., 2019)[29]	Annals of Surgery 270(1), pp. 43-58	74

4. Discussion

The risk factors associated with surgical site infection are operating room conditions, including microbial contamination, temperature and humidity, air renewal, and differential air pressure. Factors of age, gender, comorbidity, nutrition status, and transfusion [30]. Prevention of surgical wound infections includes careful surgical techniques, timely administration of preoperative antibiotics, and various preventive measures to neutralize the threat of bacterial, viral, and fungal contamination by the operating staff, operating room environment, and patient environment [31]. Giving prophylactic antibiotics to patients can reduce the incidence of surgical site infection; several studies have proved this. They give antibiotics to patients before surgery to decrease surgical site infections [32]. A systematic review also stated that administering prophylactic antibiotics to surgical patients can reduce surgical site infections, reducing treatment time and more efficient treatment costs [33].

In the case of a surgical site infection in gastrointestinal surgery, a surgical site infection occurs due to the antibiotic resistance used in administering prophylactic antibiotics [34]. The timing of antibiotic administration can also affect the efficacy of the prophylactic antibiotics given [28]. Giving prophylactic antibiotics to patients is still debatable; research shows that prophylactic antibiotics can have side effects, but not a few studies have shown that giving prophylactic antibiotics has a good impact on patients. Hence, the number of surgical infections decreases.

5. Conclusion

In data collection, there were 711 studies related to "antibiotic prophylaxis and surgical site infection." of the total, four dominant research subjects were Medicine, Toxicology and Pharmaceutics, Immunology and Microbiology, Biochemistry, Genetics, and Molecular Biology.

Analysis using VOSviewer shows that 400 concepts are relevant to the research topic and are divided into four research topic clusters, research topics that tend to be new, namely regarding adverse events, post-operative operations, and prescriptions. At the same time, the research that is most often raised is the topic of a human, controlled study, incidence. While rarely raised in research are topics related to oral drug administration, clinical practice, guideline adherence, protocol compliance, and clinical practice.

The highest number of studies per this theme is in 2021, as many as 155. Meanwhile, the country that has conducted the most research on this theme is the United States, with a total of 185 studies. Many research affiliates with this theme are affiliated with Harvard Medical School as many as 25 studies. The researchers who conducted the most research on this theme were Esposito, S; Harbarth, S; Lancella, L; Rigotti, E; Staiano, A; Venturini, E, with nine published studies. Funding on this research theme was also most widely funded by the National Institutes of Health, with 27 researchers. The most scientific fields were in the fieinuse of prophylactic antibiotics related to surgical site infections still needs to be further investigated, and how the method of administration and the time of prophylactic antibiotics affect their effectiveness in reducing infection rates.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

We have no conflicts of interest.

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