INDIAN CONTRIBUTION TO ANTIBIOTICS RESEARCH: A SCIENTOMETRIC STUDY

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Submitted for the Award of the Degree of

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in

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Supervisor

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DECLARATION

I, hereby declare that the thesis titled **"INDIAN CONTRIBUTION TO ANTIBIOTICS RESEARCH: A SCIENTOMETRIC STUDY"** has carried out by me under the supervision of **DR. M.P. SINGH**, Professor, DLIS, BBAU, Lucknow for the award of the degree of Doctor of Philosophy (Ph.D.) in Library and Information Science is an outcome of my efforts and with best of my knowledge, it is an original work. I, declare that the content of this thesis did not form a basis for the award of any previous degree or diploma to this or any other university. Further, I undertake that the thesis is essentially free from all kinds of plagiarism and the sources used in this study have been duly acknowledged.

I hereby also undertake that the thesis submitted by me to Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow satisfies all the requirements as stipulated in the *Doctor of Philosophy (Ph.D.) Regulations - 2016 as amended in 2017* and it is fit for the submission and evaluation for the award of the degree of Doctor of Philosophy in Library and Information Science of the University.

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CERTIFICATE

This is to certify that the thesis titled "**INDIAN CONTRIBUTION TO ANTIBIOTICS RESEARCH: A SCIENTOMETRIC STUDY**" submitted by **Mr. Vijay Kumar Bharati** is an original research work and has not been previously submitted in part or full for the award of any other degree or diploma to this or any other university.

The thesis submitted to Babasaheb Bhimrao Ambedkar University Lucknow satisfies all the requirements as stipulated in the *Doctor of Philosophy (Ph.D.) Regulation - 2016 as amended in 2017* and it is fit for submission and evaluation for the award of the degree of Doctor of Philosophy of the University.

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Place: *Lucknow* ***(Vijay Kumar Bharati)***

PREFACE

Scientometrics is the field of study which concerns itself with measuring and analysing scholarly literature of science discipline. It is the most powerful technique for conducting a quantitative study of research production and technological progress of science. Generally, scientometrics term is used for quantitative analysis of science subjects while bibliometrics is used for other than science subject. It is one of the best ways in getting knowledge of scientific productivity of individual author/scientist, institution and journal. It is helpful to know the pattern of literature growth, nature of research publications, collaborative research, age of literature used and information needs of the authors. It can be also used to support the decision-making by government funding agencies and universities, identify the core competency of countries in an area of research, and help in expert selection within a field.

Antibiotics are playing a much larger role in our economy and society. Before the discovery of antibiotics, not only in India but in the world, there were many deaths from infections and bacterial diseases. Antibiotics are the biggest milestone of the twentieth century in the field of science and medicine. These medicines have been used primarily to reduce the mortality and morbidity rates of infectious and anti-bacterial diseases, including pneumonia, tuberculosis, and childhood communicable diseases. Antibiotics are used to fight diseases in humans and animals.

India is the second-largest populated country in the world, so that an attempt was made in the present study to measure the trends in various aspects of published literature in the field of antibiotics research at the Indian level, as well as global. The study of scientometrics is very popular because it helps to improve scientific documentation, information, and communication activities by quantitative analysis of library collections and services. To better understand the research contribution of India in the field of antibiotics, a scientometric study of

the Indian contribution to antibiotics research has been conducted and analysed. The thesis has been divided into the following five chapters.

CHAPTER 1: INTRODUCTION

This is a brief introductory part of the thesis, which introduces scientometrics and antibiotics. In this chapter first, scientometrics and its related terms such as bibliometrics, librametrics, and informetrics, etc. have been explained. It also gives a short description of bibliometrics law and its related formulas. The historical background of antibiotics, common antibiotics and their uses, their functions, and disadvantages, have also been elaborated in this chapter.

CHAPTER 2: REVIEW OF THE LITERATURE

In this chapter, the purposes and steps of reviewing literature have been explained. The chapter is divided into two parts: in the first part, the basics papers related to the fundamental bibliometrics and scientometrics have been reviewed and in the second part, the reputed papers related to bibliometrics study in the context of antibiotics and its allied has been reviewed. More than 100 related core research papers published in leading peer-reviewed journals indexed by Scopus, Web of Science and PubMed, etc. databases have been reviewed and arranged chronologically in increasing order. For references and in-text citation, Publication Manual of the American Psychological Association (APA) 7th edition has been used with little modifications as and when necessary.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

This chapter gives a blueprint of the research work, like formulation of the research problem, objectives, scope and limitations, hypothesis formation, methods of data collection, data sorting, data analysis and data interpretations. Applicability of fundamental bibliometrics laws and their related formulas, such as relative growth rate (RGR) and doubling time (DT), activity index, degree of collaboration (DC), collaboration index (Cl), Lotka's law, Bradford's law of

scattering of journals and an overview of Vosviewer, biblioshiny, etc. have also been elaborated in this chapter.

CHAPTER 4: DATA ANALYSIS AND INTERPRETATION

In this chapter, the data retrieved from Scopus databases on antibiotics research from 2011 to 2020 have been analysed on the basis of certain formulas with the help of MS-Excel, Vosviewer, and Biblioshiny software. The analysis has been taken based on objectives and their interpretations were done using statistical formulas. The tables and graphs are created based on data analysis. Some bibliometrics laws, such as Lotka's law, Bradford's law of scattering of journals, have also been applied to measure the research output. Further, hypotheses have also been tested with the help of statistical formulas such as the z-test, f-test, t-test, and chi-square test.

CHAPTER 5: FINDINGS, CONCLUSION AND SUGGESTIONS

This chapter made up findings, conclusion, suggestions, and area of further studies. Findings are a collection of summarized form of data interpretations, which are based on previous chapter-4. After findings, the conclusion, suggestions, and areas for further research have been stated in this chapter.

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LIST OF ABBREVIATIONS

Abbreviations	Full Name
AGR	Annual Growth Rate
AHCI	Arts and Humanities Citation Index
AI	Activity Index
AMR	Antimicrobial Resistance
APA	American Psychological Associations
CI	Collaborative Index
DC	Degree of Collaboration
DF	Degree of Freedom
DT	Doubling Time
EXP	Expected Value
IPA	Indian Publications in Antibiotic
IPAS	Indian Publications in All Subject
IPSAT	Indian Publications Share in Antibiotic
ISI	Institute for Scientific Information
MAP	Multiple Authored Publications
NC	Number of Contribution
NEP	Number of Expected Publication
NO	Number of Author
NOP	Number of Observed Publication
OBS	Observed Value
RGR	Relative Growth Rate
SA	Single Author
SAP	Single Author Publication
SCI	Science Citation Index
SJR	Scimago Journal & Country Rank
SSCI	Social Science Citation Index
TA	Total Authors
TC	Total Citations
TMA	Total Multiple Authored
TP	Total Publications
WOS	Web of Science
WPA	World Publications in Antibiotic
WPAS	Indian Publications in All Subject
WPSAT	World Publications Share in Antibiotic

CHAPTER-1

INTRODUCTION

1.1 BACKGROUND

Literature is a term that is used to present and preserve basic information or knowledge on any subject. It means "a collection of basic theory or concept published on a particular topic or subject". The literature has played a very important role in conveying knowledge in any subject or topic, to understand and explain it to each other. Man has always been using some medium to reach his knowledge and conception to each other. Before printing press and written communication, scientists used to record their discoveries and knowledge in the form of marks on clay tablets, stones, strips, etc. The 6^{th} century BC Babylonian mentions important astronomical events such as lunar eclipses on clay tablets. There is evidence of many such mentions on clay tablets, and stones, etc. After that, the communication started by writing through Tarpatras, Bhojpatras, letters, books, etc. The famous scientist Galileo published his many discoveries through the chain of letters. Isaac Newton published his many types of astronomical concepts and theory as Philosophy Natural Principle Mathematic in 1686 in the form of book series. If seen in this way, it is known that scientists continue to make their assumptions and experiments available to us through some medium.

After the arrival of the printing press, the number of scientific literature has steadily increased and today its number has registered unprecedented growth. Scientific journals are multidisciplinary open- access gateways for the discovery of scientific knowledge and new research in the medical subject as well as other scientific fields. Scientific journals represent the collaborative efforts of many scientists and scholars of various disciplines.

According to data compiled by the US National Science Foundation (NSF), the number of scientific papers published worldwide increased from 1,755,850 in 2008 to 2,555,959 in 2018. According to the International Association of Scientific, Technical and Medical Publishers, approximately

28,000 scholarly journals collectively publish approximately two million articles each year. India is the world's third-largest producer of scientific articles after China and the USA. India published 48,998 science and engineering articles in 2008. It increased to 1,73,788 articles in 2018, with an average annual growth rate of 10.73% and the country is now 5.31 % of the total world publications in scientific publications.

It is a challenge to establish credibility among the publications of such a vast amount of scientific literature. Many times, more research is being published daily than we can read. Many journals send email notices to their subscribers when a new publication is published to their readers, which includes a table of contents and a link to each article. Through which it provides the facility to browse and quickly find the article related to your topic and it tells whether this article is an article of relevance to their work or not.

In this era of information explosion, access to standard publications is highly important, as it is a reliable published collection of scientific research or below standard publication. These publications can also be regarded as worth that enables authors to gain appreciation and credit as specialists in a particular field at national and international levels. The publication in peer-reviewed journals also provides international recognition for an individual, department, university, and institutions. Sometimes where a topic of major global importance is included in a publication, the author's country, and even the region the institution may also get a grander recognition. Scientific literature has evolved regarding specialties and target audiences. The report of new research findings is important to ground and advance novel assumptions and discoveries that may exist only through the publication of scientific journals. Although some science journals are multidisciplinary, most journals are very specialized and they publish articles related to specific scientific fields. With such many publications of scientific literature, it becomes important to refer to which scientific literature to maintain its quality and make sure the validity of the research. To recognize the research output and progress on any topic, subject, scientist and institutions, etc., we use the method of bibliometrics or scientometrics. Through this method,

in this thesis, we present a scientifically detailed numerical analysis of research output and progress of antibiotics with the help of some tools.

1.2 SCIENTOMETRICS : AN OVERVIEW

The statistical analysis of publications of scientific literature has not been a new subject since the letters of the last century; it has been studied in various forms. Scientometrics is the field of science in which individual researchers, teams, and funding, technical inputs, and quantitative aspects of scientific objects are studied based on certain principles. Its purpose is to manage science more favorably and to educate scientific phenomena and processes in new scientific research in a systematic way. Just as bibliometrics provides a numerical analysis of the research productivity of other disciplines, scientometrics works in the field of science to evaluate the scientific development, social relevance, and impact of science and technology tools. It is used as a quantitative and qualitative assessment of research productivity, scientific activity, productivity, and inter-comparison of progress. Scientometrics tools are used to collate and compare scientific activities on any institution, author, country, funding agencies, and any aspect and subject and different aspects of their publishing server. Scientometrics are also used for giving, mapping scientific networks, intellectual structure, and watching the development of scientific fields and devices. Scientometrics also empirically explores the constantly changing relationship between science, technology, and research productivity. Most of the present-day scientometrics-based work is based on the Derek J. de Sola price and Eguien Garfield's Principles

Thus, we can say that scientometrics deals with the quantitative and qualitative characteristics of science and scientific research. One of the major areas of this study is to use mathematical statistical theories to investigate the development and mechanisms of scientific literature in the concerned field. Through the study of scientometrics, policymakers are also helping to create programming settings in research activities, make decisions in research areas and library activities, as well as prioritize funding agencies, etc.

1.2.1 HISTORY OF SCIENTOMETRICS

Price, a physicist, historian of science, and information scientist and also served as an applied mathematics teacher at Raffles College in Singapore, is known as the father of scientometrics. He formulated his theory on the exponential development of science and noted the rise in the philosophical transactions of the Royal Society between 1665 to 1850 and introduced a numerical analysis. The term "Scientometrics" is invented from the Russian word "Naukometria". In 1966, the term "Naukometria", known in English as "Scientometrics", was used by Russian statistician Nalimov, to analyze quantitative methods of studying the development of science. Viewed in this way in the 1960s, particularly in Eastern Europe, the term "Scientometrics" was used to denote "measurement of the informatics process". The facts suggest that the term scientometrics originated as a Russian term for applying quantitative methods in the history of science, which studies quantitative aspects of science.

Nalimov and Mulchenko originated and defined the term "Scientometrics", state that “Scientometrics is an application of quantitative methods that relate to the analysis of science, seen as an information process".

Dobrov and Nalimov were two scientists working at the time in the field of the study of scientometrics. These two scientists were working together in Kiev and Moscow searched the possibilities and detailed work on the practical utility of scientometrics and in terms of measuring science. Mulchenko also collaborated with Nalimov, to present his views on scientometrics and explained that the application of quantitative approaches to the examination of science as an information process is known as scientometrics. Later on, this word emerged more rapidly when T. Braun began publishing a journal called ‘Scientometrics’ in 1977, which was originally published in Hungary, and now it is currently publishing from Amsterdam, the Netherlands. In this journal, the meaning of scientometrics was described in the process of communication as well as cultural aspects in the quantitative analysis of science. Eminent scientist E. Garfield also

contributed greatly to developing scientometrics and presented a practical study of it and then created the Science Citation Index (SCI).

Thus, it is clear from the above-mentioned descriptions that scientometrics is related to the quantitative features and characteristics of science and scientific research. Investigations have also found that the development and mechanism of science are studied by statistical mathematical methods. Scientometrics includes studies in the sociology of science, history of science, growth of literature behavior of scientists, science indicators, etc. Scientometrics is the sociology of science that is used for science policy-making, scientific decision-making, science development, and scientific research-related prediction.

1.2.2 VARIOUS FORM OF METRICS STUDIES

1.2.2.1 BIBLIOMETRICS

Along with scientometrics, another similar term is also used to measure research productivity, known as bibliometrics. Both methods of bibliometrics and scientometrics have been used to measure the research output of the subjects, institutions and experts.

The term bibliometrics was coined in 1969 by Alan Pritchard. A. Pritchard (1969) was first used this term in his article ‘Statistical Bibliography’ which was published in the "Journal of Documentation." Pritchard (1969) defined bibliometrics as stating "Bibliometrics is the application of mathematical and statistical methods to books and other media of communication."

Bibliometrics is a technique through which we calculate numerical analysis of information, books, descriptions of articles, reports, patents, software, designs, prototypes, and it is used to develop descriptive statistics as per our needs. This analysis presents a graphical representation of the output of other media of communication. As far as defining the term bibliometrics is concerned, different scientists have defined it in different ways. The word bibliometrics is made up of two words *'Biblio'* and *'Metrics*'. 'Biblio' is a combination of Latin

and Greek words which means the book or paper and ‘Metrics’ means to measure. Bibliometrics has been defined by various scientists as:

- According to Merton and Garfield, "Bibliometrics deals with the field of investigation given for quantitative analysis of science and scientific field."
- According to Pritchard, "Bibliometrics is the application of mathematical and statistical methods to books and other media of communication" and has also been described as "the metrology of information transfer process and its objective analysis and control of the process."
- According to the British Standard Glossary of Documentation of Terms, "patterns of use and publication of bibliometrics documents in which mathematical and statistical methods have been applied."
- According to Hawkins, "Bibliometrics is a quantitative analysis of the bibliography of a body of literature."
- According to Nicholas and Ritchie, "Bibliometrics provides information about the structure of knowledge and how it is communicated."
- According to Broadus, "Bibliometrics is the quantitative study of physical published units or bibliographic units or either."
- According to Sengupta, "Bibliometrics as the organization, classification and quantitative evaluation of the publication patterns of all macro and micro communications by their author as well as mathematical and statistical calculus."

In the sixth decade of the twentieth century, both the terms 'Bibliometrics' and 'Scientometrics' came into existence almost simultaneously. Renowned scientist Alan Pritchard defined the term bibliometrics as "the application of mathematical and statistical methods to books and other media of communication" while on the other hand Nalimov and Mulenko defined "Scientometrics as the application of those quantitative methods" Which are related to the analysis of science seen as an information process.

Based on the definitions of various scientists, the use of both terms is similar and a small difference is made clear that scientometrics is related to the scientific analysis of the research output of scientific disciplines, whereas bibliometrics is linked to the scientific analysis of the research output as well as other disciplines. It can be said that scientometrics is limited to the measurement of science communication, while bibliometrics is designed to deal with a more general information process. But for many decades, bibliometrics and scientometrics have been used equally in various studies. Many scientists in their study explained the difference between the two terms, stating that bibliometrics has developed for a major field of research that provides tools for evaluating and benchmarking research performance, while "Scientometrics" is primarily scholarly literature used to study all aspects of. It is noted that no means the ambiguous boundary between the two specialties during the last three decades and both words are currently being used as synonyms.

1.2.2.1.1 QUANTITATIVE AND QUALITATIVE TOOLS

Bibliometrics is associated with mostly quantitative tools and techniques, which are used to assess the study's research output. Bibliometrics also describes its various qualitative applications based on numerical analysis of research publications, including which literature on any subject is particularly useful for majors and libraries, most influential authors, institutions, classifying the areas of literature through interrelations of citations, the most effective journals, etc., and predict the communication process which is helpful in decision making. There are several bibliometric's laws and approaches that are used to measure the output of research:

1.2.2.1.1.1 LOTKA'S LAW

The Lotka's law was laid down by Alfred J. Lotka in the year 1926. Under this, the frequency of publications given by authors in any given field is analyzed. According to the Lotka's law "the number of authors contributing n (1) is $1 / n^2$ of those who make; and the proportion of all contributors, who make a single contribution, is about 60 %."

It can be said by the applicability of this law that out of all the authors in a given field, 60 % of the authors will be published only one article and 15 % of the authors will publish only two articles (1/260 times, 60) and 7% of authors will publish three articles (1/3. Times, 60) and further calculation will be made in the same way. Similarly, Lotka's law of scientific productivity states that only 6% of authors in an area will publish more than 10 articles. Alfred J. Lotka practically published his pioneering study in the year 1926 on the frequency distribution of scientific productivity determined from a decisive index of chemical essence (1907–1916) based on the Lotka's law.

1.2.2.1.1.2 BRADFORD'S LAW

The famous information scientist Bradford published his study on the frequency distribution of the journals in the year 1934 and afterward called it the Bradford law. According to Bradford, "If scientific journals are organized in order of decreasing productivity in a given subject, they can be divided into the nucleus of journals that are specifically devoted to the subject and have multiple groups or fields, contain the same number of articles when the number of periodicals. The nucleus and succeeding regions will have 1: n: n^2."

Bradford elaborated that journals can be divided into three zones, each zone having the same articles but with a difference in the number of journals.

- Journals of the first zone, in which the number of journals is very less, in such journals, one-third of all published articles are published. This type of journal is very little-this is called the core journals on the subject concerned.
- Journals of the second zone, in which the number of published articles will be equal to the first zone but the number of journals, will be more.
- Journals of the third zone, in which the number of published articles will be equal to the second zone but the number of journals, will be much more than that.

The mathematical relation of the number of journals in the core is a constant n for the first field and the relation n^2 is for the second field. Bradford expressed this relationship as 1: n: n^2. Bradford presented a study based on this rule, in which a bibliography of geophysics covers 326 journals in the field. He came to recognize that there were 9 journals containing 429 articles, 59 journals containing 499 articles and 258 journals containing 404 articles. So it took 9 journals to contribute one-third of the article, 5 times 9 or (5×9=45), to produce the next third, and 5 times 5 times 9, or (5×5×9=225), to produce the last third. Thus, Bradford's law serves as a general guideline for librarians in determining the number of core journals related to any subjects in libraries.

1.2.2.1.1.3 ZIPF'S LAW

Zipf introduced this law in the year 1933. This law refers to the calculation of the frequency of words in a text or article. The formula r×f =C was used to calculate this, where r is the rank of a word, f is the frequency of occurrence of the word, and C is a constant that depends on the analysis of the text. According to Zipf "In a relatively long text, if you list the words that fall within that text in order of decreasing frequency, multiplying the rank of a word in that list by its frequency will be a constant." This rule was implemented in James Joyce's analysis of Ulys' paper and quantified that his paper's text contained 2,653, the tenth most frequent word. The hundredth most frequent word occurred 265 times, the two hundredth word occurred 133 times, and so on. Zipf found that the term multiplied by the multiplication of the frequency of the word is then an equivalent which is approximately 26,500. This rule given by Zipf is very useful for indexers.

1.2.2.1.1.4 H-INDEX

The physicist Jorge E. Hirsch developed the H-index theory for measuring the eminence value of a single author or several authors, department or university or country, as well as a scholarly journal, etc. The H-Index is the numerical value of the progress of citation(s) and publication(s) of a single author or several authors, department or university or country, as well as a

scholarly journal. It is calculated on the basis of the number of papers published by the scientist and its citation(s), as well as how often these numbers are cited in other papers written by scientists. The H-index is calculated based on the distribution of citations received by publications of a given researcher and also applies to the productivity of a group of scientists, such as a department or university or country. For example, if a scientist has h if each of his Np papers has at least h citations, and other (Np - h) papers have most h citations each. In other words, a scholar with an index of h has published h papers with at least h citations. Thus, the H-index is the result of a balance between the number of publications and the number of citations per publication.

1.2.2.1.1.5 CITATION INDEX

The citation index is a process in which the number of times an author's article has been cited by other authors is calculated. Each day scientists report the results of experiments, studies, explorations, and inventions in thousands of publications. Which article is notable and influential in these published articles, it shows by its citation number. When an author links his article to another author's article, a relationship is established. Citation analysis uses citations in scholarly works to establish links. This author may criticize an earlier object, build upon it, and use it to extend its argument or accept an early originator. Maybe an author gives a citation only to state that the author has read extensively about his paper. Authors may use citations to explain, expand, or criticize. The method of tracking and evaluating research based on these citations is called citation analysis. Counting the citation by author, year, title, etc. is a citation process. The works cited herein are counted as measures of use and effectiveness. During citation analysis, we make the following the basis for counting citations: a personal article (how many times it was cited); an author (total citations, or average citations per article); a journal (average citations for articles in a magazine).

E. Garfield first published it by calculating the Citation Index for papers published in the academic journals of the Institute for Scientific Information

(ISI) in the year 1960. He first published the Science Citation Index (SCI) and then published the Social Science Citation Index (SSCI) and the Arts and Humanities Citation Index (AHCI). The impact factor of any journal is also determined based on the citation index of the articles published in it. Currently, many databases such as Scopus, Google Scholars, etc. automatically provide a citation index of authors, titles, etc.

1.2.2.2 LIBRAMETRICS

Father of library science in India, Dr. S.R. Ranganathan coined several words in library science; in those words, librametry is also one. Dr. S.R. Ranganathan first presented his concept on the *librametry* at the ASLIB conference at IFLA, held at Lamington Spa in the year 1948. He stated that "Just as other disciplines are used for statistical analysis; biometrics, econometrics, psychometrics, etc.; there is a need to do statistical analysis of the library and its services. Before the year 1948, such as biometry, econometry, and psychometry words originated, where the suffix 'metry' was an indicator of measurement of their field. From this time onwards *librametrics* began to be used to measure the library activities and its services as quantitative form.

1.2.2.3 INFORMETRICS

The term "informetrics" was first used by Otto Nacke in the year 1979. According to Otto Nacke, “Informatics is the study of the application of mathematical methods to the objects of informatics.” This includes information technology, information theory, cyber signs, etc.

1.2.2.4 WEBOMETRICS

When we study the relationship of various sites on the World Wide Web and the documents available on it using the bibliometric techniques, it is called webometrics. Such techniques can be used in traditional areas of the web as scientific mapping based on the time hyperlinked to other websites that are most useful or effective.

1.2.3 JUSTIFICATION FOR SCIENTOMETRICS

As mentioned earlier, under a scientometric study, we do the numerical analysis of research productivity of any topic, subject, institution, etc. This study is supported in the investigation of R & D trends. This study is also beneficial for policymakers who are deciding the priority areas in the concerned matter and also this study will be supportive in doing the following:

- Analysis of research and development trends of any institution, subject, and expert;
- Identifying prominence authors, journals, topics, institutions, number of citations and cited paper, author patterns, the annual growth rate of publications and analysis of relative growth rate in the concerned subject.
- Providing cutting-edge quick data to decision-makers.

The growing effects of scientometrics have resulted in the publication of several national and international journals i.e. Scientometrics (1979), Research Evaluation (1991), Cybermetrics: International Journal of Scientometrics, Informetrics, and Bibliometrics : An Electronic Journal (1997) on specialized journals related to scientometrics and bibliometrics. Apart from this, all journals related to library and information science give a prominent place to this study.

1.2.4 LIMITATIONS OF SCIENTOMETRICS

Some limitations of scientometrics are summarized below:

- It reckonings the text, not necessarily the meaning and context.
- It does not cover monographs.
- Its coverage of most English journals for citation analysis.
- It covers only the first author for citation count.
- Difficult to separate homographs, multiple authors listed under single names with mixed initial names with full names

- It does not trace married/ unmarried salutation in the case of a female writer
- Some articles may be ahead of their time, so they are not quoted (m) references for the same item (year, quantity, page, etc.).

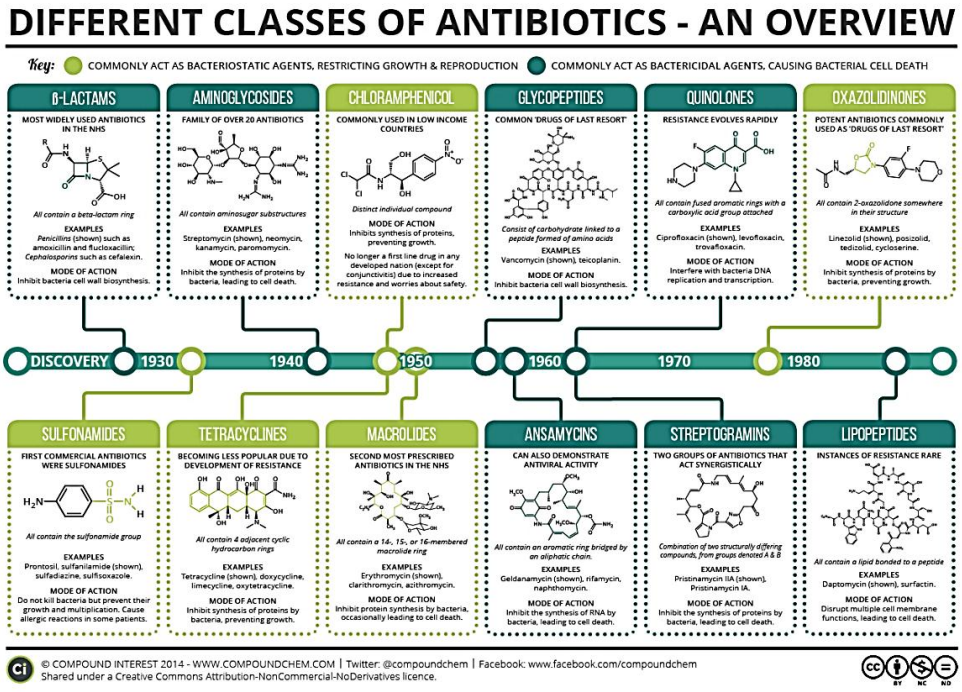
In the research area of the subject of library and information science, scientometrics or bibliometrics have a prominent place. The technique used in this should be used with caution because it is dependent on many parameters that affect the study or analysis, such as the amount of data to be studied, scientific development in a particular subject or the number of citations, etc. If one uses these techniques wisely, with other available methods, it may be the best tools available to scientists, policymakers, science administrators, and librarians, etc.

1.3 ANTIBIOTICS: AN OVERVIEW

The discovery of antibiotics was the most important discovery in modern medicine to treat humans. In the absence of this, it is not possible to imagine the treatment of human life due to bacterial infection in the present scenario. Because of these antibiotics, doctors know that they can treat practically every type of bacterial infection patient in the current era.

The term ‘Antibiotic’ was used first by Selman Waksman (1888-1973), who was later credited as being the ‘Father of Antibiotics’. The antibiotic term is coined from the word ‘antibiosis’ which literally means against life. Antibiotic is a substance that kills bacteria after entering our body or stops its growth. It is a broad group of antibacterial antimicrobial compounds, which are used to treat infections caused by bacteria. Antibiotics are medicines that strengthen our body's immune system and help us fight against bacterial diseases. Antibiotics are medicines that help prevent infection caused by bacteria. Before the invention of antibiotic medicine, huge numbers of people died of minor bacterial infections, like strep throat, before scientists, surgery was so risky but after antibiotics became available in the 1940s, life expectancy increased, surgery became safer, and people could survive what used to be fatal infections. Antibiotics are powerful medicines that fight certain infections and can save lives if used properly. They either prevent bacteria from breeding or destroy

them. In the past, antibiotics were considered to be organic compounds produced by one microorganism which are toxic to other microorganisms. Coexistence between man and the microcosm has been from ancient times. In ancient times, antibiotics were considered organic compounds produced by a microorganism which act as negative and toxic for other microorganisms. There are different types of bacteria are present inside the human body. Some of these bacteria are able to make symbiotic balance with humans, and in some form of microbes provide an insecure and stable effect on the body. These pathogenic bacteria look at their negative effects and grow in human tissues and cause illnesses, and then gradually damage the body and sometimes cause of death. For the treatment of this; scientist did a discovery, which is known as antibiotic. Due to the antibiotic bacteria causing antibacterial disease, human biological systems are known to cause harmful effects on the normal and useful micro-bacteria. Therefore, if the antibiotics are not used only in proper proportion, then it starts giving negative side effects instead of the man's positive. Therefore, the proper attribute and adequate understanding of the function of antibiotics for the safety of the human health system is an essential requirement for the person.



Source: http://www.compoundchem.com/2014/09/08/antibiotics/

Figure 1.1: Brief Overview of Classes of Antibiotics

Alexander Fleming discovered the world's first antibiotic penicillin in the year 1920, which was an important achievement in modern medical science. The result of these discoveries is that we have many antibiotics available today, using which doctors are successfully treating various types of diseases. Not only in India, in the whole world, the work of discovery of new antibiotics has been completely closed, the process of discovering new antibiotics is very complex and expensive. New antibiotic medicine takes place in medical science after several years of research work. Since 1987, no major antibiotic drug has been discovered and it is getting supposed that for the next 10 years, we will have to use the currently existing antibiotics only.

According to D.G. Shah (General Secretary of the Indian Pharmaceutical Alliance) "The science of antibiotics is complex, expensive and time-consuming; we need to find different ways to kill bacteria." On the other hand, it is not beneficial for the big pharmaceutical companies in the world because antibiotics are used for a short time, so they do not want to come forward. This makes the condition challenging the use of antibiotics all over the world, especially in India. A very important question is being asked about our future, what will happen if the existing antibiotics are neutralized?

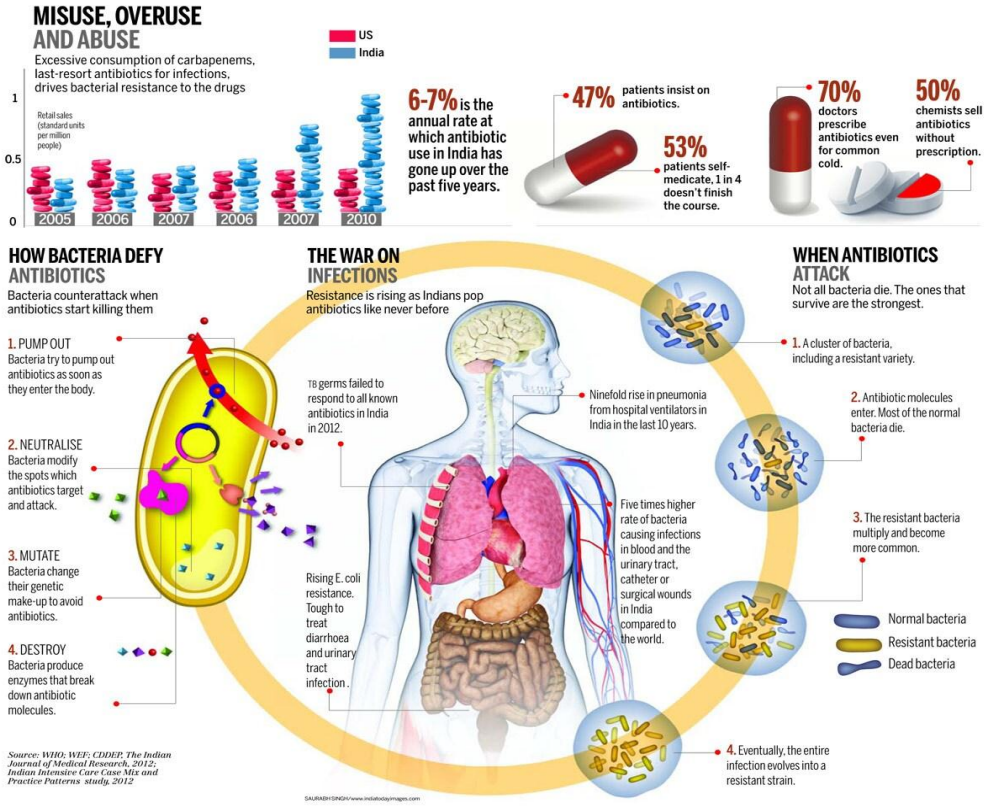
Alexander Fleming, the inventor of the world's first antibiotic penicillin, received the Nobel Prize in the year 1945, warning that if antibiotics were not used properly, these antibiotics could one day reverse the bacteria because these bacteria are the most cunning nature; Their number doubles every 20 minutes and every bacterium produces 16 third-generation, 16 offspring in an hour, which gives the genes necessary for survival in the opposite environment to its next generation. So, it is the responsibility of all of us to use it wisely.

1.3.1 FUNCTIONS OF ANTIBIOTICS

Normally, before the bacteria cause infection in our body, our immune system kills them. Our white blood cells (WBCs) attack harmful bacteria and even if there are symptoms, the immune system can usually withstand and fight infection, Whenever a negative bacteria enter our body from outside, our

immune system makes antibodies against it, which fight and destroy these negative bacteria, but when these bacteria enter our body in excessive amount, Then our immune system is not able to produce enough amount of antibodies at this stage. To make antibodies, taking antibiotics is a necessity. These antibiotics make more amounts of antibodies in our body, which helps to strengthen our body's immune system and weaken these harmful bacteria by destroying them slowly. Different antibiotics are used for different types of bacterial infections. Generally, antibiotics are of two types as seen on the basis of function:

- **Bactericidal Antibiotics:** Bactericidal antibiotics are antibiotics that kill bacteria directly as they enter the body. Its effect on our body is very fast.
- **Bacteriostatic Antibiotics:** Bacteriostatic antibiotics are antibiotics that first inhibit and weaken the growth of bacteria and then the immune system of our body kills that weakened bacteria.



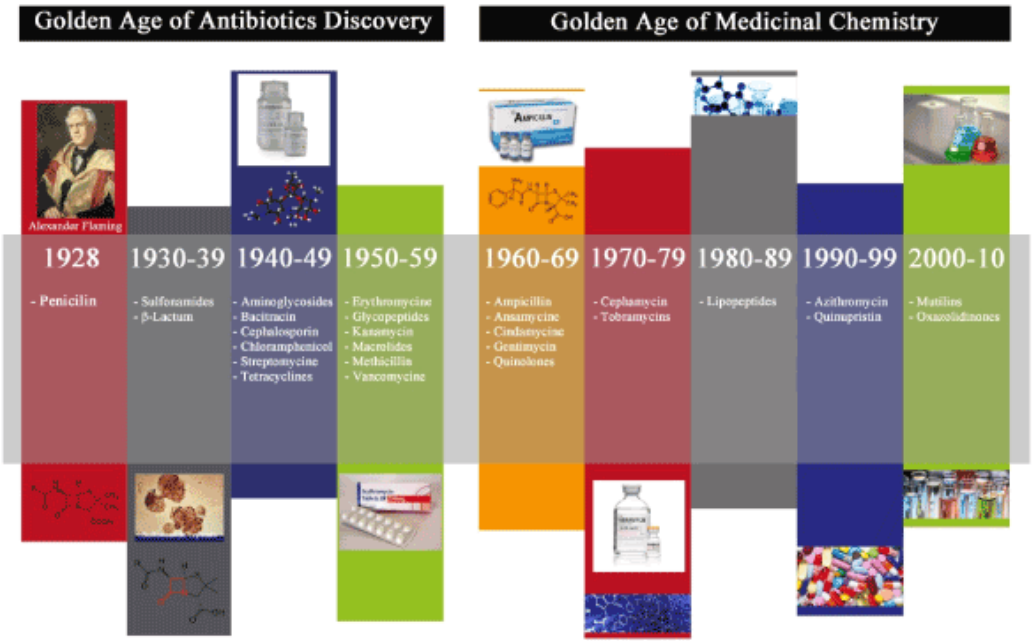
Source: https://aajtak.intoday.in/story/your-antibiotic-is-sick-1-725312.html

Figure 1.2: An Outline of Antibiotic

1.3.2 COMMON ANTIBIOTICS AND THEIR USES

The first antibiotic *penicillin* was discovered in September 1928 by an English Bacteriologist, late Sir Alexander Fleming who accidentally obtained the antibiotic from a soil inhabiting fungus Penicillium notatum but its discovery was first reported in 1929 and clinical trials first conducted on humans in 1940. Thereafter many other antibiotics had been discovered such as aminoglycosides, glycopeptides, pleuromutilin's, etc. Till now, there are around 20 classes of antibiotics that were discovered between 1928 and 1987. This period was the golden era of antibiotic detection and synthesis. From 1987 onwards, no new antibiotics become discovered. We are currently void in the discovery of a new antibiotic since 33 years. Antibiotics have aided in the relief of human suffering and saved millions of lives. Beginning with penicillin, streptomycin, and other large structural groups of antibiotics, the 'Golden Age' of antibiotic discovery (1940–1960) transformed clinical medicine, offering effective cures for the most common diseases of the time. Unfortunately, four years after the commercial release of penicillin, penicillin-resistant staphylococcus aureus has emerged. The secreting enzyme β-lactamase by resistant strain destroys penicillin (a β-lactam antibiotic). In the late 1950s, penicillin's effectiveness was limited to just 15% of S. aureus infections. By the early 1970s, these treatments proved to be unsuccessful due to the advent of antibiotic resistance, leading the hunt for new medications with minimal side effects and bacterial resistance. The spread of antibiotic resistance was increased by the increasing number of clones of methicillin-resistant S. aureus (MRSA). Along this line, researchers, academics, and pharmaceutical companies have attempted to develop a new or advanced antibacterial agent with a different mode of action than β-lactams. Glycopeptide antibiotics (Vancomycin and Teicoplanin), glycosylated cyclic or polycyclic non-ribosomal peptides that inhibit bacterial peptidoglycan synthesis, were implemented relatively quickly. Over the past 15 years, the effectiveness of newly discovered antibiotics in addressing the bacterial resistance epidemic has ensured that glycopeptide antibiotics are considered the last resort of drugs in treating gram-positive bacterial infections, including the multidrug-resistant superbug, MRSA. The second generation of glycopeptide antibiotics, such as

oritavancin, telavancin, and dalbavancin, is discovered as a part of the ongoing attempt to overcome glycopeptide resistance. When compared to vancomycin, these glycopeptides have higher antibacterial potency and efficacy. While lactams and glycopeptides remain the first lines of protection, exceptional direct therapies are urgently needed to combat bacterial infections and the threat of antibiotic resistance.



Source: https://www.oatext.com/therapeutic-potential-of-snake-venoms-as-antimicrobial-agents.php#Figures_Data

Figure 1.3: Age of Antibiotics Discovery

The golden age of antibiotics discovery and medicinal chemistry is represented in the diagram above. With the discovery of penicillin, the golden age of antibiotics discovery began, followed by drug design and chemical synthesis. Although about 2,000 antibiotics have been discovered within 20 classes so far, only a few of them are currently used clinically as most of them are not used for medical purposes due to side effects on most people. Therefore, proper characterization and adequate understanding of the action of antibiotics are important for the protection of human health care delivery systems. Common antibiotics and their uses are as follows:

Table 1.1: Common Antibiotics and their Uses

COMMON ANTIBIOTICS		
DRUG CLASS AND GENERIC NAME	**COMMON TRADE NAMES**	**COMMON USES**
Aminoglycosides (Inhibit Protein Synthesis)		
Gentamicin	Garamycin	Infections of the Respiratory and Urinary Tracts, Blood, Abdominal Cavity; Pelvic Inflammatory Disease
Tobramycin	Aktob, Nebcin	Infections of The Respiratory and Urinary Tracts, Blood, Abdominal Cavity; Pelvic Inflammatory Disease
Cephalosporins (Inhibit Cell Wall Synthesis)		
Cefaclor	Ceclor	Infections of the Respiratory and Urinary Tracts And Skin; Otitis Media
Cefamandole	Mandol	Infections Of The Respiratory and Urinary Tracts, Skin, Bone and Joints, And Blood; Peritonitis
Cefazolin	Ancef, Kefzol	Infections of the Respiratory and Genitourinary Tracts, Skin, Bone And Joints, And Blood; Endocarditis
Ceftriaxone	Rocephin	Infections of the Respiratory and Urinary Tracts, Skin, Blood, Abdominal Cavity, And Bone and Joints; Pelvic Inflammatory Disease; Gonorrhea; Meningitis
Cefuroxime	Ceftin, Kefurox	Infections of the Respiratory and Urinary Tracts, Skin, Bone and Joints, and Blood
Cephalexin	Biocef, Keflex	Infections of the Respiratory and Urinary Tracts, Skin, and Bone; Otitis Media
Chloramphenicols (Inhibit Protein Synthesis)		
Chloramphenicol	Chloromycetin	Infections of the Eyes, Ears, and Skin; Cystic Fibrosis; Prevention of Infection in Minor Wounds
Fluoroquinolones (Interfere With Dna Synthesis)		
Ciprofloxacin	Cipro	Infections of the Respiratory and Urinary Tracts, Skin, Eyes, Abdominal Cavity, And Bone And Joints; Diarrhea; Gonorrhea; Sinusitis; Pneumonia; Prostatitis; Anthrax
Norfloxacin	Chibroxin, Noroxin	Urinary Tract Infections, Stds Caused By Neisseria Gonorrhoeae, Eye Infections, Prostatitis

Lincosamides (Inhibit Protein Synthesis)		
Lindamycin	Cleocin	Infections of the Respiratory Tract, Skin, and Abdominal Cavity; Acne; Pelvic Inflammatory Disease
Macrolides (Inhibit Protein Synthesis)		
Azithromycin	Zithromax	Infections of the Respiratory Tract and Skin; Stds; Otitis Media; Chronic Obstructive Pulmonary Disease; Pneumonia
Clarithromycin	Biaxin	Infections of the Respiratory Tract and Skin; Otitis Media
Erythromycin	E.E.S., E-Mycin, Eryc	Infections of the Respiratory Tract, Skin, and Eyes; Stds; Pertussis; Diphtheria; Intestinal Amebiasis; Otitis Media; Acne; Legionnaire Disease; Prevention Of Infection In Minor Wounds
Nitrofurans (Inactivate Essential Cell Components)		
Nitrofurantoin	Furadantin, Macrobid	Urinary Tract Infections
Penicillins (Inhibit Cell Wall Synthesis)		
Amoxicillin	Amoxil, Trimox	Various Streptococcal and Staphylococcal Infections
Ampicillin	Marcillin, Omnipen	Infections of the Respiratory and Urinary Tract and Blood; Meningitis; Gonococcal Infections; Endocarditis
Penicillin G	Bicillin, Pen-G Pot, Wycillin	Streptococcal And Staphylococcal Infections
Piperacillin	Pipracil	Infections of the Respiratory and Genitourinary Tracts, Skin, Abdominal Cavity, Bone And Joints, and Blood
Ticarcillin	Ticar	Infections of the Respiratory and Gastrointestinal Tracts; Streptococcal And Pseudomonas Infections; Gonorrhea; Tonsillitis; Lyme Disease; Impetigo; Otitis Media; Meningitis
Tetracyclines (Inhibit Protein Synthesis)		
Tetracycline	Achromycin, Sumycin	Rickettsia, Pneumonia, Chlamydia, Intestinal Amebiasis, Acne, Prevention of Infection in Minor Wounds
Miscellaneous Antibiotics		
Aztreonam	Azactam	Infections of the Respiratory and Genitourinary Tracts, Skin, Abdominal Cavity, and Blood

Imipenem-Cilastatin	Primaxin	Infections of the Respiratory and Genitourinary Tracts, Skin, Abdominal Cavity, Bone and Joints, and Blood; Endocarditis
Isoniazid	Inh, Isoniazid, Nydrazid	Tuberculosis
Metronidazole	Flagyl, Protostat	Infections of the Vagina and Gastrointestinal Tract
Rifampin	Rifadin, Rimactane	Tuberculosis
Trimethoprim-Sulfamethoxazole	Bactrim, Cotrim, Septra	Urinary Tract Infections, Shigellosis, Otitis Media, Bronchitis, Traveler's Diarrhea
Vancomycin	Lyphocin, Vancocin	Infections Resistant to Penicillins and Cephalosporins

1.3.3 DISADVANTAGES OF ANTIBIOTICS

Antibiotics are life-saving as much as life-threatening. It should take always be consulted by a doctor, if you take antibiotics without consulting, it can also harm you. Wrong use of antibiotics makes the bacteria stronger and in this case the bacteria protect themselves from the effect of the antibiotic and when such a process starts developing, antibiotic resistance starts which is very serious and worrying for us. There are following side effect, which is caused by wrong use of antibiotics:

i. If antibiotics are not taken in the right way and in the right amount, then slowly they start producing resistance and the antibiotic medicine will no longer kill the bacteria present in our body and if the infection of this bacteria is from you to another person, this person also side affected by this antibiotic and gradually it takes the form of chain, resulting this type of bacteria cannot be easily killed. For this, a new dose is made by combining several antibiotics which are more expensive than normal.

ii. Antibiotics should always be taken when needed, you should avoid using them unnecessarily or else your own immunity starts to weaken. When an infection is caused by a bacterium in our body, the first antibodies

available in our body fight it and it does not need an external antibiotic, but when you start using antibiotics again and again, so your body stops making antibodies and your body's resistance weakens.

iii. There is a richness of good bacteria in our body, which controls our body system, but if we take an overdose of antibiotics, it will not only kill the harmful bacteria but it also destroys the good bacteria present in our body, due to which the balance of our body gets disturbed and we get its side effect. Many times this seems to be complaining diarrhoea etc. This is the reason why probiotics are prescribed along with antibiotics.

Normally we take antibiotics from the drugstore in case of minor illnesses and cuts, he gives you two to three doses of medicine and says that it will be cured, which proves very harmful for us. The same antibiotics are used for many types of bacterial infections; only the amount and duration are different, which only a doctor can prescribe. But there is a lot of carelessness in this, especially in India, if we ever take antibiotics directly from a chemist's shop, then he does not know that we have this disease, in what quantity and for how many days and what antibiotic medicine has to be taken. Let me tell you that the consumption of antibiotics has increased between 6 to 7 % annually in India in the last 5 years, which is very worrying. According to the doctor, "each antibiotic has its own course, which needs to be completed, even if you are feeling very healthy yourself." But many times we stop the medicine in the name of healing, due to which the condition of antibiotic resistance arises. Therefore, it is clear from the above observations that antibiotics should not be used without a doctor's advice. Using it excessively and using it excessively is both harmful. Always keep in mind that antibiotic works only in the infection caused by bacteria, it does not reduce the infection of the virus, such as cold flu and viral fever, etc., and then this type of disease cannot be cured by antibiotics.

Based on the facts mentioned above, it is clear that how much importance of antibiotics in our life; it is directly related to our healthy life. The continuous discovery, development of antibiotics in our health care delivery system signifies

that our doctors save millions of lives from infectious diseases caused by bacteria. When antibiotics were not discovered, millions of people used to die every day. After the discovery of antibiotic, it has become possible to save millions. Proper characterization and adequate understanding of the action of antibiotics is important for the safety of human health care delivery systems.

There is no doubt that the latest research has helped in curing our disease against infectious diseases caused by bacteria and thus contributed to personal and social welfare. Research is a continuous process. In order to give direction to any new research work, it is very important to have information and the latest knowledge related to it. To meet this need, library and information science play an important role as scientometrics or bibliometrics. A lot of research work is being done around the world using scientometrics techniques. This study presents a broad outline of the research productivity of scientists in India on the antibiotics literature. Bibliometric or Scientometric indicators and methods are being widely used to make various policy decisions not only in India but around the world. Scientists, evaluators, policymakers, science administrators and librarians can make policy decisions in a related subject using the outputs extracted by this research.

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CHAPTER-2

REVIEW OF THE LITERATURE

2.1 INTRODUCTION

When we start choosing the problem for research work in a subject, first we have to think that the research work has not been done on the title that we are going to choose. During choosing the research title, we have to keep in mind that the topic or title we are choosing should be new and that research has not been done on that subject. To check whether the title we have chosen is new or not, we have to study the available literature on this subject. Therefore, a comprehensive study of literature is an essential, integral part of any research, which helps in deciding the problem for research and proves to be helpful in identifying the differences of the proposed study. A review of the literature related to the proposed topic not only helps the researcher in designing and analysing the research work, but also enables the researcher to understand earlier research interests, research patterns, and the magnitude of research output in the study area. Hence a literature review is a comprehensive study of prior research about a specific topic that informs the researcher in terms of topic what research work has been done on the proposed topic or title and what is not yet known, In addition, the literature review provides a researcher with more and more information related to the subject chosen by him and helps in educating the researcher. A review of the literature also shows that the researcher has a strong understanding of the chosen topic and it helps the researcher in the learning process and enhances the credibility of the research work.

The goal of this chapter is to measure the importance of the research work already done related to the proposed research topic and based on that, identify a title where a new research work can be done. The literature review is a complete summary of previous research on a topic. Through this, we review scholarly articles, books, and other sources relevant to the particular field of the selected subject, and during the review compare previous research work with the

proposed research title and clarify its objective evaluation, thereby the proposed research has a theoretical perspective and helps decide the nature of the proposed research work. A review of the literature makes it clear that the researcher has taken up, evaluated, and assimilated the work by referring to previous work in the study area of the selected subject. A review of the literature also informs the readers that the researcher has assimilated all previous aspects of the selected subject and all the important works related to its research topic. This literature review is designed to provide an overview of the sources you have discovered while researching the selected topic and to show how the proposed research is suitable in this large field of study.

Hence, the literature review reviews literature relevant to a particular area or subject, which includes what work has been done, what has been said, who are the principal authors, what are the prevailing theories and hypotheses, which questions are being asked, and what methods and methods are correct and useful and where is the gap in it. The criteria of systematic literature review suggested by **(Parahoo, 2006)** are shown in Fig. 1.

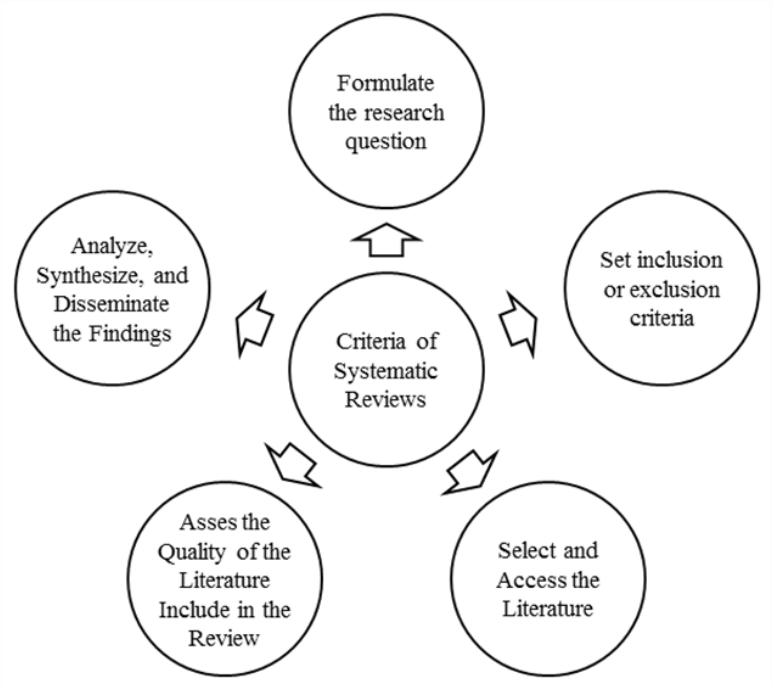

Figure 2.1: Criteria of Systematic Literature Review

2.2 PURPOSE OF THE REVIEW OF LITERATURE

The purpose of the literature review is to tell the reader what knowledge and ideas have been established so far on the proposed topic, and their strengths and weaknesses. It aims to provide a guiding concept to the study. The literature review, therefore, shows readers where the reviewer is entering academic conversation on a particular subject in the context of existing scholarship. Lawrence and (Brenda, 2016) proposed the purpose of reviewing the literature is as follows:

- To provide a reference for the proposed research.
- To identify fundamental works and scholars in the field of the proposed research
- Accepting existing theories, approaches, hypotheses, etc. in the proposed research area
- Justify the selected problem
- To clear misconceptions about previous research
- Ensuring that the proposed research has not been done before
- To demonstrate where the proposed research fits into the existing study area of knowledge
- Enabling the researcher to learn from previous theory on the subject
- Tells which subject has been studied before
- Uncovering flaws in previous research
- Displaying the outline in previous research
- Show that work is adding to the understanding and knowledge of the field
- To contribute to the refinement and development of the proposed subject.

2.3 BASIC STEPS AND COMPONENT (INFORMATION) OF THE LITERATURE REVIEW

A literature review is a survey of scholarly studies that is an important summary of a particular subject. The following stages of literature review work are major:

- Selecting a topic
- Setting the subject into context
- Viewing information sources
- Using information sources
- Gained knowledge
- Organization of Information
- Status of literature review
- Write a literature review

The basic components of a literature review include:

- Description of the publication;
- Summary of the publication's main points;
- Discussion of gaps in research;
- Evaluation of the publication's contribution to the topic.

It is clear from the above facts that the literature review has an important role in any research work. In this chapter, the literature related to various aspects of scientometric and bibliometric studies has been reviewed in the context of the proposed research topic antibiotic and its related topics. This literature review enables us to analyse and identify areas of research concentration and the magnitude of research output in the particular branch of the antibiotic. In addition, it aims to analyse past trends of antibiotics concerned with bibliometric studies i.e. emerging new areas of research, growth of literature, the productivity of researchers and the performance of research institutes in relation to antibiotics. This chapter also attempts to identify past scientific analyses of research output performance concerned with antibiotic and bibliometrics. It may be noted that there are several studies contributing to the evaluation of research performance through scientometric analysis near to antibiotics. Therefore, the current study needs to review such important functions and their relevance. The review of related studies further avoids repetitive work already done in that area

and enables the researcher to identify unexplained areas, creating new grounds for research. By considering this proficiency of various dimensions of scientometric and bibliometric studies, the researcher has presented the comprehensive literature review of scientometric and bibliometric studies in relation to antibiotics in chronological order.

2.4 STUDIES BASED ON RELATED DISCIPLINE

Cole and Eales (1917) used the term “Statistical Analysis" in their articles "The History of Comparative Anatomy". They described the publications distributing and graphically representation of the activities of comparative anatomists with animal anatomy for the period 1543 to 1860.They informed that “it seemed possible to reduce to geometrical form of activities of the corporate body of anatomical research, and the subject”. They find out the description of literature, publication counts and graphic illustrations by year and country.

Hulme (1923) first used the term “Statistical Bibliography” during his lecture delivered in the Sandars Reader in Bibliography at the University of Cambridge. In his lecture, he used the term to illuminate the processes of science and technology through counting. Hulme summarized the works of Cole and Ells and he produced original work on the changes displayed in the UK Patent and International Catalogue of Scientific Literature (relating changes in subject and country production of literature to international developments).

A.J. Lotka (1926) published his classic paper in the Journal of the Washington Academy of Sciences on the frequency distribution of scientific productivity. He proposed an analysis of the number of publications listed in Chemical Abstracts based on the frequency of publications by particular authors for 1907 to 1916.

Bradford (1934) presented an empirical law of scattering of publications in journal and state that “If scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones

containing the same number of articles as the nucleus; when the succeeding zones will be as 1: n: n^2 (i.e. 1:5:25)."

Ranganathan (1948) coined the term librametry which is analogous to bibliometrics. He presented his concept in 1948 at the ASLIB conference held at Lemington Spa. He said that "there is a need to develop this subject on the lines of biometry, econometry, psychometry, etc. He used the term to include statistical approaches to the study of library and its services."

Kessler (1961) first to introduce the concept of bibliographic coupling and presented a detail report on "Bibliometric Coupling". This report published in 1962 and revised in 1963 and again published in IEEE Transaction on Information Theory. He indicated that bibliographic coupling is "a new method for grouping technical and scientific papers."

Price (1965) reported in his article "Networks of Scientific Papers" that the number of papers cited n times in a year followed an inverse power law (Zipf's Law) with exponent in the range 2.5-3.0.

Zipf (1965) produced a theory regarding distribution of frequency of appearance of words in texts. He stated that "In long textual matters if the words are arranged in their decreasing order of frequency, then the rank of any given word of the text will be inversely proportional to the frequency of occurrence of the word."

Pritchard (1969) coined term "Bibliometrics" and used it in his article "Statistical Bibliography or Bibliometrics" which was published in the Journal of Documentation. He highlighted that, "the use of this term is to shed light on the processes of written communication and of the nature and course of development of a discipline (in so far as this is displayed through written communication), by means of counting and analysing the various facets of written communication."

Price (1976) presented the "General Theory of Bibliometric and other Cumulative Advantage Processes" He stated through this paper that "This has been shown to be a suitable underlying probabilistic theory for Bradford's law,

Lotka's law, Pareto and Zipf's distribution, and for all empirical results of citation frequency analysis."

Price and Ciirsey (1976) presented a study on the relation between source author and cited author populations. They stated that "Transient authors have only a chance of about one in four of having their sole paper cited, non-core continuants have about 0.7 chance of being cited, and core continuants are almost all cited every year. The correlation between citation and productivity is therefore very high and most effective in the crucial decision to remain at the research front or retire from it."

Frame (1977) presented a study on 22 Latin American and Caribbean countries based on Science Citation Index (SCI) appearing during 1973-1975. In this study, He proposed the concept of activity index. He indicates "whether a country has a relatively higher or lower share in world publications in a particular field of science than its overall share in world total publications."

Nicholas and Ritche (1978) proposed two groups of the bibliometric studies, first descriptive studies and second behavioural studies. They specified that the both studies are complimentary to each other.

Nacke (1979) proposed the term "informetrics" and focused on the statistical analysis of information productivity. He states that "it integrates the information technology and complex connections of information theory, cybermetrics and decision theory etc."

W.G. Potter (1981) presented an overview on bibliometrics and divided the bibliometric studies into two broad categories i.e. descriptive study (means to study the body of literature) and more evaluative study (attempts to study the use of a body of literatures with help of citation analysis).

Subramanyan (1983) presented his paper entitle "Bibliometric studies of research collaboration: A review". In this paper, He identified several types of collaboration, and earlier research on collaboration has been reviewed.

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I.N. Sengupta (1985) presented a study on “Bibliometrics: A Bird’s eye view” in IASLIC bulletin and declared that this study lies between the broader areas of the physical science and the social science.

Mahapatra (1985) presented a paper in the 15th conferences of IASLIC in 1985 on the validity of the theory of exponential growth of scientific literature. In this paper, he proposed the formulas for various types of growth curves such as exponential growth, relative growth rate (RGR) and doubling time (DT). He also presented the logistic pattern of growth of publications.

Egghe (1988) presented “Methodological aspects of bibliometrics” and stated that “the notion of scientometrics deals more with science policy research and therefore is more related with citation analysis studies.”

Lancaster (1991) conducted a study on bibliometric methods in assessing productivity and impact of research and listed the limitations of bibliometric study.

Kumar and Kaliyaperumal (2015) presented a scientometric study on mobile technology research. This research paper was published in Scientometrics International Journal. This paper was focused on growth and development mobile technology research. In this paper, they proposed the formula for the calculation of annual growth rate (AGR) and compound annual growth rate (CAGR) of a publication. They also calculated RGR, DT, Degree of Collaboration and Collaboration index.

2.5 STUDIES BASED ON RELATED DISCIPLINE CONCERNING ANTIBIOTICS

Lu et al. (2020) presented a scientometric study on antimicrobial resistance research in social science. This report seeks to recognize research holes and potential directions in the existing scholarly literature on AMR in the

social science field by looking at international contributions, new subjects, important publications, and popular sources. Bibliographical data is taken from the Social Science Citation Index and Web of Science. A total of 787 peer-reviewed journal publications written over the period from 2010 to 2019 were retrieved. The extracted papers had been checked with bibliographic networks. It is found that in the last five years, social science research on AMR has accelerated. Although western developed countries made the most contributions to the field over the last decade, research in emerging regions like Asia and Africa has risen in the last two years. From monitoring and risk assessment of AMR to the promotion of effective antimicrobial use in primary care and therapeutic environments, social sciences have contributed to AMR research in a variety of ways. Though the concept of one health has been integrated into AMR research in the medical and microbial science fields, it has not received much attention in the social sciences. In the future, more focus should be put on social problems surrounding AMR between humans, animals, and the environment.

Şahin et al. (2020) conducted a bibliometric study on environmental science of aquatic environments literature from 2015 to 2019,using the keywords "Antibiotic Resistance (AR)" and "Escherichia coli," "freshwater," "seawater," and "wastewater," . It was discovered that 217 out of the overall 2115 research on AR are mainly done in the “Waste Water” group with human health in mind. Since the leakage of antibiotic-resistant bacteria (ARB) and antibiotic resistance genes (ARGs) from wastewater treatment plants must be mitigated, and up-to-date approach should be formulated based on the studies. As a result, it is self-evident that focusing on micro and macro environments would increase the chance of discovering antibiotic resistance strategies. A discussion of coliform bacteria removal techniques, especially for antibiotic-resistant Escherichia coli, was discussed. One of the study's interesting features is that it proposes a novel approach for eliminating them using new crystalline hybrid materials called metal-organic frameworks (MOFs). MOFs are effective antimicrobial substances in the atmosphere, biology, and food. As a result, future studies of antimicrobial resistance removal via adsorption using MOFs as adsorbents may be inspired.

Maghsoudi et al. (2020) summarise the role of SRBC in the poultry studies, they did a qualitative approach and use scientometric techniques such as pattern analyses, scientific partnerships and visualisation, and word co-occurrence assessments. Web of Science (WoS) search technique was used to locate publications that used SRBC in poultry studies. Nutrition, anatomy, microbiology, and physiology were the four divisions used to divide the publications. Scientific maps and networks were created for scientometric assessment in order to explain the presence of SRBC in the poultry tests. The data used consisted of 702 publications collected from the WoS archive over a 50-year period (1968-2018).The English language was used in 95 percent of the publications. The main subjects of publications were indigenous, experimental, and commercial poultry, quail, and medicinal plants. Authors have used SRBC to study humoral immune response as a secondary goal of their research in recent years, especially when studying poultry production/performance.

Aleixandre et al. (2020) conducted a bibliometric study on Tendencies and Challenges in Scientific Research on Probiotics at global level. The study's key aim was to look at empirical developments in probiotics studies, such as the number of papers, financing, country partnerships, and most cited publications. The thesis employs bibliometric and social network analysis of articles from the Web of Science and Science Citation Index Expanded database. A total of 7221 papers were found, with 64 percent of them being funded. Food Science & Technology, Microbiology, Biotechnology and Applied Microbiology, Nutrition & Dietetics and Agriculture, and Dairy & Animal Science were among the journals that published papers. Coword research exposes associations between microorganisms, pathogens, physiological phenomena, and other main terms associated with food, population, or study type. In terms of the number of articles published, the United States led the world (n = 919), followed by China (n = 689), India (n = 633), and Brazil (n = 506). The most quoted papers discussed the description and proper use of the term probiotic, its impact on the prevention and treatment of certain intestinal diseases, its effects on the suppression of immune disorders, the role of probiotics and prebiotics in obesity, the evaluation of psychotropic-like properties, and the use for type 2 diabetes.

Li et al. (2020) did a bibliometrics on meta-analysis studies to approximate global PJI research. PubMed, Scopus, and Web of Science databases were used to execute data for study. A total of 117 papers were retrieved including the report. Scopus database was used to locate the most important PJI literature. China contributed the most to global science, followed by the United States and the United Kingdom. The University of Bristol was the school with the most contributions. The Journal of Arthroplasty has the largest number of articles, while the Journal of Clinical Medicine had the fastest acceptance period. In meta-analysis articles, the most common number of writers was four. The periprosthetic hip and knee were the subjects of the majority of research. In recent years, the most common topics have been the alpha-defensin diagnostic procedure, antibiotic use prevention, and risk factors for intra-articular steroid injections. They concluded that there is no single database that holds all related articles; instead, a mixture of databases is the best approach for bibliometric research. Alpha-defensin, antibiotic utilisation, risk factors for intra-articular steroid injections, and the position of prosthetic hip and knee infections were among the most common research topics on PJI.

Arshad et al. (2020) conducted a bibliometric analysis of top 100 classics on antibiotics. The data were retrieved from Clarivate Analytics' Web of Science's, Scopus and Google Scholar database. Citations in Web of Science ranged from 940 to 11,051, in Scopus from 1053 to 10,740, and in Google Scholar from 1162 to 20,041 times. There were 513 writers who contributed to the ranked list, with Robert E.W. Hancock contributing six papers that made the cut. The United States of America contributed 66 research contributions. The most contributions (n = 5) were provided by five publications connected to the University of Manitoba, Canada, which was listed as the educational institution. According to the methodology, review-type works accounted for 26 of the most quoted works, accompanied by 23 expert opinions/perspectives. Nature published eight papers in this area, making it the journal with the most scientific contributions. The correlation between the publishing age and the number of citations was found to be statistically important ($p = 0.012$).

Shi et al. (2020) examined some of the most recent advances in antibiotic science in water. They examined 5420 publications on antibiotics in water or wastewater published between 2000 and 2017 for countries, institutes, magazines, and keywords. According to the findings, China is the leading respondent, and the United States has the highest h-index of 104. Adsorption, photolysis and photo catalysis, biodegradation, ozonation, and electrochemical oxidation are the most common methods of elimination. New materials and technology, such as the ionising laser, are currently being researched in order to increase performance and lower costs. The conversion of wastewater into fuels like H2 and methane is also a hot subject of science right now.

Zheng et al. (2020) analysed the global patterns and results of ARG analysis. The bibliometric database for the current study was developed using ARG literature published between 1974 and 2016 from the Site of Science Core Selection, in which we merged cluster analysis and network analysis to visualise research patterns of ARGs with international partnerships and trans-disciplinary advances. International cooperation is far more prevalent in Stage II (1998-2016) than it was in Stage I (1974-1997), particularly among the US, the UK, and China. The most observed environmental compartment was wastewater, which was accompanied by dirt. Bacteria, especially ARB, were the most studied organisms, which included Escherichia coli, Staphylococcus aureus, and Methicillin-resistant Staphylococcus aureus. In addition, swine were a common research animal. The testing hotspots were metagenomics, sulfonamides, and a few pathogens. International collaborations and cross-disciplinary collaborations will help to enhance the content of publications while also increasing the number of papers published. Mechanisms study including antibiotics, ARGs, and ARBs, as well as ARG removal methods, will be research hotspots in the future.

Liu et al. (2020) presented a study on Web of Science (WOS) Central database to pull data on related publications on antibiotic-resistant Acinetobacter baumanii from 1991 to 2019. On the years, publishers, countries, organisations, keywords, and citations of the publications, VOSviewer and CiteSpace tools were used to perform co-citation visualisation network rendering and cluster

research. The below are the outcomes: There were 3915 valid documents found for the study of antibiotic-resistant Acinetobacter baumanii. Year after year, the number of related publications increased. The United States is the most dominant government in the region, working closely with other nations and writing the bulk of articles. In this sector, the University of Sydney is the most prestigious institution. The majority of the articles are published by Robert A Bonomo. The scientific fields of antimicrobial agents and chemotherapy include the largest number of publications. In this area, “nucleotide sequence” and “outbreak” were once hotspots, but “bacteriophage,” “biofilm,” and “colistin resistance” have recently emerged as research hotspots. Conclusion: The number of publications on antibiotic-resistant Acinetobacter baumannii has increased dramatically since 1991, and numerous countries and organisations have paid close attention to the issue of antibiotic resistance.

Yacouba and Olowo (2020) presented a bibliometric marker for colistin resistance analysis from around the world. Reports on colistin resistance were based on the Scopus collection. The bibliometrix R-package was used to review the papers found. a total of 1105 publications were found. In the last decade, there has been a significant rise in the number of publications on colistin resistance studies. The core zone of colistin study provided 35.83 percent of the published papers, with six publications making up the core zone. By comparing the time periods 1973-2009 and 2010-2019, the study showed some keywords that had increased or decreased in use. Over the period 1973-2009, the authors' keywords 'Acinetobacter baumanii' and 'Pseudomonas aeruginosa' were the most often observed, while'mcr-1,' Enterobacteriaceae,' Escherichia coli, and Klebsiella pneumoniae' appeared in the last decade.

McNickle et al. (2020) presented a systematic literature review in the area of urgent care medicine. The publishing year, journal, research study nature, study population, clinical significance (clinical or non-clinical), and study topics were all abstracted from each paper. The researchers looked at 144 articles from 94 peer-reviewed journals. From 2010 to 2019, the annual number of publications has gradually grown. Retrospective (55.5%), research specific

(24.3%), prospective (15.3%), and quality assurance (15.3%) were the most popular study designs (4.9%). Adults (33.3%) were the most commonly reported research group, led by paediatricians (18 percent), and both adults and paediatricians (18 percent) (16.7 percent). Clinical (48.6%) and non-clinical (48.6%) publications were classified (51.4%). Urgent treatment use (n = 34), 23.6%; particularly efficacy (n = 9) and disease-based (n = 7), diagnostic testing (n = 20, 13.9 percent; especially HIV (n = 7) and sexually transmitted infections (n = 6), and antibiotic stewardship (n = 17, 11.8 %) were the most common research topics.

Frid-Nielsen et al. (2019) presented a bibliometric description on the genealogy of social science research into antimicrobial resistance. The data were retrieved by Web of Science and network analysis of citations and bibliometric couplings have been analysed. The analysis shows that academic attentiveness in AMR has enlarged significantly over the last few years and social science research continues to constitute a negligible share of total academic contributions. They suggest how the influence of social science research on the scientific discourse on antimicrobial resistance is both peripheral and blow-out tinny.

Cawcutt et al. (2019) discussed the role of online communication podiums to increase the distribution of critical publications in various medical science field and suggested the thoughtful clinical, financial, and public health influence of infection prevention and antimicrobial stewardship pooled with the unfinished uptake of best practices, multimodal approaches employing social media are important to increase the speed and reach of research.

Zheng et al. (2019) did a bibliometric analysis, to evaluate publications on antibiotics in sediments from the aspects of countries, subject categories and keywords etc. The analysis indicate that USA and China dominated studies in the recent period from 2005 to 2016.Further, the study reveals that the Applied and Environmental Microbiology and Environmental Science and Ecology respectively were the most demonstrative journal and subject and study also

reports that sorption, adsorption and biodegradation were the majority research areas under antibiotic resistance.

Gomez-Rios and Ramirez-Malule (2018) presented a bibliometric overview of global research on multidrug and antibiotics resistance from 2017-2018. A total of 2,362 records were retrieved from the Scopus database, indexed between 2017 and 2018. The consequences of this study reveal that the United States, China, and India were the most productive countries while the United States, Germany, and the United Kingdom are having the highest impact factor. Further, the study indicate that most of multidrug- and antibiotics-resistance studies focused on the so-called critical bacteria according to the WHO but less on those bacteria catalogued as high and medium priority.

Asokan et al. (2019) provided a bibliometric picture of medline-pubmed for knowledge mobilization to infection prevention and control practices in Bahrain. The purpose of the paper was to quantify published reports of AR in this group of pathogens using the Medline-PubMed databases and rank the top five reported AR pathogens globally, regionally and for Bahrain. The study reveal that 42 136 documents increased in the last five years on the mention subject. It is categorised as more high tier pathogen documents (33 640) than critical (6405) and medium (2091). It is found that Methicillin-resistant Staphylococcus aureus was the topmost documented pathogen globally and in the Gulf Cooperation Council (GCC) region zone of classification, whereas ESBL resistant enter bacteria ranked the top in Bahrain. Further the findings suggest the need for a comprehensive, multipronged policy and recommend thoughtful, integrated infection prevention and control strategies of AR in Bahrain and the GCC.

Shi et al. (2019) analysed countries, institutes, journals and keywords of 5420 articles on antibiotics in water or wastewater published between 2000 and 2017. The findings of the study show that the China is the first contributor and the USA has the highest h-index of 104 and explored that, to improve efficiency and decrease cost the new materials and technologies, such as ionizing beam

should be used. Further, the study reveals that Conversion of wastewater into fuels such as H2 and methane is the mainstream research thirst area.

Wang et al. (2019) did a bibliometric study to on drug therapy for ventilator associated pneumonia (VAP).The aim of the study was to find out the status and trends of the top 100 cited articles on drug therapy for ventilator-associated pneumonia .The data for study were retrieved from the Web of Science core collection database and time period was beginning of the database to September 30, 2018 on the VAP related articles. SPSS and VOSviewer were used for generate a term co-occurrence graph that visualized a reference pattern for different terms in the 100 articles. The study reveals that Critical Care Medicine journal published highest papers followed by American Journal of Respiratory and Critical Care Medicine with 11 articles and Clinical Infectious Diseases with 10 articles. The most dominant author was Marin H. Kollef from the University of Washington while United States and France were contributed the most articles on VAP. Further, it is also find out that the number of citations for the 100 selected articles ranged from 142 to 3,218 and all 100 articles related to ventilator-associated pneumonia were published after the year of 2000.

Xu et al. (2019) presented a Correlation Analysis of Pathways and Operons of Helicobacter pylori Resistance Genes using Bibliometric parameter. The data were collected from PubMed websites. A total of 148 genes were extracted from the literature using bibliometrics, and 46 enriched pathways were identified using KEGG. Further, the findings provide theoretical fundamentals for epidemiological prevention and strengthen our understanding of the molecular mechanism of Helicobacter pylori resistance to antibiotics.

De Freitas and Baptista (2019) did a scientometric study, to find out the numbers of South America's research and provide a full network list to encourage scientific collaborations. The findings show that the most research groups working in, antimicrobial photodynamic therapy (aPDT) are based in the North and South Americas, and Brazil leads this research field, accounting for 26% of all the aPDT publications in the world, 55% of the Americas and more

than 95% of the publications in South America alone. Further, the study reveals that aPDT is the only research topic in which Brazil publishes more papers than any other country in the world.

Ortega-Cuadros and Tofino-Rivera (2019) identified knowledge gaps and address new research topics related to the potential use of bio inputs as antimicrobial agents. The databases EBSCO, Embase, Pubmed, Science direct, Scielo and Lilacs were used for data collection. The bibliometric indicators such as year, country, bio input used and result obtained. The analysis of the study show that the bio input most commonly used was essential oils (73 %), mostly obtained by hydrodistillation (68.6 %). Both extracts and oils were found to be able to control bacterial and fungal species. Further, study reveals that registries related to the topic have been included since 1996 and it is mainly related to Brazil (59.1 %) and Colombia (18.1 %).

Qin et al. (2019) presented an overview of the state of play with regard to the research trend of antimicrobial peptides in recent years and the situation of targeting tumor cells, and statistical analysis of the patents related to anticancer peptides published in recent years, is important both from toxicological and medical tumor therapy point of view. The data were collected from Science Citation Index Expanded version and were analyzed through the Thomson Data Analyzer. The findings of the study reveal that the research and development of global antimicrobial peptides and anticancer peptides has been in an incremental mode. This study may be helpful for clinical implications for cancer treatment, especially in patients with conditions that are not currently treatable by other drugs, or that are resistant to existing cancer drugs.

Gomez-Rios and Ramirez-Malule (2018) presented evaluated the impact and the progress of clavulanic acid studies in the last four decades and carried out a bibliometric analysis of the global scientific production of clavulanic acid. The data were extracted from the Scopus database for a 43-year period of study i.e. 1975–2017. A total of 39,758 records were found out in the field of clavulanic acid. The findings of the study show that numbers of publications on

clavulanic acid have grown in three phases that is (1975–1999, 2000–2003 and 2004–2017). Further the study explore that Medicine was the main subject area for clavulanic acid studies, whereas biochemistry, genetics and molecular biology were areas of research for CA production while the United States, France, the United Kingdom, Spain and Brazil were the leading countries in the scientific production of studies on clavulanic acid and its related discipline.

Sweileh (2018) presented a bibliometric study on transgender health literature for 1900 - 2017.The data were retrieved from the Scopus database using keyword "transgender health" for time span 1900 to 2017.A total of 5772 peer-reviewed documents were retrieved on transgender health. Findings of the study show that the 86.8 % articles were written in English language. VOSviewer software was used to mapping the author keywords while ArcGIS 10.1 software was used to mapping the geographical distribution of the retrieved documents. Further, study reveals that the Professor Gooren, L.J.G. was the prolific author with 104 (1.88%) in the transgender health literature publications.

Ekundayo and Okoh (2018) carried out a bibliometric analysis that aimed to examine publication trends in Plesiomonas related research by time and place, international collaborative works, find gaps and recommend directions for future investigation. The data were retrieved from the Web of Science database using keyword "Plesiomonas Shigelloides". The analysis of the study indicates that average of publication was 5.54±2.66 articles per year and an annual growth rate was recorded −0.8%. Further, the study reveals that the United States ranked first with 29 articles and 451 citations and most research thirst area were traced Plesiomonas shigelloides ,lipopolysaccharide and nuclear magnetic .

Xu et al. (2018) did a hotspot analysis of sepsis literature. This strategy organizes for hotspot research, were lead using a co-word matrix using BICOMB software and Ggluto software. 2511 studies were selected related to the treatment of sepsis within the past 5 years as research samples. Findings show that the 41 high-frequency words, text, and co-word matrix were conducted within the 2511 studies .Further; the study shows that the relationship between the prognosis of

sepsis and the hematological prognosis was in the fourth quadrant of the deliberate diagram.

Zheng et al. (2018) carried out a bibliometric study on antibiotics in aquatic systems for the period of 1945–2017. The findings of the study reveal that early research on antibiotics in water was mostly performed in America and Europe, while, in recent years, publications for the same subject was dominated by China and the USA. The journal Chemosphere published highest articles and the tetracyclines in wastewater were most studied class. Further it is suggested that ARGs is a major public health concern and much attention should be directed at the problems with antibiotics in the future studies of water.

Zama et al. (2018) presented a Bibliometric analysis for the past 10 years to determine the increasing trend in research related to biochar in soil for contaminant remediation. The findings of the study indicate that biochar has grown over the years with significant focus on its properties, and how these affect biochar's ability to immobilize organic and inorganic contaminants in soil. Further some recommendations are made aimed at stimulating future research in areas where significant knowledge gaps exist.

Urbanetto et al. (2018) presented the scientific proof published in literature regarding the risk factors for the development of phlebitis. A total of 14 original articles selected from the LILACS, Scielo and PubMed databases .It is analysed by levels of proof and frequency, associated factors, degree and cure of phlebitis. The study shows that the most articles reported an association of phlebitis with risk factors, including the dwell time. Further, it is suggested that there is a need to be developed in order to grant a real understanding of this disease in the daily routines of a hospital.

Sweileh et al. (2018) carried out a bibliometric study on Antimicrobial resistance (AMR) among uropathogens. The data were collected from the Scopus database and SPSS and VOSviewer software were used for data analysis. A total of 1087relevant documents were retrieved for the period 2002–2016 with an h-index of 50. Findings of the study show that 615 (56.6%) were in

epidemiology followed by 275 (25.3%) articles in molecular biology or microbiology or in immunology and pharmacological with 197 (18.1%). Mean value of the author was counted 5.3.The USA secured first position with 148 (13.6%), documents followed by India 97 (8.9%) and Iran 84 (7.7%). Tehran University of Medical Sciences was the most productive institution followed by Kobe University in Japan. The Journal of Antimicrobial Chemotherapy published highest articles. Further, it is concluded that publication on AMR among uropathogens are increased in the past decade.

Zhang et al. (2017) presented studies relevant literatures at home and abroad in recent years for acute pharyngitis treated with traditional Chinese medicine from 2006, to 2016. The study was based on bibliometric parameter. A total of 493 papers were retrieved but finally 182 articles were selected for the study. Findings of the study show that Traditional and Western Chinese medicine have their personal individualities in the treatment of this disease and further, it is indicated that the Traditional Chinese medicine doctors are having rich experiences in the treatment of the syndrome differentiation, safe and reliable medication, significant curative effect, low drug resistance. Traditional Chinese medicine forms are more convenient portability and charging low price, and reduce side effects.

Tian et al. (2017) provided a detailed calculation of the hundred most cited articles in microbiota of diabetes research using bibliometric technique. The data were collected from Web of Science databases published from 2007 to 2015 and hundred most-cited publications in microbiota of diabetes research were selected for further analysis based on bibliometric indicators i.e. authorship pattern, citations count, article type, source journal, geographic origin etc. result of the study show that number of citations ranged from 1289 to 35 for 100 most cited publications,59 journals published the 100 most cited articles and 24 countries and 174 scientific research institutions participated in those researches. The USA published the highest 32 papers followed by Belgium with 22 papers and Patrice D. Cani was the prolific author with 15 papers .The study

provide a list of intellectual milestones that are focused on microbiota of diabetes research in the past decade.

Mitchell et al. (2017) explored the trends in infection control peer-reviewed journals, mainstream media, and blogs written by infection control professionals. The data were calculated using word frequencies. For the study, a total of 1,059 journal articles were initially identified but at last 961 articles were remained for final study. The findings of the study show that the terms 'superbug' and 'antibiotics' were most generally used for the titles of news websites and newspapers while the terms 'infection' and 'prevention' were most generally used in infection control websites or blogs.

Sweileh et al. (2017) carried out a bibliometric study on multi-extensively, and totally drug-resistant tuberculosis. The data were collected from the Scopus database using multidrug resistant (MDR), extensively drug-resistant (XDR), and totally drug-resistant (TDR) tuberculosis keywords for the time span 2006-2015. In this study Year-wise publication, most productive countries, most prolific institutions, collaboration, most prolific authors, most productive journals and citation, etc. were analysed. A total of 2260 journal articles were identified on mentioned topic. Findings of the study reveal that the average citations were analysed 7.0-16.0 per article. Three main countries India, China, and South Africa were published most of articles. Molecular biology, co-infection with HIV, and new anti-TB drugs were the thirst are of mostly publications

Sweileh et al. (2017) carried out a bibliometric overview of literature on triazole antifungal drug resistance. The data for study were collected from the Scopus database using “triazole drug class and resistance” keyword for1980 to 2015. The bibliometric parameter such as growth of publications, the most active countries and institutions, the most cited articles were analysed. Findings of the study show that a total of 1648 journal articles were retrieved from the Scopus database and calculated an average of 20.46 citations per article. The study reveal that the United States of America ranked first in productivity with 27.06%

publications followed by the United Kingdom with 10.68% and China 8.07%. Radboud University Nijmegen Medical Centre, Netherlands was ranked on top institution while the most articles published in journal Antimicrobial Agents and Chemotherapy on triazole resistance. The study concluded that growth of publications on triazole resistance in the past two decades is increasing pattern.

Al-Jabi (2017) carried out a bibliometric analysis on West Nile Virus (WNV) for 1943 to 2016 at global level. The purpose of the study is to analyse the quantity and quality of publications indexed in Scopus database. The data were retrieved from the Scopus database using West Nile Virus (WNV).Year-wise publications, Document type, prolific authors, affiliated institutions, countries, language of publication, prolific journals, citations, and collaboration patterns were analysed. A total of 4729 publications were retrieved for 1943 to 2016 on West Nile Virus (WNV). Findings of the study show that the USA was on the top to publish WNV research with 2304 (48.7%) publications, followed by France with 224 (4.7%) publications. Further study reveals that the Emerging Infectious Diseases was the most productive journal with 227 articles, followed by Journal of Virology with 162 publications.

Lin et al. (2017) carried out a bibliometric analysis to identify the 100 most cited papers on the cataract surgery. The data for the study were collected from the literature search on the Thomson Reuters Web of Knowledge database. Authorship pattern, year of publication, major subjects, journal of publication, country and institution of origin of the articles were analysed. For find the correlation between the published year and the number of citations, the Pearson's correlation analysis was applied. The findings of the study show that the paper focussed on endophthalmitis have more citations that were mostly published by European Society of Cataract & Refractive Surgeons (ESCRS) group. The USA published highest number of publications and also published from American institute i.e. Johns Hopkins University, Harvard Medical School, etc. Further the study reveal that the latest 5 years citations and ACY were significantly related with the published year.

Sweileh et al. (2016) carried out a bibliometric study of literature on carbapenem resistance published from 1986 to 2015 and indexed in Scopus database. The data were collected from the Scopus database using carbapenem resistance keyword. Retrieved data were analysed by appropriate bibliometric indicators and visualization maps presented by visualization software. A total of 2617 journal articles were retrieved with average number of citations 21.47 per article. Findings of the study show that 9 % of retrieved articles were published in Antimicrobial Agents and Chemotherapy journal while The United States of America contributed as first rank with 437 (16.70 %) articles followed by China with 257 (9.82 %) articles.

Daughton (2016) presented a bibliometric analysis on Pharmaceuticals and the Environment. Objectives of the study were to provide a new outlook to the topic, to enable more efficient and effective review of the literature by others, and to identify the more significant, seminal contributions to the advancement of Pharmaceuticals and the Environment. Findings of the study identified that some articles began to appear in published works in the 1940s and earlier, while others only began to receive attention in the 1990s and later. Further, the study identified a core group of articles which are received at least 200 citations, in which one article had received 5424 citations.

Doull (2016) did a study on Cystic Fibrosis Papers of the Year 2015the study reveal that the last year has expanded our knowledge of potential disease modifying agents in the treatment of class II, III and IV CFTR mutations. The study presented the first report of an efficacious gene therapy for Cystic Fibrosis and gave an important message on increasing use of conventional chronic therapies even in milder disease, and the pernicious effect of chronic infection on pulmonary function.

Ohlendorf et al. (2016) presented a scientometric analysis of Osteomyelitis literature published from 1900-2009 and indexed by Web of Science databases. The data were collected from ISI web of science databases and Equalizing Density Map Projection are used for visualize the structures of

the global research. A total of 12632 publications were retrieved. The findings of the study show that maximum papers were published in surgery, orthopedics, internal medicine and radiology osteomyelitis subject. The result of the study also indicate that this research is centrally focused in North America and Europe, with further strengthening of cross-linking international research expenses as area of further efforts.

Linares et al. (2016) presented scientific evidence supporting the gut microbiome in relation to health maintenance and links with various disease states afflicting humans, from metabolic to mental health using bibliometric technique. Findings of the study indicated to improve microbial balance in the intestinal tract and promote the return to a baseline microbial community following a perturbing event (dysbiosis) such as antibiotic therapy.

Diaz et al. (2016) evaluated research productivity of swine diseases using bibliometric indicator and H-Index. In this study, a database of 137 pig infectious agents were constructed, including its taxonomic division, zoonotic potential, status as emerging pathogen and whether it was OIE-listed. Bibliometric indicators were used to evaluate research productivity outcome on swine diseases. The H-index and the total number of citations were calculated for those pathogens and the location of the affiliation of the first author of each paper included in the H-index core was registered and, for the ten pathogens with the highest H-index, evolution over time was measured.

Zyoud (2016) presented a bibliometric analysis on Global research trends of Middle East respiratory syndrome coronavirus. The data were retrieved from Scopus database for MERS-CoV publications published between 2012 and 2015. The purpose of the study is to ranked year of publication, publication type, patterns of international collaboration, research institutions, journals, impact factor, h-index, language, and times cited. A total of 883 research publications were published across the world on MERS-CoV. Findings of the study reveal that the USA was on the top with 319 articles published over 4 years, followed by KSA (113 articles).The total citations calculated 8,015, with an average of

9.01 citations per each publication. The h-index was 48 for MERS-CoV publications. Further, the study observe that the USA have the highest h-index (32), followed by KSA (26) and Netherland produced the greatest publications with (72.7 %) followed by the UK (71 %).

Sweileh et al. (2016) presented a bibliometric analysis of Campylobacter literature. The data were collected from the Scopus database using the keywords (Campylobacter/campylobacteriosis, C. jejuni, C. coli) for 2000-2015. In this study year-wise publications, annual growth rate of publications, country -wise, collaboration pattern, and citation analysis etc. were analysed. Hirsch index and impact factor of journals were observed by Databases. A total of 5522 articles were retrieved on Campylobacter with h-index of 113. The findings of the study reveal that the Applied and Environmental Microbiology journal and Journal of Food Protection were published highest papers on Campylobacter. The USA was the most productive country while at institutions level; Danmarks Tekniske University was identified as the highest productive institution. Further the study show that the Netherlands was the most collaborative country with 57.7%) while France was the lowest collaborative country with 33.5% of articles. 50.1% of articles were published in the "Immunology/Microbiology" subject while the article molecular biology/genetics and public health burden of campylobacteriosis got highest citations.

Sweileh et al. (2016) carried out a bibliometric study on carbapenem resistance. The data were collected from the Scopus database using keyword carbapenem resistance for 1986 -2015.In this study the bibliometric indicator such as year wise number of publications, most prolific authors, most prolific journals, Top productive countries , Most dominant institutes, co-authorships, highly cited articles, international collaboration, citation analysis on carbapenem resistance were observed. The retrieved data were analysed through SPSS and Visualization map software. A total of 2617 journal articles were identified on carbapenem resistance at global level. Findings of the study show that the average citation was 21.47 per article and Antimicrobial Agents and Chemotherapy journal published the highest articles on carbapenem resistance.

Further the study indicates that the United States of America was at top contributor with 437 articles followed by China with 257 articles. Europeans institutions were the dominant followed by Asian institutes for the carbapenem resistance research.

Head et al. (2015) described the publication trends for UK pneumonia R&D investment published outputs 1997-2013.The study show that the Translational pneumonia research (33.3%) received increased funding compared with 1997-2010 where funding was almost entirely preclinical (87.5%, here 30.9%). Further, the findings of the study show that there has been a welcome growth for pneumonia funding awarded to UK institutions in 2011-2013 associated with 1997-2010 and publication productivity concern to pneumonia rose steadily from 1997 to 2013. This study recommended that though global mortality of pneumonia is declining, it should still be an area of high priority for funders, policymakers and researchers.

Santibanez et al. (2015) carried out a bibliometric study on Primary Literature in the Field of Antimicrobial Stewardship published during 2000-2013. A total of 305 publications were identified from PubMed Data base using the term "antimicrobial stewardship" to retrieve existing publications within this area of study but only 88 (29%) were found to be primary literature investigating an AS strategy. Findings of the study reveal that North America produced the largest number of publications i.e.58, followed by Europe (14) and Asia (12). The journal Infection Control and Hospital Epidemiology published the most articles on Antimicrobial Stewardship during 2000-2013.

Vera-Polania et al. (2015) quantified the research output of dengue literature contributed by Latin Americans. The data were collected from SCI, MEDLINE/GOPUBMED, Scopus, SCIELO, LILACS on dengue literature. Document types, year-wise, country-wise, prolific journals and prolific authors, citations and H index were analysed in the study. Findings of the study were calculated separately for each database. A total of 2598 articles were retrieved by SCI database, 2646 articles by Scopus database, 825 records by SCIELO, and

1178 articles were retrieved by LILACS database. Findings of the study show that Brazil was the highest contributor as all databases. H-index is recorded 35 as Scopus database.

Breugelmans et al. (2015) presented a study on research output of poverty-related diseases in the context of European and African researchers. The data were collected from web of Science database using searching term title abstract and keywords for 2003-2011. Findings of the study reveal that 33% of global publications were accounted to European researchers while 10% publications were accounted to African researchers. Malaria was the dominant field in which highest publications were counted 43.4 % by European researchers and 22.2 % by African researchers.

Rajshekhar (2015) presented a study on a true legacy of neurosurgery. For measuring the excellence for neurosurgical research, one can use the help of indices such as the h-index and i10 index is not sufficient. The study indicates that No single measure, whether for surgical excellence or excellence in research, however, incorporates a measure of qualities such as empathy, integrity and mentorship. These intangible qualities should be an integral part of the assessment of a neurosurgeon and his/her work.

Sweileh et al. (2015) assessed the scientific research output on infectious diseases of Arab countries and compared to non-Arab countries. The data for study were extracted from Web of Science database during the time span 1900-2012 using the keyword "infectious diseases". A total of 227188 articles were retrieved at global level, in which 2408 publications were identified from Arab countries on infectious diseases. Findings of the study show that only 1.06% of worldwide research output was from Arab countries. Egypt was ranked at first position with 464 publications while Kuwait University published highest number of publications i.e.158 publications. Further, the study reveals that the average citations were calculated 13.25 per articles and h-index was 64. Tuberculosis, malaria, and hepatitis were the top three subtopics under infection

diseases, in which (230; 9.55%), (223; 9.26%), (189; 7.8%) articles were published respectively.

Addicks et al. (2014) carried out the first combined density-equalizing mapping and scientometric analysis of Methicillin-resistant Staphylococcus Aureus (MRSA) research and illustrates the global MRSA research architecture. The data were collected from the Web of Science database from 1961 to 2007.A total of 7671 articles were retrieved on MRSA. Findings of the study show that the USA is the leading country with a total output of 2374 publications, followed by the UK (1030) and Japan (862). Purtagal scored highest citation with a rate of 35.47 citations per article, followed by New Zealand and Denmark.

Liu et al. (2014) did a bibliometric study of treatment with linezolid for nocardia infection over 2013. The PubMed, SCI, Embase, and CNKI are used for data collection and year-wise growth, corresponding authors and research institutions, types of literature, contents and cited frequency variable considered for analysis the result. A total of 349 papers were identified but finally 163 papers were considered for study. The result of the study shows that 77 case reports (49.68%) in the papers were the main type of literature in which 27 reports of nocardia infection treated with linezolid. The study also identifies the list of cited paper and its number of citations and described various case reports on cause of infection, clinical manifestation, diagnosis, treatment status and efficacy of linezolid.

Brandt et al. (2014) presented a study on antibiotics and antimicrobial resistance using scientometric data. A total of 54 000 publications related to 'infectious diseases' and 50 000 publications related to antimicrobial resistance' were extracted by using the semantic search engine 'Go PubMed' since 19740. Finding the study provides a fast, reliable and global overview of the clinical and public health importance of a specific resistance including the period of the 1940s-1980s.

Rodriguez et al. (2014) carried out a study to analyse the contributions by Mexican investigators for the understanding of the mechanisms of bacterial

antibiotic resistance. For the study, the data were collected from PubMed databases indexed between 1973 and July 2013.The study indicate that the Author productivity extended to metallo-beta-lactamases, carbapenemases, spectrum beta-lactamases resistance mechanisms of Pseudomonas aeruginosa. This study also states that Mexican literature on the mechanisms of bacterial resistance will prove to be relevant in organizing antibiotic resistance crises and developing plans.

Chen et al. (2014) presented a bibliometric study on compost research. The data for study were collected from ISI Web of Science for 1997-2012 using keyword "compost". The bibliometric parameter such as publication year, type, language, articles type, countries, subject, journals, and author keywords were analysed. Findings of the study shoe that publications under compost were increased rapidly over the last 15 years. Further the study point out that the Developed countries were dominant compared to developing countries but the publications of developing countries had been considerable progress during the study period.

Geronimo (2014) described the frequency of dose notification of anti-infective for systemic use in clinical cases published in the journal Revista Espanola de Anestesiologia Reanimacion. The date was collected through the journal Revista Espanola de Anestesiologia Reanimacion from 2010 to 2012. The findings of the study show that the published 167 articles were cited 1317 times. Further the study indicate that 73 of the citations regarding to drugs belonging to Anti-infective which was divided into perioperative prophylaxis (n. = 15) and active treatment (n. = 58).

Akcan et al. (2014) presented a citation analysis of clinical research articles. Propose of the study is analyse to which extent citation frequencies and journal impact factors correlate with the methodological quality of clinical research articles. The data were extracted from the SBU systematic review "Antibiotic Prophylaxis in Surgery". A total of 212 papers were received. Findings of the study show that the Bibliometric indicators are not a valid means

by which to assess methodology quality in clinical trials of antibiotic prophylaxis in surgery, while funding for most research is provided on the basis of bibliometric assessment.

Mousavi et al. (2013) carried out a bibliometric study of rational use of medicines in Iran. The objectives of paper was to asses scientific output on rational usage of drugs in Iran with a bibliometric analysis of publications. The data for study were collected from Google Scholar, Pubmed, International Pharmaceutical Abstract, Web of Science, CINAHL, Proquest, and Persian databases including SID, MagIran and Iran Medex. A total of 668 papers were identified from all database but after verification only 466 articles were included for study. Findings of the study reveal that the most cited topic was Antimicrobial resistance and adverse drug reaction and articles Published on rational use of drugs research in Iran has undergone an important increase during last ten year. Result of the study also show that after 2001, Number of publications increased more than 10 times.

Suarez (2012) presented a bibliometric and social network analysis of the reputed Infectio journal. The data were collected from Medline and Scopus databases to compare the publication by topics and the citation. A total of 15 volumes of the journals articles were identified during the period from 1995 to 2011.The bibliometric variables such as production rate, collaboration, citation and visibility were analysed. Findings show that a total of 303 articles were published during 1995 to 2011, in which 49.19 % articles were original. Further, the study reveal that the microbial drug resistance, tuberculosis, toxoplasma, and HIV were accessed frequently and impact factor calculated 0.18 to 0.59. Neutropenia and HIV were cited mostly.

Xiong et al. (2012) review and evaluate the global clinical research literatures that were based on the principles of evidence-based medicine, and parameters of bibliometrics. The data for study were collected from the PubMed database and the times span was selected from January 1st 2000 to April 10th 2011.A total of 388 articles were retrieved for the study. The findings show that

average age of patent calculated from 10 days to 83 years old and publications of Americans were ranked as the first position while with collaboration to European scientists they had been published 36 papers (44.44%) whatever Chinese scholars published only 2 papers in English language.

Esterle and Picard (2011) presented a study on the Journal of the History of Medicine and Allie Between clinical medicine and the laboratory-based on bibliometric parameters. In this study, medical research eventually led to science-based medicine that today in France Popular is made the main causes. This study show the important features of biomedical research, which one affects the funding systems for clinical research and the development of a system of research grants that will be helpful for new funding agencies.

Luiza et al. (2011) observed the hot topics within respiratory infections literature published in the last trimester of 2009 and in 2010. The findings of the study reveal that the core publication under respiratory infections were published from the British Thoracic Society guideline and other core publication belong to respiratory infections were published under SEPAR-SEIMC and use of interferon-gamma publication are concerned to the diagnosis of tuberculosis infection.

Rosas et al. (2011) reported a bibliometric analysis for evaluating research and its impact. The data were extracted from the NIH/NIAID HIV/AIDS clinical trials networks for 2006-2008.Most prolific authors , journals, visualization of co-authorship and evaluate the presence of publications, collaboration pattern and interdisciplinary across the inventiveness and co-authorship outlines were analysed in this study.

Heneberg (2011) conducted a bibliometric study on cyclization, MALDI-TOF, and antibiotics in Chinese prospective. The protocol of Li and Willett were used in this study. He tested the reported increases are methodical artifacts or they reflect the real trends. Findings of the study indicate that the non-random absence of abstracts and address fields in some references affects the trends of publications and using the topic search instead of title is reported more

publications output. The study suggested that inappropriately designed search procedures and methodology may influence or confuse the publications output.

Li and Willett (2010) presented a bibliometric analysis on cyclization, MALDI-TOF, and antibiotics in the context of China and compared their research output to USA, Germany, and Japan. Analysis of the study show that the research output of Chinese research on cyclization, MALDI-TOF, and antibiotics are growing rapidly. It is not growing in number of publications of Chinese research but the impact factor of the published work is also very high. Further, the study reveals that Chinese Academy of Sciences plays the dominant role for the publications of china research and It has also been recognized that national and international collaboration patterns of writing also do not increase the number of citations.

Van and Waltman (2010) published a research paper in Scientometrics Journal on Software Survey: VOSviewer ; a computer program for bibliometric mapping. This paper was in three parts, in the first part they overviewed VOSviewer, in the second part they discussed about the technical implementation of specific parts of the program and in third part they demonstrated bibliometric data by using the program to construct and display a co-citation map of 5,000 major scientific journals. After that they launched VOSviewer software for public use.

Zheng et al. (2009) concluded a bibliometric analysis on John Cunningham Virus. The data were collected from Sci-expanded and PubMed database. They ranked highly-productive authors, highly-cited authors, top ten journals and most productive countries etc. They further examined the highly-cited articles were subjected to co-citation and chronological analysis with highly-frequent MeSH words for co-occurrence analysis. A Total of 1785 articles were retrieved from Sci-expanded and 1506 from Pubmed on John Cunningham Virus. Findings of the study show that the USA, Japan and Italy were the largest three productive countries on John Cunningham virus. Temple University published maximum128 papers and ranked the first, followed by

University of Tokyo. Khalili K and Yogo Y was the core authors published more than 20 articles. Journal of Neurovirology published more than 15 papers and ranked the first. Padgett, B.L. and Berger, J.R. were the first two highly-cited authors. Journal of Virology and Journal of Neurovirology respectively ranked to the first two highly-cited journals.

Uthman (2008) presented a bibliometric study on Nigeria's SCI publications in HIV/AIDS from 1980 to 2006. The data were collected from ISI databases for the period of 1980 to 2006 on HIV/AIDS literature. Purpose of the study is to identify the authorship patterns, articles type, institutional affiliations, subject content and International collaboration etc. findings of the study show that number of publications and international collaborations had been increased on HIV/AIDS literature. The USA was the most collaborative country for Nigeria's HIV/AIDS research and about 85 % papers were authored by two or more than two authors.

Cai et al. (2008) carried out a bibliometric study on biofilm research over the last 10 years in the context of Chinese research output. The purpose of the study was to find out the research output on Biofilm research on china based. The data were collected from pubmed, China Hospital Knowledge Database and VIP Chinese Journal Database from 1997 to 2007.In this study the bibliometric indicators i.e. literature count, affiliated institutions, financial assistance, contents analysis, and collaborative, etc. were analysed. A total of 240 Chinese papers were retrieved from above mentioned data base. The findings show that the college affiliated to china were the leading research output and the thirst areas of the research were pseudomonas aeruginosa and staphylococci. Further, the study reveals that the antibiotics currently available are very useful for biofilm control.

Schadel-Hopfner et al. (2008) presented a detail study on Evidence-based hand surgery and investigated whether increasing importance of evidence-based hand surgery is reflected in the actual status of Cochrane reviews. Findings of the study reported that out of a total of 14 fourteen Cochran reviews, five

reviews were in the area of distal radial fracture and four related carpal tunnel syndrome. In addition, the relationship with the antibiotic has been detailed. All of these reviews have been reported to have influenced methodological flaws and significant clinical heterogeneity of the included studies.

Matthys et al. (2007) presented a bibliometric analysis for evidence in national guideline for the management of acute sore throat in adult. The data for study were retrieved from MEDLINE and EMBASE databases. A total of ten guidelines were retrieved in which 4 are connected to North American and 6 are connected to European guidelines. The study show that recommendations differ with regard to the use of a rapid antigen test and throat culture in different country and the North American guidelines (87.2%) were cited than European guidelines (48.0%).the study also indicate that there is a lacking of transparent and standardized guideline and the findings of this study are play a very important role in the context of appropriate antibiotic use, the problem of growing antimicrobial resistance.

Van and Waltman (2007) presented a paper in annual conference of the German Classification Society on VOSviewer: A new method for visualizing similarities between objects. In this paper they explored the steps and methods for graphical representation of bibliometric data by computer software.

Pulver and Tett (2006) explored the critical evaluation of recent journal articles which cover the Medline definition for drug utilization review and multiple healthcare sites. The data were collected from PubMed using MeSH topic drug utilization. A total of 646 papers were identified, in which 495 (77%) did not meet the definition for drug utilization review, while 151 (23%) articles were selected for final study. Findings of the study show that 35 studies were used for DUR and eight directed an intervention while three delivered feedback to the prescribers. Further it is also found that most of DURs were not directed across a number of centres and most DUR presented an initial audit only and it is not completed the quality cycle with intervention and feedback.

Hirsch (2005) introduced h-index in 2005 in his paper "An index to quantify an individual's scientific research output". He defined the term h index as "A scientist has index h if h of [his/her] Np papers have at least h citations each, and the other (Np−h) papers have at most h citations each Or in other words, a scholar with an index of h has published h papers each of which has been cited at least h times"

Ramos (2005) conducted a bibliometric study to investigate the scientific production on antimicrobial agents and susceptibility tests based on Spanish authors from 1990-2002.The articles published and indexed in the MEDLINE database (WEBSPIRS version 4.2) were considered for the study during the period 1990-2002. A total of 5,259 articles were retrieved in which 1,041 (19.8%) articles were identified as antimicrobial agents. Findings of the study reveal that the Journal Antimicrobial Agents and Chemotherapy published most 183 (17.1%) articles on antimicrobial agents while hospital contributes highest number of articles 571 (54.9%) followed by universities 351 (33.7%). Further the study show that the institute Ramon Cajal Hospital published highest articles followed by the Seville University Faculty of Medicine. Finally the study conclude that the scientific research output of Spanish researchers on antimicrobial agents had been increased during the period 1990-2002 and hospitals were the most productive canter for the highest publication on antimicrobial agents and susceptibility tests.

Cyranoski (2004) presented a bibliometric study of scientific publications based on Chinese research. The study explore that the production of Chinese research is improving to some extent in the number as well as its quality. It has also been noticed that the improvement in research output in other countries tested by the authors was not correct, most of which operated in the years 1991 and 1973, despite lack of sufficient stimulus in the context of higher science funding or new policies.

Glover and Bowen (2004) concluded a bibliometric analysis of research published in Tropical Medicine and International Health during 1996-2003. The

study report the bibliometric profile of Tropical Medicine and International Health using the subjects of the articles published and the geographical distribution of the authors. In this paper they also highlighted most common subject areas of papers published during 1996-2003 and delivered a list of the most cited papers.

Macias-Chapula (2000) presented a bibliometric analysis on AIDS in Haiti. The data were collected from AIDSLINE database for the period 1980 to 1998 on Haitian AIDS research. Propose of the study is to identify the patterns of the growth in AIDS literature, as well as the types of documents published, authorship, institutional affiliations of authors, and subject content. Findings of the study indicated that most of the articles were published in Journals. The United States, Haiti, and Canada were the main productive countries on Haitian AIDS research. Further the study reported that the mostly AIDS papers are focused on epidemiology, complications, and trends issues.

Garciaaltes et al. (1999) presented a socioeconomic analysis on antibiotic resistance based on bibliographic search. The purpose of the study is to review the economic literature in the context of antibiotic resistance. The data were collected through the bibliographic search in the main biomedical databases. Two studies were identified which is influenced the economic aspect on the appearance of antibiotic resistance. Findings of the study estimated that the minimum cost of the hospital has gone between $ 1300 million and net social cost between $ 100 and $ 30,000 million which is based on the review of Economic Literature with reference to antibiotics

In this way, the literature relating to basic bibliometrics rules and more than a hundred studies allied to antibiotics and bibliometrics or scientometrics has been reviewed in this chapter. After reviewing the existing literature, it has been observed that standard bibliometrics and scientometrics techniques such as Bradford, Lotka, and Zipf's terms and activity index, growth rate, collaboration index, etc. have been used by previous authors. In addition, the citation counting was emphasized in most of the research papers, and many studies incorporating

recent techniques of bibliometrics or scientometrics. The researcher has also used some software and techniques that have not been used in earlier studies such as citation maps, co-authored visualizer maps, historical maps, bibliographic coupling maps, co-word maps, and more. On the basis of the review, it was also known that a lot of studies are being done in the medical field by scientometrics and the subject of this study is progressing not only in India but also in other parts of the world. Finally, it has been found that no study has been attempted on the Indian contribution to antibiotics research productivity. The researcher has therefore chosen scientometrics as the subject area and analysed the productivity of antibiotic research included in the Scopus database during the period 2011–2020.

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CHAPTER-3

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

The method of calculating and collecting data is the backbone of any research. It is an important part of the research process through which researchers have to conduct their research work. Through the literature review, the researchers determine their problem and purpose and then calculate the results from the data obtained using a certain method. This chapter discusses the research problem, purpose, hypothesis, data collection, and data calculation method, as well as all the research methodology that has been used during the research process. It covers the research method of study from the selection of the research problem to the obtained result. Therefore, the purpose of this chapter is to enlighten all the procedures used by the researcher to complete their research work.

3.2 RESEARCH PROCESS OF THE SCIENTOMETRIC STUDY

Different types of research problems have their own research procedure or method. Scientometrics have their own defined research procedure. Scientometrics or bibliometric study is a numerical analysis of the research productivity of literature, subject, part of subject and institution, etc. So for this type of study, we first select an institution, journal, subject, part, or keyword. After the selection of the problem, we study the literature review of the proposed problem, which may affect the scientific demand and originality of the proposed study. After defining the title studied under the scientometric study, the first challenge for the researcher is the choice of the scientific research platform i.e. database(s) that forms the base of the study. Determining the scientific research platform is a difficult task, it has a significant impact on our scientometric studies, so it must be determined carefully to achieve a clear result and avoid re-evaluation. This scientific research platform is an important tool for data mining

in order to complete research work, so we should choose the database related to the subject of study in which maximum data can be found as well as to fulfil the objectives of our study.

Scopus, PubMed and Web of Science, etc. enable the extraction of data required to perform scientometric analysis. In this study, the Scopus database is selected for data collection due to a robust database as scientific research platforms and the reasonable availability of search filters that provided access to thousands of Indian scientific articles on antibiotics published by publishers such As Elsevier (www.sciusirect.Com), Emerald (www.emeraldinsight.com), Springer (www.springerlink.com), Willie (www.wiley.com), and Taylor & Francis (www.tandfonline.com), and etc.

The search strategy for publications on the proposed topic begins after scientific research platforms (databases) are determined. To achieve high-quality relevant data mining, the search strategy must reliably reflect the research topic, study objectives, and limitations of the research field. For more assertive results related to the prescribed problem, it is recommended to use Boolean expressions "and" /"or"/ "not" and follow the rules for searching in databases. During the search publications in databases, specific conditions of the area under study should be sought primarily in the form of title, keywords, and abstract of the articles. Among the variety of documents available on databases, articles, book chapters and reviews published in journals are the most reliable sources for scientometric study, as they are peer-reviewed in their full version. Great care must be taken to extract data through a database. It is also recommended that the title of the article be analysed to verify its suitability for the purposes of the study. If there is any doubt after the title examination, it is necessary to read the article abstract. After extracting the data from the determined database, the data should be analysed using different bibliographic parameters keeping in mind the proposed objectives.

3.3 STATEMENT OF THE PROBLEM

The problem selected for the current study is entitled "Indian Contribution to Antibiotics Research: A Scientometric Study" with the Scopus database during 2011-2020. Since antibiotics are directly related to our lives, so it is very important to know what Indian research output is being done in this field. During the literature review, it has been found that few studies have been done on the research trends in the scholarly literature on various disciplines of medical science with different databases but there has been no comprehensive study the assessment of Indian contribution to antibiotics research with the Scopus database during 2011-2020. Therefore, there is a need to assess and map the strength of Indian scientists in scientific production in the field of 'antibiotics', which aims to provide a scientometrics overview of Indian scientists on antibiotics research in the world level.

3.4 OBJECTIVES OF THE STUDY

The scientometric study of publications on antibiotics research by Indian scientists and researchers are completed with the following objectives:

i. To study the contribution of Indian scientists and to compare India's performance with the world's performance in the field of antibiotics research.

ii. To analyse country wise, language-wise, communication channel distribution of research work on antibiotics.

iii. To examine the various growth pattern such as AGR, RGR and doubling time of the literature.

iv. To identify the core journals and prolific authors in the research.

v. To study the authorship pattern in the context of single and multiple authors.

vi. To examine collaboration patterns.

vii. To find out the applicability of Bradford's law and Lotka's law in antibiotics research in India.

viii. To study citation patterns on antibiotics research.

3.5 HYPOTHESES OF THE STUDY

The following hypotheses are formulated and tested:

i. India is the leading country in antibiotics publication in the World.

ii. English is most preferred language and USA is most productive country in antibiotic research.

iii. The proportional growth rate on antibiotics is almost the same in India and the world.

iv. Journals are most preferred communication channels for research publication.

v. Joint authorship publications are preferred for research publication.

vi. Collaboration between 2 to 4 authors is more prevalent among authors.

vii. Degree of Collaboration is high in research publications

viii. Bradford's law of scattering of journals and Lotka's law of scientific productivity is applicable in this research.

3.6 SCOPE AND LIMITATIONS OF THE STUDY

Antibiotics research literature output, though available in parallel another database sources also but in this study, no one database has been included for publication measurement except the Scopus database. The scientometric study is focused on the productivity of antibiotics research for ten years i.e. 2011-2020 only, so papers published up to 2010 and in 2021 have been excluded from the study.

3.7 DATA COLLECTION

The Scopus database launched in the year 2004 by Elsevier has been chosen as the data collection platform for this study. This database has indexed the largest online bibliographic database and inclusivity journal articles including social and physical science articles from all major subjects published since 1966. This database offers more citation analysis than PubMed, Web of Science, etc. The Scopus database contains the personal identity of the author of articles published in indexed journals, as it contains articles on an affidavit by the author and co-authors. This database allows different rewrites for authors with similar names, and if an error is found, authors can report errors or omissions to maintain the accuracy of their listings. Whereas in contrast, PubMed, Google Scholar, and WOS all group authors to search for specific strings of text, so that authors with similar names are no different.

The Scopus databases offer the largest collection of articles of Indian scientists in the field of antibiotics. A major strength of this database is that it provides adequate coverage of the most important and influential journals and core literature internationally in science & technologies as well as antibiotics. Throughout this study, a scientific search platform Scopus has been used to conduct the proposed methodology and to collect bibliographic data for analysis. The main reason for using Scopus is the multi-disciplinary of these databases. They cover relevant and extensive collections of Indian scientific publications and provide huge information about a publication that is very important for scientometric study.The study was extracted from articles on antibiotics published over a 10 year period starting from 2011 to 2020. For the purpose of covering all available articles on the antibiotics, the search keyword (TITLE-ABS-KEY(antibiotics) AND PUBYEAR > 2010 AND PUBYEAR < 2021) and (TITLE-ABS-KEY (antibiotics) AND PUBYEAR > 2010 AND PUBYEAR < 2021 AND (LIMIT-TO (AFFILCOUNTRY, "India"))) has been used then it is refined as per needs.

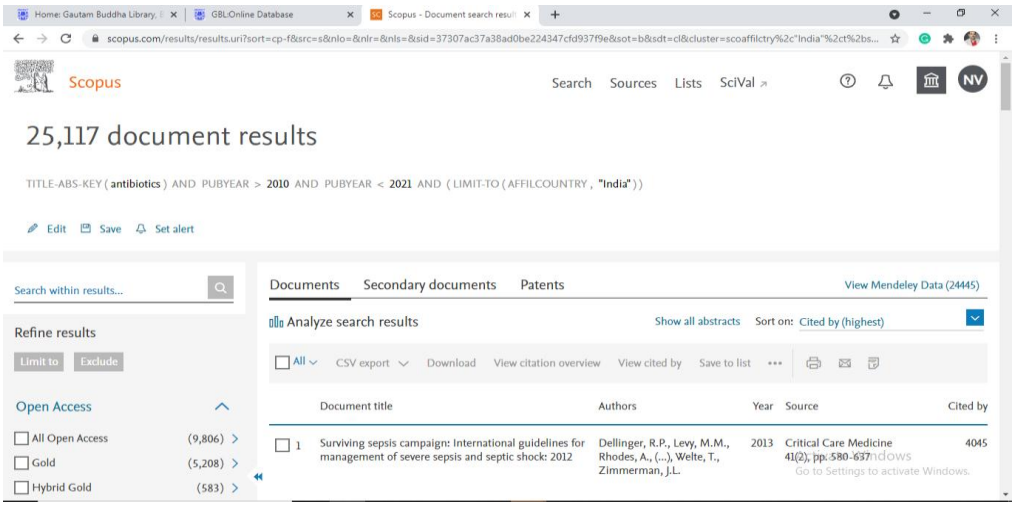

Figure 3.1 Snapshot of the Scopus data retrieved result

In this study, inclusions and exclusions have been done to measure the research productivity of the prescribed topic as per the following table.

Table 3.1 Descriptions of Inclusion and Exclusion Criteria

S. No.	Descriptions	Inclusion criteria	Exclusion criteria
1.	Database	Scopus	Others databases
2.	Publication period	2011-2020	Article published up to 2010 and in 2021
3.	Document type	Articles Conference papers, book chapters, books, and reviews	Notes, letters, editorials
4.	Source type	Journals, Books, conference proceedings, trade publications,	Doctoral thesis, websites, masters dissertations
5.	Subject area	Medical, Science, Physical, life, social, health and humanities sciences	-
6.	Language	English and Other languages	

Thus, according to the objectives, the description of the relevant articles, authors, journals, year of publication, number of citations, institutes, countries, keywords, and title of bibliography, etc., download and export in different formats as required, using the above search criteria. The format for downloading and exporting the relevant data is shown in figure no. 3.5.

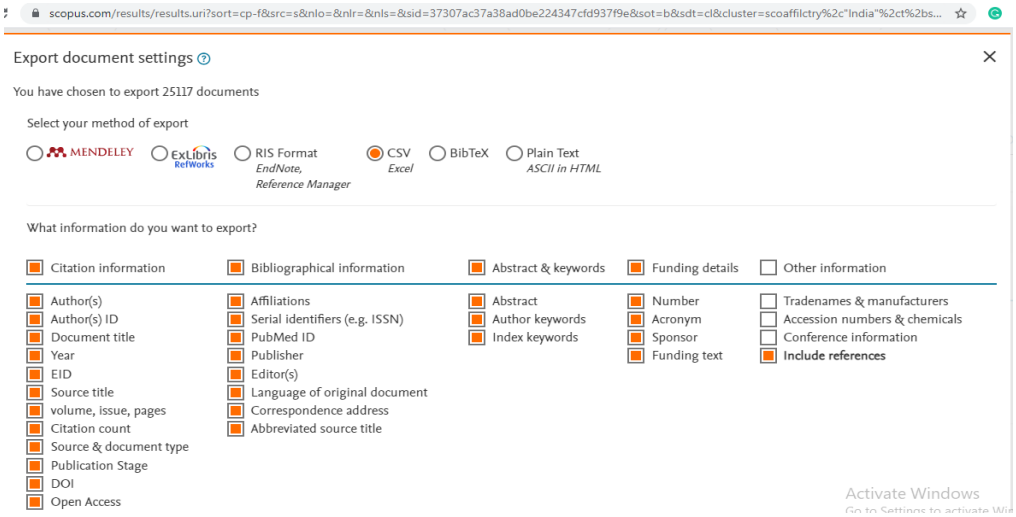

Figure 3.2 Format for Downloading and Exporting the Relevant Data

3.8 DATA ANALYSIS AND INTERPRETATION

In this part of the research, the collected data by using the prescribed tools based on the proposed objectives were analysed and explored some findings and conclusions. This is a very important and difficult task of research. Under this, we remove inappropriate data from the collected data and then analyse and interpret using formulas and principles determined based on the proposed objectives. A total of 25117 data were retrieved on antibiotics published in the period from 2011 to 2020 and indexed in the Scopus database. A major strength of this database is that it provides adequate coverage of the most important and influential journals and core literature internationally in science and technologies. Data exported from the Scopus database was entered in MS Excel and VOSviewer software on Windows 10 for graphical representation and analysed using various bibliometric formulas, laws, and principles. Numerical analysis has been performed through imported data, assuming that the following bibliographic parameters are the basis. After obtaining bibliometric parameters, a bibliometric network of research generated with the help of VOSviewer software, which refers to countries in articles, authors, journals, institutions and bibliographic references with citations, co-citations, co-authors, and bibliographic coupling. There are some bibliometric parameters of imported bibliographical data, which are calculated in this study, shown as a table no.3.2.

Table 3.2 Scientometric / Bibliometric Parameters

S.No.	Bibliometric Data	Bibliometric Parameters	Descriptions
1.	Year of publication	Evolution of publications AGR RGR DT Activity Index Collaborative Index	
2.	Keywords	Most Used Keywords	Author Keywords
3.	Article title	Most Cited Articles	Position in the citation ranking, title of the article, authors, journal, year of publication, number of citations, evolution of citations over the years
4.	Funding Agencies	Most funded agencies	Detail of sponsors
5.	Authorship	More productive authors Single and Multi-authored Most cited authors	Position in the citation ranking, name of the author, institution, H-index, number of publications, number of citations, evolution of citations in the field of study over the years
6.	Institutions	Most cited institutions More productive institutions	Position in the citation ranking, institution name, country, number of publications, number of citations
7.	Journals	More productive journals More cited journals	Position in the citation ranking, name of the journal, publishing area, SJR or JCR,, number of publications, number of citations
8.	Countries	More productive countries Most collaborative countries	Position in the citation ranking, country name, number of publications, number of citations
9.	Bibliometrics laws		Bradford's law Lotka's law

3.9 STATISTICAL TOOLS FOR SCIENTOMETRIC ANALYSIS

3.9.1 Calculation of Annual Growth Rate

The formula used for AGR calculation is given by Kumar and Kaliyaperumal in 2015. The following formula is used for AGR Calculation:

$$\mathbf{AGR} = \frac{\mathbf{W2 - W1}}{\mathbf{W1}} \times \mathbf{100}$$

In this formula AGR represent Annual Growth Rate, W2 present the end value of the publication and W1 present the first/ initial value of the publication

3.9.2 Calculation of Relative Growth Rate (RGR)

The Relative growth rate on the publications is calculated by a certain formula. It shows the relative growth rate of publication during a year. The RGR for all publication has been calculated on the basis of a derived model. This model is developed by Mahapatra. The RGR is calculated through the cumulative number of publications in the specified year and the Doubling Time is calculated directly to RGR. The RGR will be calculated by the following formula:

$$\textbf{Relative Growth Rate (RGR)} = \frac{\text{Log } e\ \text{W2} - \text{Log } e\ \text{W1}}{\mathbf{T2 - T1}}$$

Where

RGR = Growth rate over the particular period of time

Log e W1 = Log of initial number of publications / pages

Log$e$ W2 = Log of the final number of publications / pages after a particular period of the interval

T2-T1 = The unit difference between the initial time and final time.

The Year can be assumed here as the unit of time. The relative growth rate for both publications and pages can be calculated separately.

3.9.3 Doubling Time (DT)

This shows the direct equivalence existing between the Relative Growth and Doubling Time. If the number of publications or pages of a discipline doubles during the given period, then the difference between the logarithms of the numbers at the starting and at the end of the period should be the logarithms of the number two. If natural logarithm is used difference has a value of 0.693. The doubling time of the publication on a research is calculated by the following formula:

$$\textbf{Doubling Time (DT)} = \frac{\mathbf{0.693}}{\boldsymbol{R}}$$

Whereas 0.639 is the constant value in the formula and R represent the relative growth rate (RGR) in the concerned year.

3.9.4 Degree of Collaboration (DC) and Collaboration index

Subramanyam gave a formula in 1983 to measure the degree of collaboration. It is defined as the ratio of the number of collaborative research papers to the total number of research papers in the discipline during a certain period of time. The following formula was suggested by Subramanyam is used to calculate the degree of collaboration in this study.

$$C = \frac{Nm}{(Nm + Ns)}$$

Where, C = Degree of collaboration

Nm = Number of multiple authored papers

Ns = Number of single authored papers

Collaboration index

The Collaboration Index (CI) has been presented by (Lawani, 1980). It refers to the average number of authors per joint publication. The Collaboration index is represented mathematically

C. I. = Total number of authors of joint articles/Total number of joint publications

C.I = Nam /Na,

Where, Nam is the number of authors of total joint publications and Na denotes the number of total articles

3.9.5 Lorenz Curve

The cumulative percent curve is known as the Lorenz curve. It's a graphical representation of two series dispersion. The steps below are used to create the curve.

i. The two series components are added up individually.

ii. Percentages of the total are calculated from the accumulated components

iii. The percentages are then represented as subject and factor on the graph.

The Lorenz curve is used to calculate deviation from the mean. It's a handy tool for displaying the type and degree of dispersion. It also allows you to compare the level of dispersion between two series.

3.9.6 Activity Index

Through the formula of activity index, we measure the national level share of publication on a subject comparison than the global level. It shows how much percentage of contributions on a particular subject is published in comparison to the world in a year. This study specifically calculates whether India has a relatively high or low share of world publications in the antibiotic on a yearly basis. The activity index (AI) has long been used in bibliometrics (Frame, 1977, Shubert and al., 1989), which, in turn, is a variant of the comparative advantage index for antibiotics. In calculation, When AI = 100, the country's research effort in a specific field is identical to the global average. When AI for a topic area is more than 100, it means that a country publishes

more articles in that topic area as a percentage of its total production. Al <100, on the other hand, denotes a lower-than-average commitment to the research topic.

The activity index is calculated as following formula:

$$\text{Activity index (AI)} = \frac{N_{ig} / N_{ia}}{N_{wg} / N_{wa}} \times 100$$

Where, Nig is No. of Indian publications in antibiotics

Nia is No. of Indian publications in all subjects

Nwg is No. of all countries publications in antibiotics

Nwa is No. of all countries publications in all subjects

Or

$$= \frac{Share\ of\ particular\ subject\ of\ the\ country\ total\ publications}{Share\ of\ particular\ subject\ of\ the\ world\ total\ publications} \times 100$$

3.9.7 Lotka's Law

According to the Lotka's law "the number of authors contributing n (1) is $1 / n^2$ of those who make; and the proportion of all contributors, who make a single contribution, is about 60 %." It can be said by the applicability of this law that out of all the authors in a given field, 60 % of the authors will be published only one article and 15 % of the authors will publish only two articles (1/260 times, 60) and 7% of authors will publish three articles (1/3. times, 60) and further calculation will be made in the same way. Similarly, Lotka's law of scientific productivity states that only six percent of authors in an area will publish more than 10 articles. Alfred J. Lotka practically published his pioneering study in the year 1926 on the frequency distribution of scientific productivity determined from a decisive index of chemical essence (1907–1916) based on the Lotka's law.

3.9.8 Bradford's Law

According to Bradford, "If scientific journals are organized in order of decreasing productivity on a given subject, they can be divided into the nucleus of journals that are specifically devoted to the subject and have multiple groups or fields contain the same number of articles when the number of periodicals. The nucleus and succeeding regions will have 1: n: n^2 ".

Bradford elaborated that journals can be divided into three zones, each zone having the same articles but with a difference in the number of journals.

- Journals of the first zone, in which the number of journals is very less, in such journals one-third of all published articles are published. This type of journal is very less; this is called the core journals of the subject concerned.
- Journals of the second zone, in which the number of published articles will be equal to the first zone but the number of journals, will be more.
- Journals of the third zone, in which the number of published articles will be equal to the second zone but the number of journals, will be much more than that.

The mathematical relation of the number of journals in the core is a constant n for the first field and the relation n^2 is for the second field. Bradford expressed this relationship as 1: n: n^2. Bradford presented a study based on this rule, in which a bibliography of geophysics covers 326 journals in the field. He came to recognize that there were 9 journals containing 429 articles, 59 journals containing 499 articles and 258 journals containing 404 articles. So it took 9 journals to contribute one-third of the article, 5 times 9 or (5×9=45), to produce the next third, and 5 times 5 times 9, or (5×5×9=225), to produce the last third. Thus Bradford's Law serves as a general guideline for librarians in determining the number of core journals related to any subjects in libraries.

3.9.9 Zipf's Law

This law refers to the calculation of the frequency of words in a text or article. The formula r×f =C was used to calculate this, where r is the rank of a word, f is the frequency of occurrence of the word, and C is a constant that depends on the analysis of the text. According to Zipf "In a relatively long text, if you list the words that fall within that text in order of decreasing frequency, multiplying the rank of a word in that list by its frequency will be a constant". This rule was implemented in James Joyce's analysis of Ulys' paper and quantified that his paper's text contained 2,653, the tenth most frequent word. The hundredth most frequent word occurred 265 times, the two hundredth word occurred 133 times, and so on. Zipf found that the term multiplied by the multiplication of the frequency of the word is then an equivalent which is approximately 26,500. This rule given by Zipf is very useful for indexers.

3.9.10 H-Index

The H-Index is the numerical value of the progress of citation(s) and publication(s) of a single author or several authors, department or university or country, as well as a scholarly journal. It is calculated on the basis of the number of papers published by the scientist and its citation(s), as well as how often these numbers are cited in other papers written by scientists. The H-index is calculated based on the distribution of citations received by publications of a given researcher and also applies to the productivity of a group of scientists, such as a department or university or country. For example, if a scientist has h if each of his Np papers has at least h citations, and other (Np - h) papers have most h citations each. In other words, a scholar with an index of h has published h papers with at least h citations. Thus, the H-index is the result of a balance between the numbers of publications and the number of citations per publication. In this study, H- index indicators which have been measured in online Scopus database.

3.9.11 Citation Index

The citation index is a process in which the number of times an author's article has been cited by other authors is calculated. Each day scientists report the results of experiments, studies, explorations, and inventions in thousands of publications. Which article is notable and influential in these published articles, it shows by its citation number. When an author links his article to another author's article, a relationship is established. Citation analysis uses citations in scholarly works to establish links. This author may criticize an earlier object, build upon it, and use it to extend its argument or accept an early originator. May be an author gives a citation only to state that the author has read extensively about his paper. Authors may use citations to explain, expand, or criticize. The method of tracking and evaluating research based on these citations is called citation analysis. Counting the citation by author, year, title, etc. is a citation process. The works cited herein are counted as measures of use and effectiveness. During citation analysis, we make the following the basis for counting citations: a personal article (how many times it was cited); an author (total citations, or average citations per article); a journal (average citations for articles in a magazine).

3.9.12 VOSviewer

VOSviewer is a type of software tool used to construct and visualize a bibliometric network of data received from a database. It was developed in the year 2007 by Nees Jan van Eck and Ludo Waltman at Leiden University's Center for Science and Technology Studies (CWTS). Its first version was developed in the year 2007, after which it has been continuously updated. Currently, its VOSviewer version 1.6.15 has been developed. VOSviewer version 1.6.15 has been installed to construct and visualize bibliometric networks of citation, bibliographic coupling, and co-citation or co-author relationships. In this study, VOSviewer software has been used to construct and visualize a co-occurrence network of keywords extracted from a body of scientific literature. The data obtained from the Scopus database was visualized using the VOSviewer software tool, which is used for visualization of the bibliometric network. It

presents network visualization through maps that use colour, circle size, font size, and connecting lines to represent it. These uniformly coloured units indicate that these units were related to the close units of a single group or groups that could be countries or authors. It also indicates the colour, circle size, font size, and strength of connecting lines and the co-operation between countries. The thickness of the connecting lines numerically represents their mutual relations such as higher relative link strength suggested a stronger association and larger circle size or font size indicated greater productivity or citation.

3.9.13 Biblioshiny

Biblioshiny is metrics software that offers you a web-based bibliometrix GUI. It assists scholars in making the most of bibliometrix's key features. Bibliometrix is a one-of-a-kind platform built in the mathematical computation and graphics R programming language to follow a logical bibliometric workflow. Since R is an object-oriented and functional programming language, it's simple to simplify analyses and add new features. Massimo Aria and Corrado Cuccurullo developed Bibliometrix. It is an open-source tool for scientometrics and bibliometrics quantitative testing that incorporates all of the big bibliometric methods of study. Since it is open-source software, it is also simple to get help from the users' community, which is mostly made up of well-known statisticians.

Bibliometrix is adaptable, with the ability to be quickly updated and combined with other predictive R sets. As a consequence, it is useful in an area like bibliometrics, which is still evolving. Bibliometrix has become very easy to use, particularly for those who have no coding experience, thanks to biblioshiny, the shiny software released in version 2.0. The Bibliometrix package includes routines for importing bibliographic data from databases such as SCOPUS, Clarivate Analytics' Web of Science, PubMed, Digital Science Dimensions, and Cochrane, conducting bibliometric analysis, and creating data matrices for co-citation, coupling, technical collaboration analysis, and co-word analysis. In this study, Biblioshiny software has also been used to construct and visualize a co-occurrence network of keywords extracted from a body of scientific literature.

3.10 DESCRIPTIVE ANALYSIS OF THE DATA

3.10.1 Mean

The mean is the arithmetic average, and it is the most recognisable metric of central tendency. It is extremely easy to figure out what the mean is. Simply sum up all of the values in your dataset and divide by the number of observations.

Mean = $\frac{x_1 + x_2 + \cdots + x_n}{n}$

3.10.2 Median

The median is the score that falls in the centre of a collection of data that has been ordered in order of magnitude. The most critical step in calculating the median is to arrange the data in ascending order from smallest to largest. Finding the median for a piece of data involves the following steps:

i. Arrange the information in ascending order, from smallest to greatest.

ii. Using the formula n+1/2, where n is the sample size; locate the median in the sorted data.

iii. The median is the value that represents the place discovered in Step 2.

Median = $[(n+1)/2]^{th}$ observation, if n is odd.

Median = mean of $(n/2)^{th}$ observation and $[(n/2)+1]^{th}$ observation, if n is even.

3.10.3 Mode

Arrange the data in ascending order to get the mode. Then count, how many times each number appears. The mode is the number that appears the most.

3.10.4 Standard Deviation

It is defined as the square root of the mean squared deviation of individual measurements from the mean. This parameter's unbiased estimate from the sample is given by

$$S = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

Or $$\sqrt{\frac{n}{n-1}(\overline{x^2} - \bar{x}^2)}$$

Where, $\overline{x^2} = \frac{\sum x^2}{n}$ (It is called mean of squares)

$\bar{x}^2$ is squared mean

S is standard deviation

and n is number of individuals in the sample

Standard deviation as a variability is most adaptable to statistical analysis.

3.10.5 Variance

Variance is nothing, but it is square of the standard deviation.

Where, Variance = S^2

3.11 REFERENCING STYLE

Referencing style is a compilation of guidelines for properly acknowledging the views, concepts, and works of others. Referencing is an important part of academic writing, particularly when it comes to avoiding plagiarism and upholding academic credibility in assignments and analysis. We recognise the contributions of other authors and scholars in your work by referencing them. Citations must be used with any university assignment that builds on the thoughts, sentences, or study of other authors. Referencing is also a means of giving credit to the authors whose words and concepts you have borrowed. It assists you in avoiding plagiarism by identifying which thoughts are your own and which are those of someone else. It demonstrates your awareness of the subject. It offers facts to back up your theories, claims, and perspectives. It

enables others to see what sources you've used. In this research work, the 7th edition of the APA referencing style has been used to refer to the documents. 7th edition was published on October 11, 2019 by Raimo Streefkerk and revised on December 24, 2020.

Research design and methodology are the backbone of any study and play a major role in any research work. Collecting and interpreting data is also a most important task in any research. The quality of the research depends to a large extent on how the data has been collected to complete this research and which method has been used to explain it. In this way, keeping in mind the proposed objectives, a detailed explanation of all the methods and tools for collecting and interpreting data has been described in this chapter which will be helpful in understanding and providing quality to this research.

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CHAPTER-4

DATA ANALYSIS AND INTERPRETATION

In this chapter, the detailed research output on antibiotics research has been analysed as per prescribed objectives in the Indian context. The antibiotics research literature was retrieved from the SCOPUS database for 2011-2020 using keyword (TITLE-ABS-KEY (antibiotics) AND PUBYEAR > 2010 AND PUBYEAR < 2021) and (TITLE-ABS-KEY (antibiotics) AND PUBYEAR > 2010 AND PUBYEAR < 2021 AND {LIMIT-TO (AFFILCOUNTRY, "India")} and a total of 25117 documents published in the field of antibiotics during 2011-2020 were used in this analysis. The analysis has been categorized into many heads such as year-wise publications, overall countries growth ratio, relativity growth rate, doubling time, activity index, year-wise authorship pattern commutations channel, collaborative pattern, source impact, document type, affiliation-wise, citations analysis, source titles, keyword occurrences, Bradford law, and Lotka's law, etc. The VOSviewer, Biblioshiny for bibliometrics, Rstudio, MS-excel, and KU statistical tools were used to analyse the publications and interpret them for the study's purposes. In addition the, hypotheses set during the study have also been tested with suitable bibliometric laws and statistical formulas in the chapter.

4.1 YEAR-WISE DISTRIBUTION

Table 4.1 depicts the year-wise distribution of papers on antibiotics research in India and the world for the period 2011-2020. A total of 25117 and 344452 records were extracted from the database during the period of study in India and the world, respectively. The highest productivity of India's publications were observed in 2020 with a total of 3060 (12.18%) documents and the lowest productivity was recorded in 2011 with the total productivity of 1904 (7.58%). The total world productivity in antibiotics research during the study period was retrieved 344452 documents, in which the highest research output has been observed in 2020 with a total of 45503 (13.21%) and the lowest in 2011 with 26704 (7.75%). It has been noted that there is a steady growth of publications for India (except 2017-2018), while in the world, it has been increased continuously. The average publications were recorded 2511.7 and 34445.2 documents per year in India and the world, respectively. The other details of descriptive statistics of antibiotics literature are shown in table 4.1 (A).

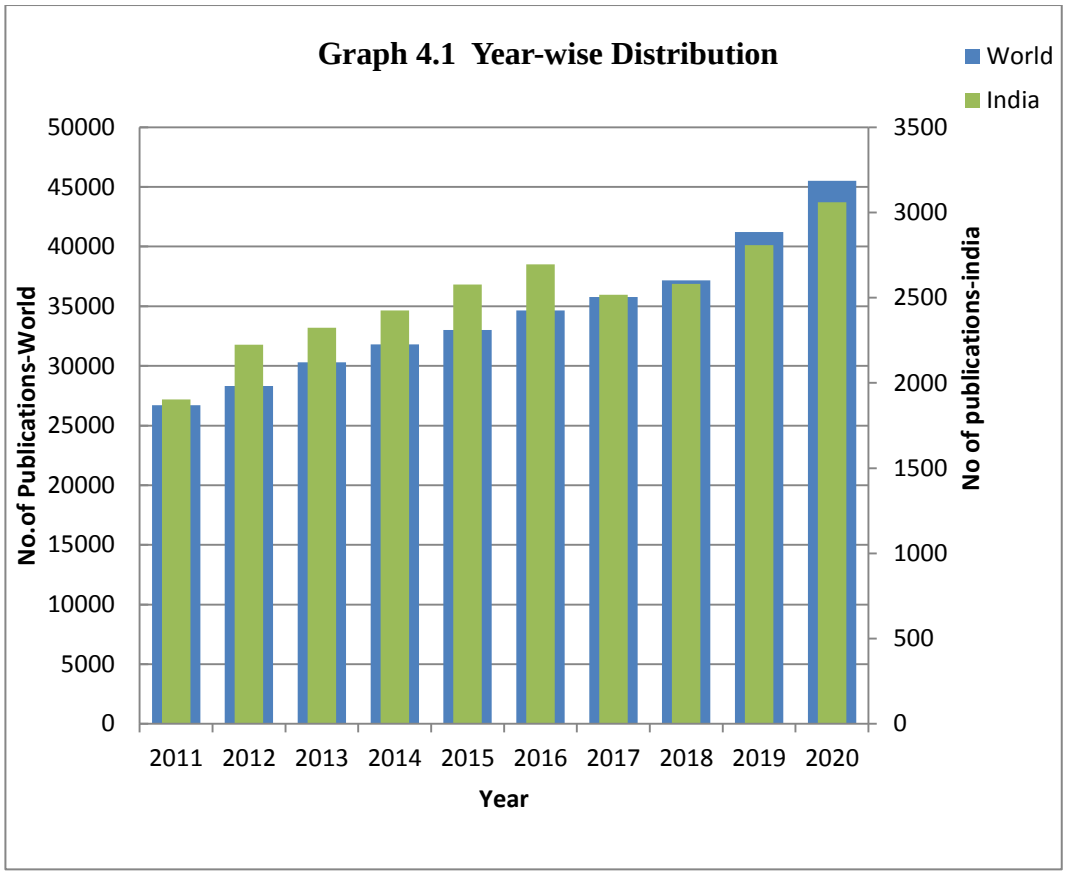
Table 4.1 Year-wise Distribution

Year	IPA	Cumulative	% (N=25117)	WPA	Cumulative	% (N=344452)
2011	1904	1904	7.58 %	26704	26704	7.75 %
2012	2224	4128	8.85 %	28302	55006	8.22 %
2013	2323	6451	9.25 %	30302	85308	8.80 %
2014	2425	8876	9.65 %	31807	117115	9.23 %
2015	2578	11454	10.26 %	33020	150135	9.59 %
2016	2695	14149	10.73 %	34644	184779	10.06 %
2017	2518	16667	10.03 %	35765	220544	10.38 %
2018	2582	19249	10.28 %	37180	257724	10.79 %
2019	2808	22057	11.18 %	41225	298949	11.97 %
2020	3060	25117	12.18 %	45503	344452	13.21 %
Total	**25117**		**100.00%**	**344452**		**100.00 %**

IPA- Indian publications in antibiotics WPA- World publications in antibiotics

Table 4.1(A) Descriptive Statistics of Antibiotics Literature

Descriptive Statistics	India	USA	China	World
Mean	2511.7	8391.4	3879.8	34445.2
Standard Error	101.4669	348.3998724	586.7013209	1829.765
Median	2548	8393.5	3480	33832
Standard Deviation	320.8666	1101.737133	1855.31248	5786.225
Sample Variance	102955.3	1213824.711	3442184.4	33480404
Kurtosis	0.681019	-1.033050194	0.438409074	0.038809
Skewness	-0.24368	0.027445115	0.962532326	0.644078
Range	1156	3262	5908	18799
Minimum	1904	6748	1747	26704
Maximum	3060	10010	7655	45503
Sum	25117	83914	38798	344452
Count	10	10	10	10
Confidence Level (95.0%)	229.5341	788.1352669	1327.210596	4139.216

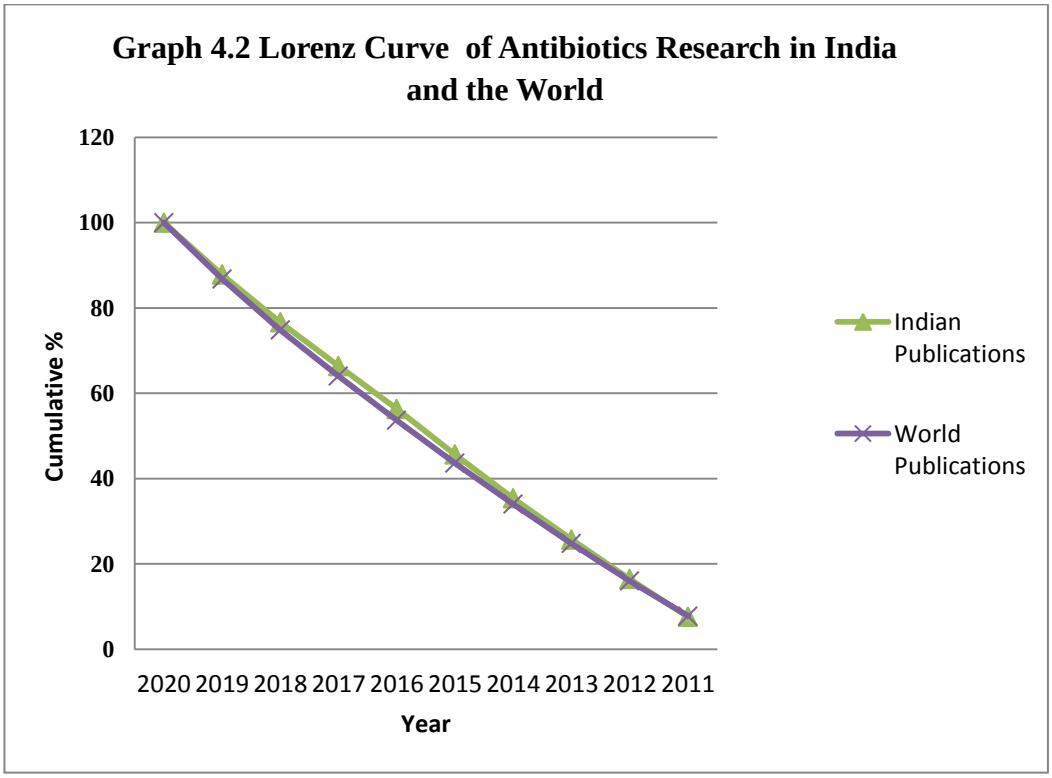


4.2 LORENZ CURVE OF ANTIBIOTICS RESEARCH IN INDIA AND THE WORLD PUBLICATIONS

Table and Graph 4.2 Show the Lorenz curve of antibiotics research in India and the world. Lorenz curves are used for the distribution and comparison of articles published in particular years in antibiotics research in India and world publications. Lorenz curve is a function of the cumulative proportion of ordered publication counts mapped onto the corresponding cumulative proportion of their number during 2011-2020. From table and graph 4.2, It is observed that the trend line is fitted to data from 2011 until 2014 and little extended until 2015 -18 as a dashed line. The dispersion and cumulative percentage were recorded in the year 2015, 2016, 2017 and 2018 with 45.60%:43.59%, 56.33%:53.64%, 66.34%:64.03% and 76.64:64.82% respectively. The low dispersion has visible on the Lorenz curve in India and world publications on antibiotics research.

Table 4.2 Lorenz Curve of Antibiotics Research in India and the World

Year	Inequality % of year	IPA	%	Cumulative %	WPA	%	Cumulative %
2011	10	1904	7.58	7.58	26704	7.75	7.75
2012	20	2224	8.85	16.44	28302	8.22	15.97
2013	30	2323	9.25	25.68	30302	8.80	24.77
2014	40	2425	9.65	35.34	31807	9.23	34.00
2015	50	2578	10.26	45.60	33020	9.59	43.59
2016	60	2695	10.73	56.33	34644	10.06	53.64
2017	70	2518	10.03	66.36	35765	10.38	64.03
2018	80	2582	10.28	76.64	37180	10.79	74.82
2019	90	2808	11.18	87.82	41225	11.97	86.79
2020	100	3060	12.18	100.00	45503	13.21	100.00
		25117			**344452**		



4.3 INDIA'S SHARE IN WORLD ANTIBIOTICS RESEARCH

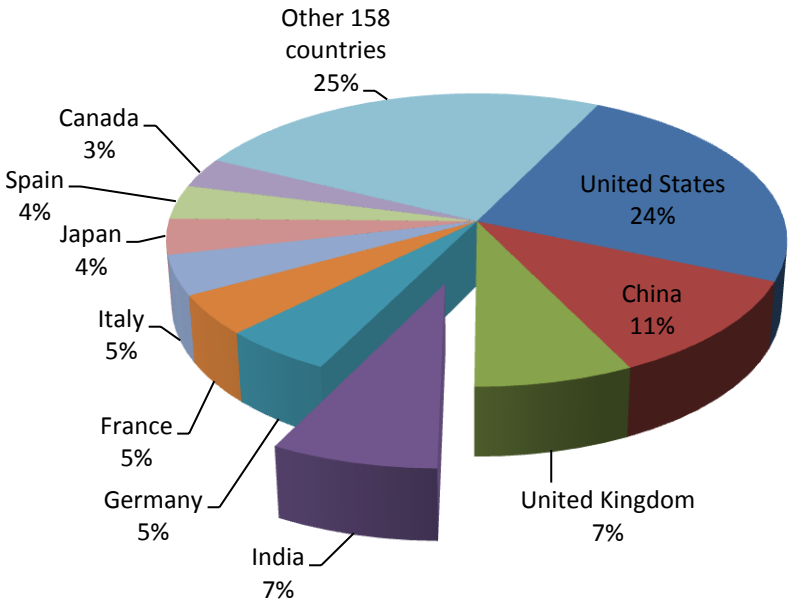
4.3.1 Publication Share of India in World Output

Publication's share of India's contribution with world contributions during 2011-2020 in antibiotics research is shown in table 4.3.1. A total of 159 countries' authors contributed their paper (s) on antibiotics research during the study period. From table 4.3.1 and graph 4.3.1, it is analysed that the total no of publications by Indian contributors during 2011-2020 in antibiotics research was 25117 which is around 7.29 % of the total world output of 344452. Further, the study reveals that the *USA* was sharing the highest publications 83914 which is around 24.36 % of the world's output followed by *China* with 38798 (11.26 %) and the *United Kingdom* with 24672 (7.16%). During the analysis, it has also been found that India's sharing percentage in world secured at the third position.

Table 4.3.1 Publication Share of India in World Output

S.No.	Country	Articles	%
1.	United States	83914	24..36
2.	China	38798	11.26
3.	India	25117	7.29
4.	United Kingdom	24672	7.16
5.	Germany	17797	5.14
6.	France	15319	4.45
7.	Italy	15099	4.38
8.	Japan	13486	3.92
9.	Spain	13047	3.79
10.	Canada	11415	3.31
11.	Other 158 Countries	85888	24.93
	Total	**344452**	

Graph 4.3.1 Publication Share of India in World Output



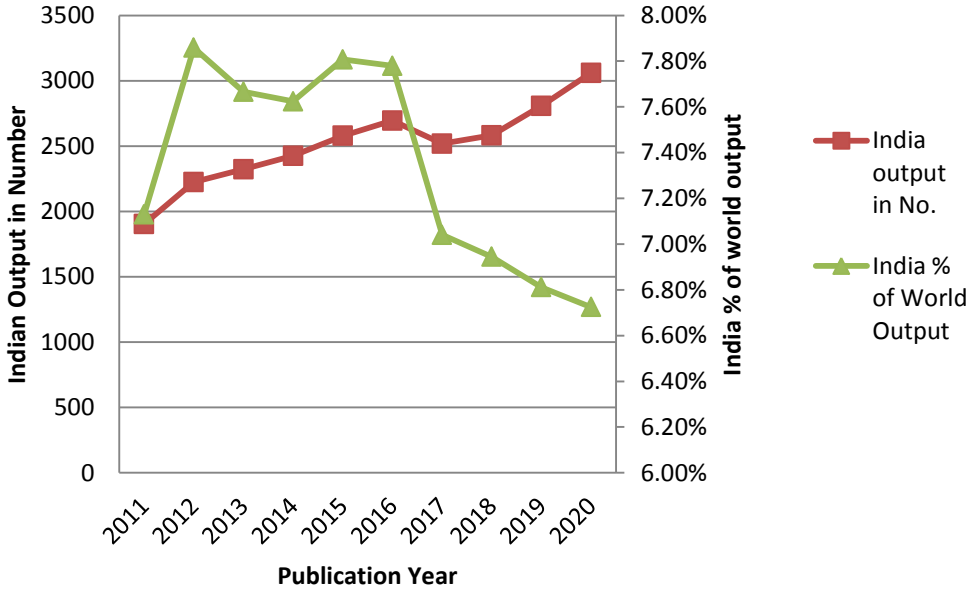
4.3.2 Year-wise Publication Share

Year-wise India's share in world publications on antibiotics research from 2011 to 2020 is presented in table 4.3.2 and graph 4.3.2. It is observed that the number of Indian antibiotics publications increased consistently every year. The highest share percentage was calculated in 2012 with 7.86 % and the lowest share was calculated in 2020 with 6.72 %. Further, it is found that the Indian share of world antibiotics production has fluctuated from 2011 to 2016 and after that, it is decreased consistently. However, the year-wise growth percentage of India and the world was found about similar in antibiotics research during the study.

Table 4.3.2 –Year-wise Publication Share of India in World Output

Year	IPA	WPA	India % of World Output
2011	1904	26704	7.13%
2012	2224	28302	7.86%
2013	2323	30302	7.67%
2014	2425	31807	7.62%
2015	2578	33020	7.81%
2016	2695	34644	7.78%
2017	2518	35765	7.04%
2018	2582	37180	6.94%
2019	2808	41225	6.81%
2020	3060	45503	6.72%
Total	25117	344452	7.29%

Graph 4.3.2 Year-wise Publication Share of India in World Output



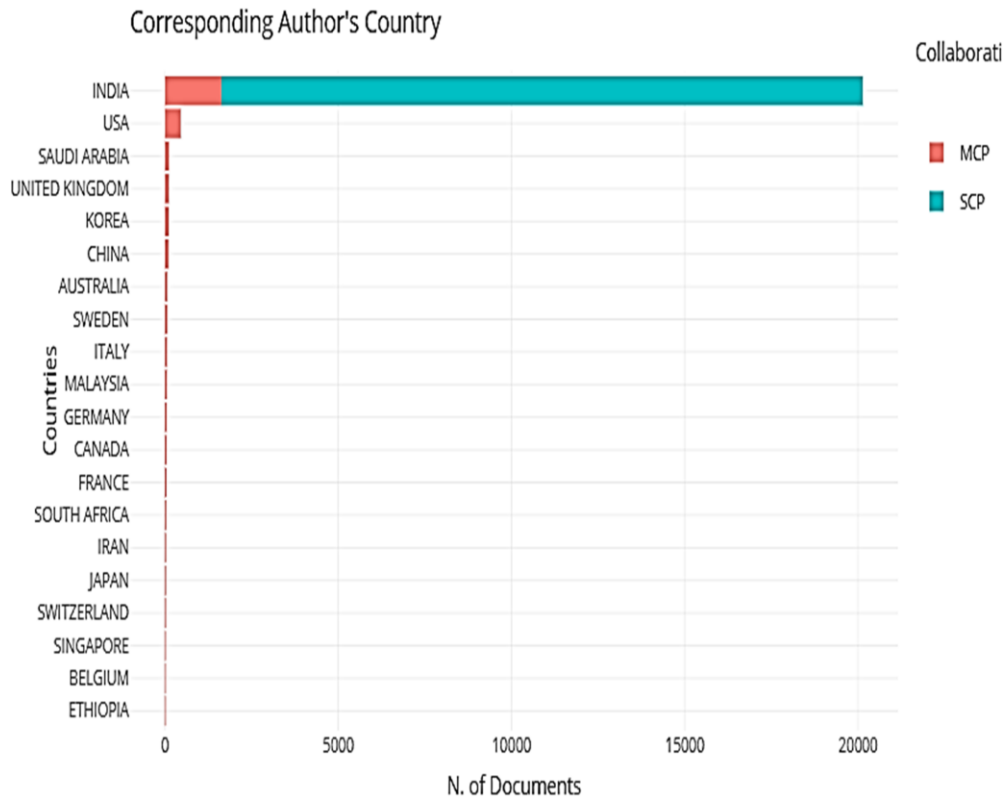
4.4 MOST COLLABORATIVE COUNTRY BY CORRESPONDING AUTHOR

Table 4.4 depicts the most collaborative country by the corresponding author in antibiotics research from 2011 to 2020. Collaboration gives more visibility to the research output. An analysis of the authorship pattern of Indian antibiotics reveals the tendency among Indian researchers to collaborate with scientists from other countries. From the table 4.4 and graph 4.4, it is observed that a total of 168 countries have collaborated with Indian author, in which the highest collaboration on antibiotics research is mainly with the *USA* (464 papers) which is about 2.1% followed by the *United Kingdom* and *Saudi Arabia* with 120 papers, *Korea* with 111 papers and *China* with 102. It is marked from citation analysis that India has profited from international collaboration in attracting and receiving more citations**.**

Table 4.4 Most Collaborative Countries by Corresponding Author

S.N.	Country	Articles	%
1.	India	20143	91.60%
2.	USA	464	2.11%
3.	Saudi Arabia	120	0.55%
4.	United Kingdom	120	0.55%
5.	Korea	111	0.51%
6.	China	102	0.46%
7.	Australia	65	0.30%
8.	Sweden	65	0.30%
9.	Italy	57	0.26%
10.	Malaysia	54	0.25%
11.	Germany	50	0.23%
12.	Canada	47	0.21%
13.	France	43	0.20%
14.	South Africa	35	0.16%
15.	Iran	31	0.14%
16.	Japan	31	0.14%
17.	Switzerland	28	0.13%
18.	Singapore	24	0.11%
19.	Netherlands	21	0.10%
20.	Belgium	22	0.10%

Graph 4.4 Most Collaborative Countries by Corresponding Author

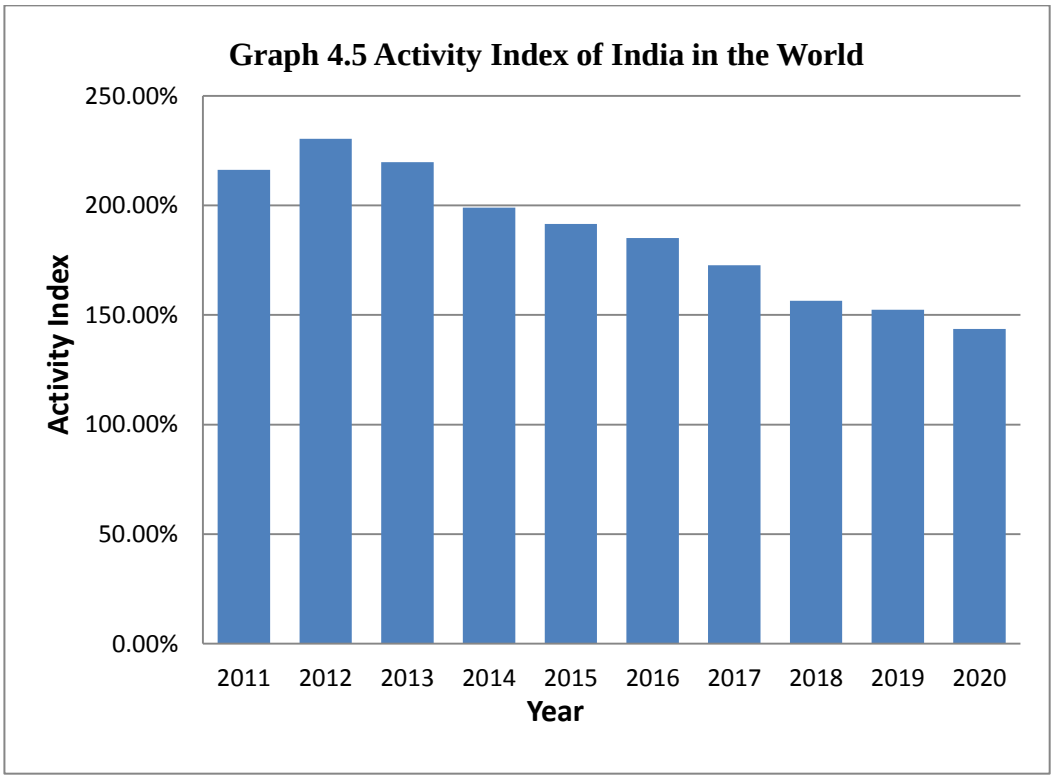


4.5 ACTIVITY INDEX OF INDIA IN THE WORLD

Table 4.5 shows the activity index of India on antibiotics research in the World. Data in table 4.5 indicates whether a unit is more or less active in India than the rest of the world. The study reveals that India's research efforts in antibiotics research have been higher than the world average. The average AI for India was calculated 180.24 during 2011-2020. The highest AI was analysed in the year 2012 with 230.29 while the lowest AI was recorded in 2020 with 143.64. It is evident from AI data that Indian contributions to antibiotics research are strong in the world.

Table 4.5 Activity Index of India in the World

YEAR	IPA	IPAS	IPSAT	WPA	WPAS	WPSAT	AI
2011	1904	98457	1.93%	26704	2985314	0.89%	216.19%
2012	2224	109168	2.04%	28302	3199231	0.88%	230.29%
2013	2323	117465	1.98%	30302	3366900	0.90%	219.74%
2014	2425	133335	1.82%	31807	3479921	0.91%	198.98%
2015	2578	142966	1.80%	33020	3506700	0.94%	191.50%
2016	2695	154905	1.74%	34644	3686469	0.94%	185.13%
2017	2518	156538	1.61%	35765	3838463	0.93%	172.64%
2018	2582	179049	1.44%	37180	4035084	0.92%	156.50%
2019	2808	187014	1.50%	41225	4181955	0.99%	152.31%
2020	3060	198754	1.54%	45503	4245288	1.07%	143.64%
Total	**25117**	**1477651**	**1.70%**	**344452**	**36525325**	**0.94%**	**180.24%**



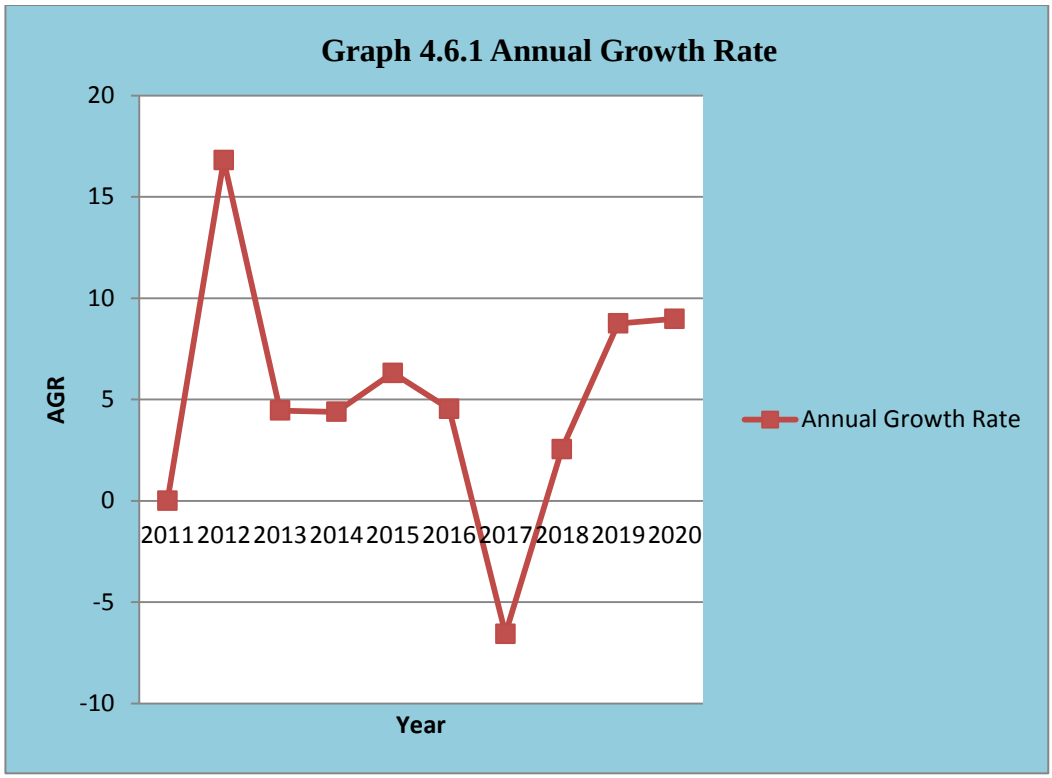
4.6 GROWTH RATE OF ANTIBIOTICS RESEARCH IN INDIA

4.6.1 Annual Growth Rate

The annual growth rate (AGR) of the total publications in antibiotics research from 2011 to 2020 is presented in table 4.6.1 and graph 4.6.1. It is observed from table 4.6.1 that the AGR is decreased from 16.81 in 2012 to 2.54 in 2018 wherein -6.57 AGR recorded in 2017 and it is increased in 2019 and 2020 with 8.75 and 8.97 respectively. A fluctuating trend has been observed for India during the study period.

Table 4.6.1 Annual Growth Rate

Year	Initial /First Value of Publication W1	End Value of the Publication W2	AGR
2011	0	1904	Not define
2012	1904	2224	16.81
2013	2224	2323	4.45
2014	2323	2425	4.39
2015	2425	2578	6.31
2016	2578	2695	4.54
2017	2695	2518	-6.57
2018	2518	2582	2.54
2019	2582	2808	8.75
2020	2808	3060	8.97

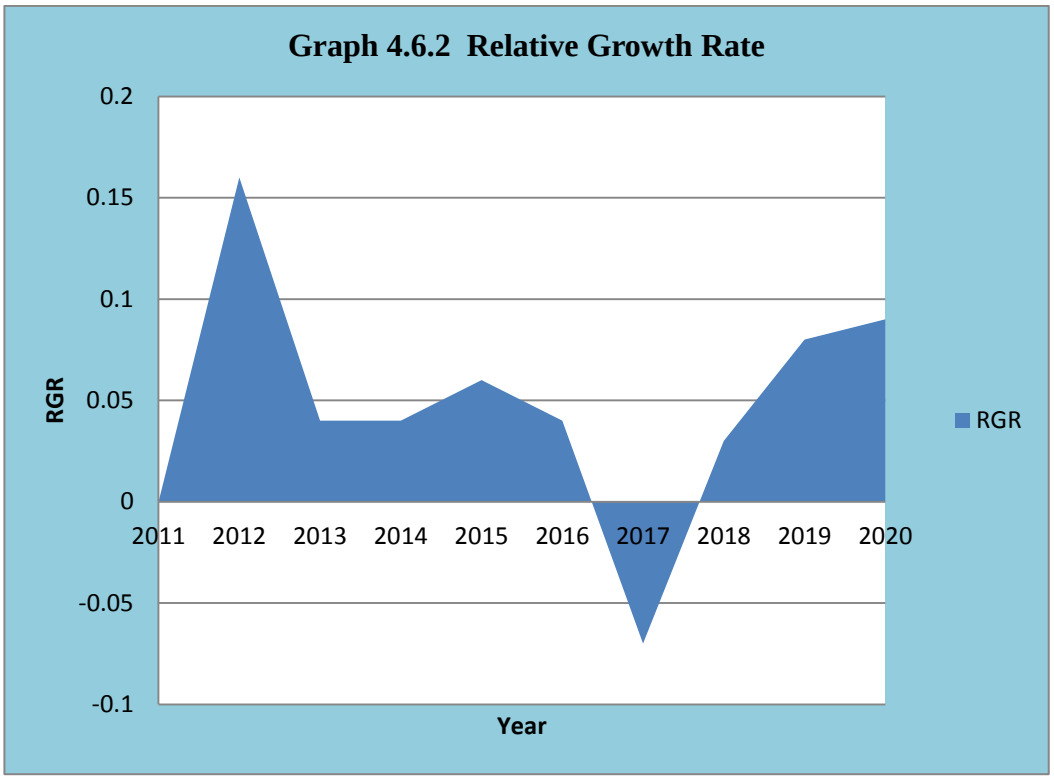


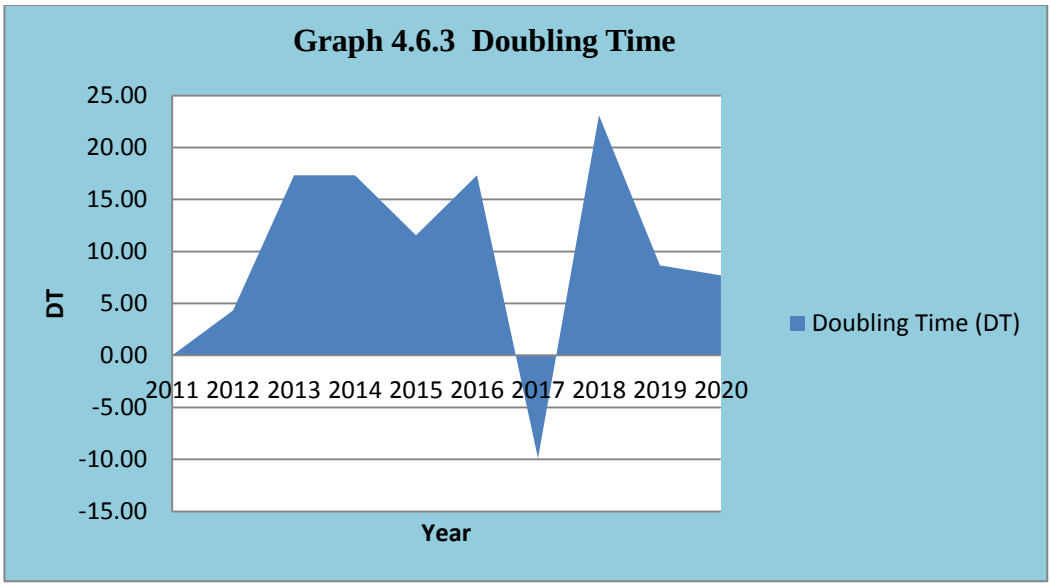
4.6.2 Relative Growth Rate and Doubling Time

The relative growth rate (RGR) is defined as the increase in the number of articles or pages per unit of Time. The mean of RGR of articles over the specific period has been calculated by a certain formula. Table 4.6.2 presents the relative growth rate (RGR) and doubling time (DT.) of Indian publications in antibiotics research during 2011-2020. The study reveals that the RGR value has been decreased from 0.16 in 2012 to -0.07 in 2017 and again it is increased to 0.09 in 2020. Further, the doubling time (DT) of the publications has been calculated by a certain formula and it is found that the value of DT has fluctuated. The highest DT calculated in 2018 with 23.10 while the lowest DT is seen in 2017 which is around (-) 0.90.

Table 4.6.2 Relative Growth Rate and Doubling Time

Year	Initial Value	New added Publications	End Value	W1	W2	RGR	DT
2011	0	1904	1904	0.00	7.55	-	0.00
2012	1904	2224	4128	7.55	7.71	0.16	4.33
2013	2224	2323	6451	7.71	7.75	0.04	17.33
2014	2323	2425	8876	7.75	7.79	0.04	17.33
2015	2425	2578	11454	7.79	7.85	0.06	11.55
2016	2578	2695	14149	7.85	7.90	0.04	17.33
2017	2695	2518	16667	7.90	7.83	-0.07	-9.90
2018	2518	2582	19249	7.83	7.86	0.03	23.10
2019	2582	2808	22057	7.86	7.94	0.08	8.66
2020	2808	3060	25117	7.94	8.03	0.09	7.70





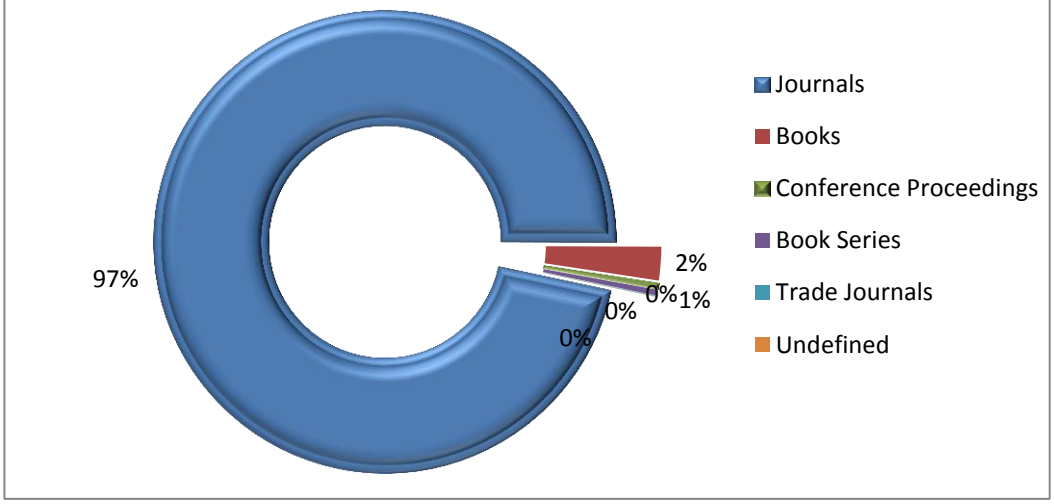
4.7 COMMUNICATION CHANNELS

Table 4.7 presents the detail of the communication channels of Indian antibiotics research publications during 2011-2020. It is observed from table 4.7 that out of a total of 25117 papers, most of the papers have categorized under *journals articles*, which are around 24294 (96.72 %) followed by *books* with 589 (2.35%) and the rest of 0.93 % publications has considered under *conference proceedings, trade journals,* etc. The study reveals that the majority of the publications have been categorized under journal articles.

Table 4.7 Communication Channels

S.N.	Communication Channels	Articles	% (N=25117)
1.	Journals	24294	96.72
2.	Books	589	2.35
3.	Conference Proceedings	115	0.46
4.	Book Series	102	0.41
5.	Trade Journals	12	0.05
6.	Undefined	5	0.02
	Total	**25117**	**100.00**

Graph 4.7 Communication Channels



4.8 BRADFORD'S LAW AND DISTRIBUTION OF ARTICLES ON RESEARCH JOURNAL(S)

4.8.1 Distribution of Articles in Journal(s)

Indian contribution to antibiotics in various journal(s) during 2011–2020 is presented in Table 4.8.1 (A) and 4.8.1 (B). A total of 25117 publications on antibiotics were retrieved during the study period, with 24294 publications found under the journal categories, so only these publications were considered for calculation. In the analysis of Table 4.8.1 (A), it is found that a total of 3377 journals published 24294 articles in antibiotics research during the year 2011-2020. It is also seen that 1516 journals have published only one paper; on the other hand, there is one journal in which 713 papers have been published. It is also found that 2 to 10 papers were published in 1425 journals, which are about 5362, while 27 journals were published 100 to 400 articles and 51 such journals have published 50 to 100 papers i.e. 3483 articles. The category-wise distribution of records in the journals of antibiotics research in India is presented in Table 4.8.1 (B), reveals that 2641 journals have published 1- 10 articles, which is about 6878 articles, while only 12 journals have published more than 200 articles which is about 4040 article. A detailed distribution of articles in journals along with the publication is shown in Table 4.8.1 (A&B).

Table 4.8.1 (A) Distribution of Articles in Journal(s)

No. of Journal (s)	No. of Articles	Total Articles	Cumulative Journal(s)	Cumulative Total Articles	% of Articles	Zone
1	713	713	1	713	2.93%	Zone 1
1	405	405	2	1118	4.60%	Zone 1
1	369	369	3	1487	6.12%	Zone 1
1	368	368	4	1855	7.64%	Zone 1
1	344	344	5	2199	9.05%	Zone 1
1	299	299	6	2498	10.28%	Zone 1
1	288	288	7	2786	11.47%	Zone 1
1	271	271	8	3057	12.58%	Zone 1
1	266	266	9	3323	13.68%	Zone 1
1	252	252	10	3575	14.72%	Zone 1
1	244	244	11	3819	15.72%	Zone 1
1	221	221	12	4040	16.63%	Zone 1
1	192	192	13	4232	17.42%	Zone 1
1	182	182	14	4414	18.17%	Zone 1
1	175	175	15	4589	18.89%	Zone 1
1	170	170	16	4759	19.59%	Zone 1
1	167	167	17	4926	20.28%	Zone 1
1	155	155	18	5081	20.91%	Zone 1
1	153	153	19	5234	21.54%	Zone 1
1	142	142	20	5376	22.13%	Zone 1
1	130	130	21	5506	22.66%	Zone 1
1	126	126	22	5632	23.18%	Zone 1
2	118	236	24	5868	24.15%	Zone 1
1	108	108	25	5976	24.60%	Zone 1
1	107	107	26	6083	25.04%	Zone 1
1	106	106	27	6189	25.48%	Zone 1
1	103	103	28	6292	25.90%	Zone 1
1	99	99	29	6391	26.31%	Zone 1
1	98	98	30	6489	26.71%	Zone 1
1	95	95	31	6584	27.10%	Zone 1
2	94	188	33	6772	27.88%	Zone 1
1	93	93	34	6865	28.26%	Zone 1
1	91	91	35	6956	28.63%	Zone 1
1	88	88	36	7044	28.99%	Zone 1
1	86	86	37	7130	29.35%	Zone 1
3	83	249	40	7379	30.37%	Zone 1

1	78	78	41	7457	30.69%	Zone 1
1	77	77	42	7534	31.01%	Zone 1
2	74	148	44	7682	31.62%	Zone 1
1	71	71	45	7753	31.91%	Zone 1
3	70	210	48	7963	32.78%	Zone 1
2	68	136	50	8099	33.34%	Zone 1
2	67	134	52	8233	33.89%	Zone 2
1	66	66	53	8299	34.16%	Zone 2
2	65	130	55	8429	34.70%	Zone 2
2	64	128	57	8557	35.22%	Zone 2
3	63	189	60	8746	36.00%	Zone 2
2	62	124	62	8870	36.51%	Zone 2
1	59	59	63	8929	36.75%	Zone 2
1	58	58	64	8987	36.99%	Zone 2
5	55	275	69	9262	38.12%	Zone 2
1	54	54	70	9316	38.35%	Zone 2
3	52	156	73	9472	38.99%	Zone 2
3	51	153	76	9625	39.62%	Zone 2
3	50	150	79	9775	40.24%	Zone 2
6	48	288	85	10063	41.42%	Zone 2
1	47	47	86	10110	41.62%	Zone 2
2	46	92	88	10202	41.99%	Zone 2
3	45	135	91	10337	42.55%	Zone 2
1	44	44	92	10381	42.73%	Zone 2
2	43	86	94	10467	43.08%	Zone 2
2	42	84	96	10551	43.43%	Zone 2
3	41	123	99	10674	43.94%	Zone 2
5	40	200	104	10874	44.76%	Zone 2
4	39	156	108	11030	45.40%	Zone 2
6	38	228	114	11258	46.34%	Zone 2
4	37	148	118	11406	46.95%	Zone 2
3	36	108	121	11514	47.39%	Zone 2
3	35	105	124	11619	47.83%	Zone 2
2	34	68	126	11687	48.11%	Zone 2
8	33	264	134	11951	49.19%	Zone 2
8	32	256	142	12207	50.25%	Zone 2
4	31	124	146	12331	50.76%	Zone 2
5	30	150	151	12481	51.37%	Zone 2
6	29	174	157	12655	52.09%	Zone 2
7	28	196	164	12851	52.90%	Zone 2

7	27	189	171	13040	53.68%	Zone 2
11	26	286	182	13326	54.85%	Zone 2
7	25	175	189	13501	55.57%	Zone 2
5	24	120	194	13621	56.07%	Zone 2
9	23	207	203	13828	56.92%	Zone 2
12	22	264	215	14092	58.01%	Zone 2
15	21	315	230	14407	59.30%	Zone 2
9	20	180	239	14587	60.04%	Zone 2
13	19	247	252	14834	61.06%	Zone 2
15	18	270	267	15104	62.17%	Zone 2
11	17	187	278	15291	62.94%	Zone 2
20	16	320	298	15611	64.26%	Zone 2
39	15	585	337	16196	66.67%	Zone 2
20	14	280	357	16476	67.82%	Zone 3
24	13	312	381	16788	69.10%	Zone 3
23	12	276	404	17064	70.24%	Zone 3
32	11	352	436	17416	71.69%	Zone 3
41	10	410	477	17826	73.38%	Zone 3
42	9	378	519	18204	74.93%	Zone 3
56	8	448	575	18652	76.78%	Zone 3
65	7	455	640	19107	78.65%	Zone 3
85	6	510	725	19617	80.75%	Zone 3
105	5	525	830	20142	82.91%	Zone 3
123	4	492	953	20634	84.93%	Zone 3
328	3	984	1281	21618	88.98%	Zone 3
580	2	1160	1861	22778	93.76%	Zone 3
1516	1	1516	3377	24294	100.00%	Zone 3

Table 4.8.1 (B) Range-wise Distribution of Articles in Journals

S.N.	Range of Articles	No. of Journals	Total Articles
1.	1-10	2941	6878
2.	11-20	206	3009
3.	21-30	84	2076
4.	31-40	48	1657
5.	41-50	23	1049
6.	51-100	48	3333
7.	101-200	15	2252
8.	200>	12	4040
	Total	**3377**	**24294**

4.8.2 Bradford's Law of Scattering of Articles in Journal(s)

In 1934, Samuel C. Bradford described the Bradford's law of scattering for journals. According to Bradford, "It is a pattern that estimates the exponentially diminishing returns of extending a search for references in science journals, and that can be used to identify the core journals in a field. Further he elaborated that if journals in a field are arranged by the number of articles into three zones, each with approximately one-third of all articles, then the number of journals in each zone will be proportional to **1:n:n^2**." He termed the first one as the nuclear zone, which is highly productive; the second zone as a moderately productive zone; and the third zone as peripheral zone or low productive zone.

Table 4.8.2 depicts the Bradford zones of scattering for antibiotics literature. It is found that 3377 scholarly journals have published 24294 articles on antibiotics in India during 2011-2020. Total articles are divided into three zones, each publishing approximately 33% (8098 articles) of the total antibiotics articles (24294). Further, it is also observed that 1.48% (50 journals) of the journals that published articles on antibiotics have been scattered in zone 1. However 8.50% (287 journals) have been scattered in zone 2 and 90.02% which is 3040 journals have distributed in zone 3. It is evident from data analysis that zone 3 has a lower influence than zone 1 or 2. The zone for the journals and articles have been analysed as follows:

The total articles are divided into three parts. Approximately 33% of articles have been taken in each zone as follows

= 8099: 8098: 8097 (1st 33%: then next 33%: then next 33%)

The number of journals published to the first 8099 papers has been placed in zone 1 and the number of journals publishing the next 8097 journals has been placed in zone 2. Similarly, the number of journals publishing the next 8098 journals has been placed in zone 3.

For the calculation of the expected values of three zones, the Bradford formula is used as follows:

= 1: n: n^2 (where multiplier 'n' =8.17 (average) is calculated from the division of observed journals with each other)

= $50x8.17^0$: $50x8.17^1$: $50x8.17^2$

= 50: 408: 3337

In this way, the expected values of journals for all zones have been calculated. It has been observed from Table 4.8.2 that the calculated value of zone 2 is 408 while the observed value is 287. For zone 3, the calculated value was observed 3337 while the observed value 3040. A graphical presentation of the Bradford's law of scattering of articles in journals on antibiotics research can be seen in graph 4.8.2. It is evident from analysis that there is too much difference between expected values and observed values so that Bradford's law of scattering of articles in journals is not applicable in antibiotics research.

Table 4.8.2 Bradford's Law of Scattering of Articles in Journal(s)

Zone	Expected no. of Journals	Observed Journals	% of Journals	No. of Articles	% of Articles	Cumulative of Articles	Bradford' Multiplier
Zone I	50	50	1.48%	8099	33.34%	8099	-
Zone II	408	287	8.50%	8097	33.33%	16196	5.74
Zone III	3337	3040	90.02%	8098	33.33%	24294	10.59
Total	**3795**	**3377**	**100.00%**	**24294**	**100.00%**		**8.17**

4.8.2 (A) Chi-square Test for Check Applicability of Bradford's Law

Chi-square test has been applied to check whether the journals productivity distribution follows the Bradford's law or not. The formula for the calculation of $\chi 2$ value is as follows:

$$\chi 2 = \sum \frac{(Observed\ value - Expected\ value)^2}{Expected\ Value}$$

It is observed from table 4.8.2 (A) that the calculated $\chi 2$ value for all journals productivity is

$\chi 2$ (Calculated value)=62.32

The critical value of chi-square at the 5% level of significance at degree of freedom (3-1) =2 is

$\chi 2$ (Tabulated value)=5.99

Hence 62.32>5.99

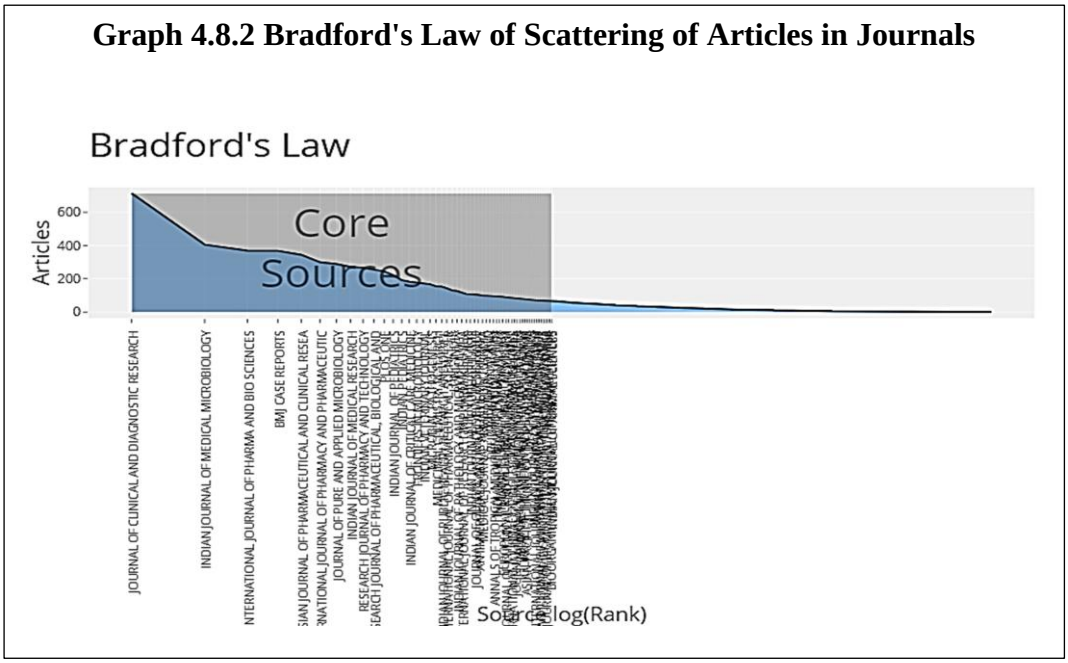
$\chi 2$ (Calculated value)> $\chi 2$ (Tabulated value)

On comparing, it is found that the calculated value of Chi-square is greater than the critical value of chi-square. Thus, it is conclude that the Bradford's law is not fit in the observed given all journal productivity distribution.

Table 4.8.2 (A) Chi-square Test for Check Applicability of Bradford's Law

Zone	**Expected Value of Journals**	**Observed Value of Journals**	**Obs-Exp**	**(Obs-Exp)2**	$\frac{(\textbf{Obs.}-\textbf{Exp.})^2}{\textbf{Exp}}$
Zone I	50	50	0	0	0
Zone II	408	287	-121	14641	35.88
Zone III	3337	3040	-297	88209	26.43
Total	**3795**	**3377**			$\chi 2$ =62.32

Graph 4.8.2 Bradford's Law of Scattering of Articles in Journals



4.9.1 Most Productive Journals

Table 4.9.1 and Graph 4.9.1 show the most preferred twenty journals with the percentage of the total, the cumulative number of articles, their H-index, and published country on antibiotics from 2011 to 2020. A total of 3377 journals have been observed for the output of 24294 articles. The H-index of journals was ascertained by the Scimago Journal and Country Rank (SJR) 2020 Powered by SCOPUS. To more closely examine the leading journals, it is found that *Journal of Clinical and Diagnostic Research* with 713 (2.84%) articles was the most preferred journal of Indian authors for publishing antibiotics articles followed by the *Indian Journal of Medical Microbiology* with 405(1.16%) articles and *International Journal of Pharma and Bio Sciences* with 369 (1.47%) articles. In the ranking of twenty most preferred journals, it is observed that five listed journals i.e. *BMJ Case Reports* (368 articles), *Plos One* (244articles), *Frontiers in Microbiology* (175articles), *Microbial Pathogenesis* (167 articles), and *Medicinal Chemistry Research* (155 articles) have published by the United Kingdom, United States, Switzerland, Netherlands and United States respectively. Ranking list of most productive journals along with the publication detail is shown in Table 4.9.1.

Table 4.9.1 Most Productive Journals

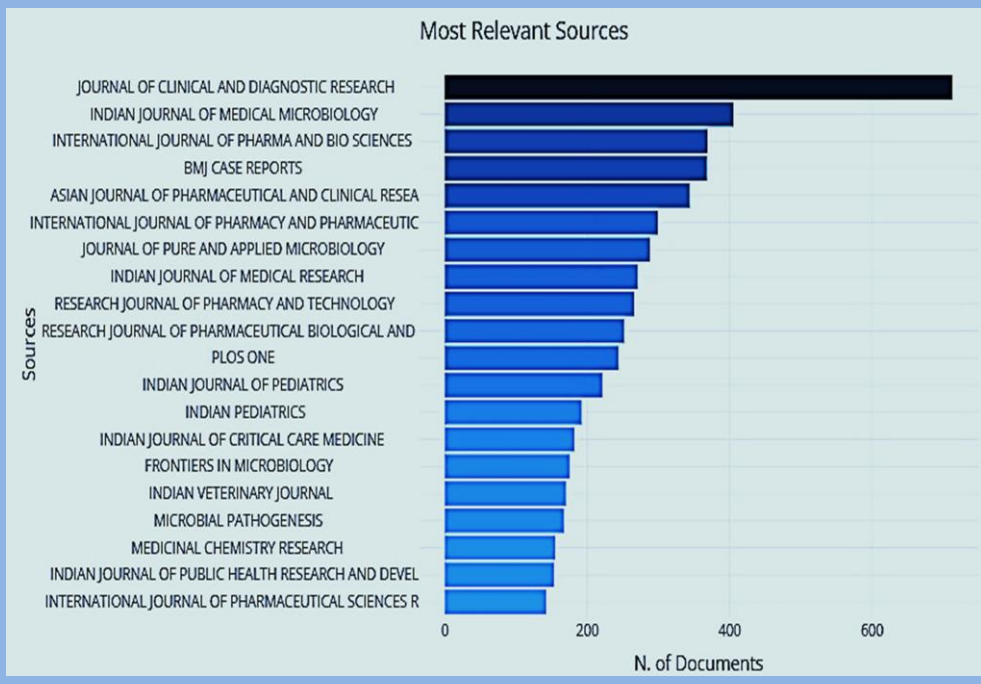
Rank	Name of the Journal (Source)	Articles	%	Country	H-Index*
1st	Journal of Clinical and Diagnostic Research	713	2.84%	India	35
2nd	Indian Journal of Medical Microbiology	405	1.61%	India	40
3rd	International Journal of Pharma and Bio Sciences	369	1.47%	India	27
4th	BMJ Case Reports	368	1.47%	United Kingdom	22

Table Contd…

Rank	Name of the Journal (Source)	Articles	%	Country	H-Index*
5th	Asian Journal of Pharmaceutical and Clinical Research	344	1.37%	India	30
6th	International Journal of Pharmacy and Pharmaceutical Sciences	299	1.19%	India	41
7th	Journal of Pure and Applied Microbiology	288	1.15%	India	13
8th	Indian Journal of Medical Research	271	1.08%	India	18
9th	Research Journal of Pharmacy and Technology	266	1.06%	India	14
10th	Research Journal of Pharmaceutical Biological and Chemical Sciences	252	1.00%	India	27
11th	Plos One	244	0.97%	United States	300
12th	Indian Journal of Pediatrics	221	0.88%	India	46
13th	Indian Pediatrics	192	0.76%	India	49
14th	Indian Journal of Critical Care Medicine	182	0.72%	India	27
15th	Frontiers in Microbiology	175	0.70%	Switzerland	108
16th	Indian Veterinary Journal	170	0.68%	India	15
17th	Microbial Pathogenesis	167	0.66%	Netherlands	67
18th	Medicinal Chemistry Research	155	0.62%	United States	42
19th	Indian Journal of Public Health Research and Development	153	0.61%	India	11
20th	International Journal of Pharmaceutical Sciences Review and Research	142	0.57%	India	27

As per Scimago Journal & Country Rank (SJR) 2020 Powered by SCOPUS.

Graph 4.9.1 Most Productive Journals



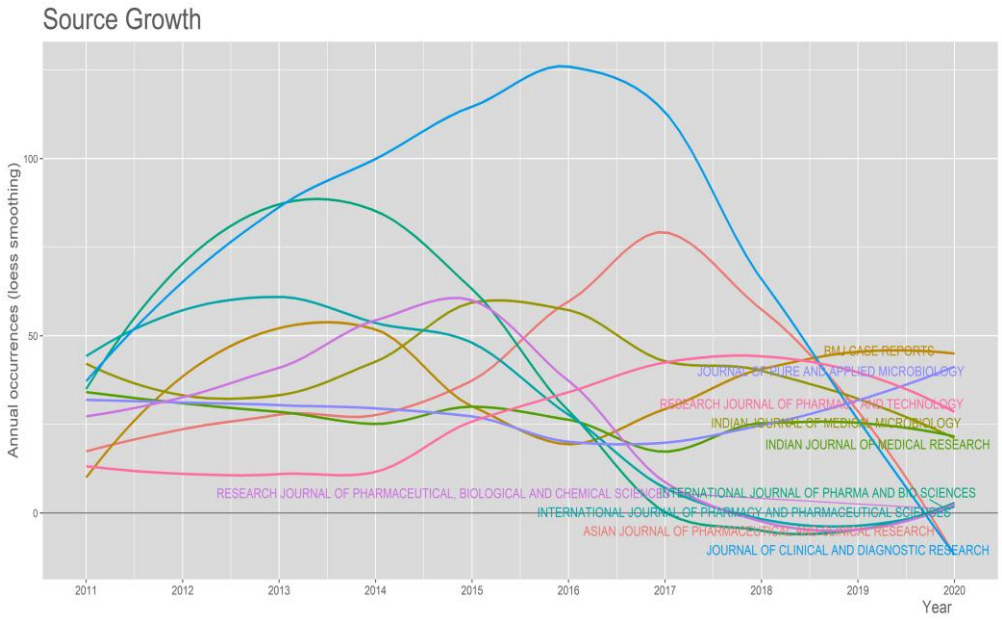
4.9.2 Year-wise Source Growth

The year-wise source growth on antibiotics research from 2011 to 2020 is shown in table and graph 4.9.2. It is observed that the *Journal of Clinical and Diagnostic Research* has been published the highest 136 articles in the year 2016 but during 2019 and 2020, it has not published even single articles. *Indian Journal of Medical Microbiology* has been ranked as the second-highest source journal, which publishes every year 16 to 42 articles. It is seen that the number of publications in the top ten source journals has been decreased in the year 2019 and 2020. It is also observed from analysis that three journals i.e. *International Journal of Pharma and Bio Sciences, International Journal of Pharmacy and Pharmaceutical Sciences, and Research Journal of Pharmaceutical, Biological and Chemical Sciences* having a position in the top 10 productive journals on antibiotics but during the last four years, they have not any publication on antibiotics.

Table 4.9.2 Year-wise Source Growth

Name of the Sources	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Journal of Clinical and Diagnostic Research	37	64	92	101	106	136	108	69	0	0
Indian Journal of Medical Microbiology	42	35	28	40	64	58	40	38	44	16
International Journal of Pharma and Bio Sciences	34	71	93	74	77	20	0	0	0	0
BMJ Case Reports	13	29	63	49	31	17	27	50	45	44
sian Journal of Pharmaceutical and Clinical Research	13	33	28	27	37	57	81	68	0	0
International Journal of Pharmacy and Pharmaceutical Sciences	40	68	55	57	45	34	0	0	0	0
Journal of Pure and Applied Microbiology	31	35	24	32	29	17	21	26	32	41
Indian Journal of Medical Research	30	43	17	31	28	27	21	12	50	12
Research Journal of Pharmacy And Technology	11	16	10	16	16	49	27	55	38	28
Research Journal of Pharmaceutical , Biological And Chemical Sciences	31	26	36	56	60	43	0	0	0	0

Graph 4.9.2 Year-wise Source Growth

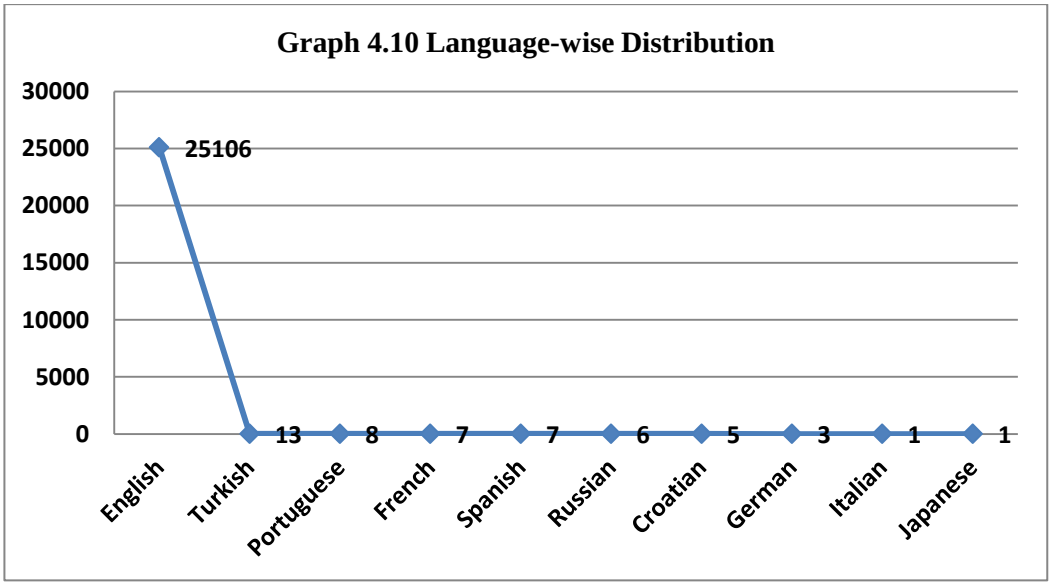


4.10 LANGUAGE-WISE DISTRIBUTION

The Language-wise distribution of articles on antibiotics research in India has been shown in Table 4.10. The study reveals that the maximum number of publications on antibiotics research has been published in the *English language* with 25106 publications (99.8 %), followed by the *Turkish language* with 13 publications (0.052 %), *Portuguese language* ranks the third position with 8 publications (0.32 %) and the remaining languages such as *French, Spanish* and other languages have been published very fewer articles. it is seen that the *English language* dominance was found in every year in total productivity on the subject during the study period.

Table 4.10 Language-wise Distribution

S.N.	Language	No. of articles	%
1.	English	25106	99.797%
2.	Turkish	13	0.052%
3.	Portuguese	8	0.032%
4.	French	7	0.028%
5.	Spanish	7	0.028%
6.	Russian	6	0.024%
7.	Croatian	5	0.020%
8.	German	3	0.012%
9.	Italian	1	0.004%
10.	Japanese	1	0.004%



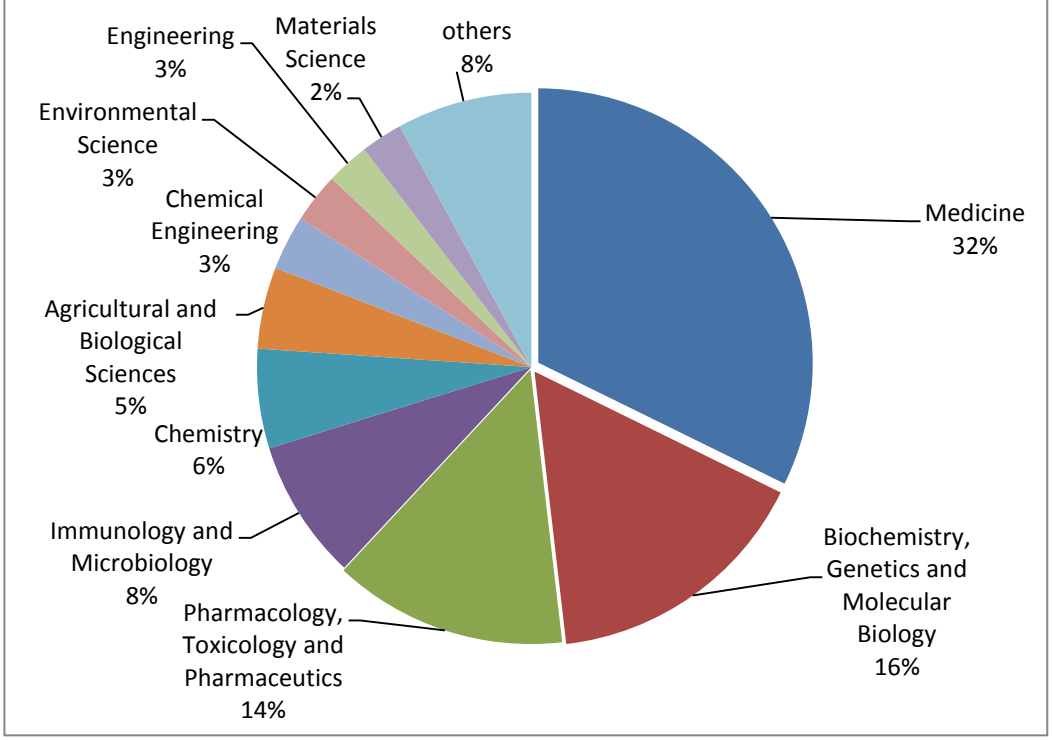
4.11 SUBJECT-WISE DISTRIBUTION

Table 4.11 shows the subject wise publications of the papers. It is observed from the table that highest 12573 (33.2%) papers were published under *Medicine* subject, followed by *Biochemistry, Genetics and Molecular Biology* with 6188 (15.9%) and *Pharmacology, Toxicology and Pharmaceuticals* with 5373 (13.8%). It is also observed that around 35 subjects published papers on antibiotics, indicating the multidisciplinary nature of the subject.

Table 4.11 Subject-wise Distribution

S.No.	Subject	Documents	%
1.	Medicine	12573	32.3%
2.	Biochemistry, Genetics and Molecular Biology	6188	15.9%
3.	Pharmacology, Toxicology and Pharmaceutics	5373	13.8%
4.	Immunology and Microbiology	3223	8.3%
5.	Chemistry	2283	5.9%
6.	Agricultural and Biological Sciences	1875	4.8%
7.	Chemical Engineering	1260	3.2%
8.	Environmental Science	1143	2.9%
9.	Engineering	983	2.5%
10.	Materials Science	964	2.5%
11.	Veterinary	681	1.7%
12.	Physics and Astronomy	539	1.4%
13.	Multidisciplinary	472	1.2%
14.	Dentistry	334	0.9%
15.	Neuroscience	291	0.7%
16.	Energy	217	0.6%
17.	Health Professions	187	0.5%
18.	Computer Science	149	0.4%
19.	Social Sciences	127	0.3%
20.	Earth and Planetary Sciences	101	0.3%
		Total	**100.0%**

Graph 4.11 Subject-wise Distribution

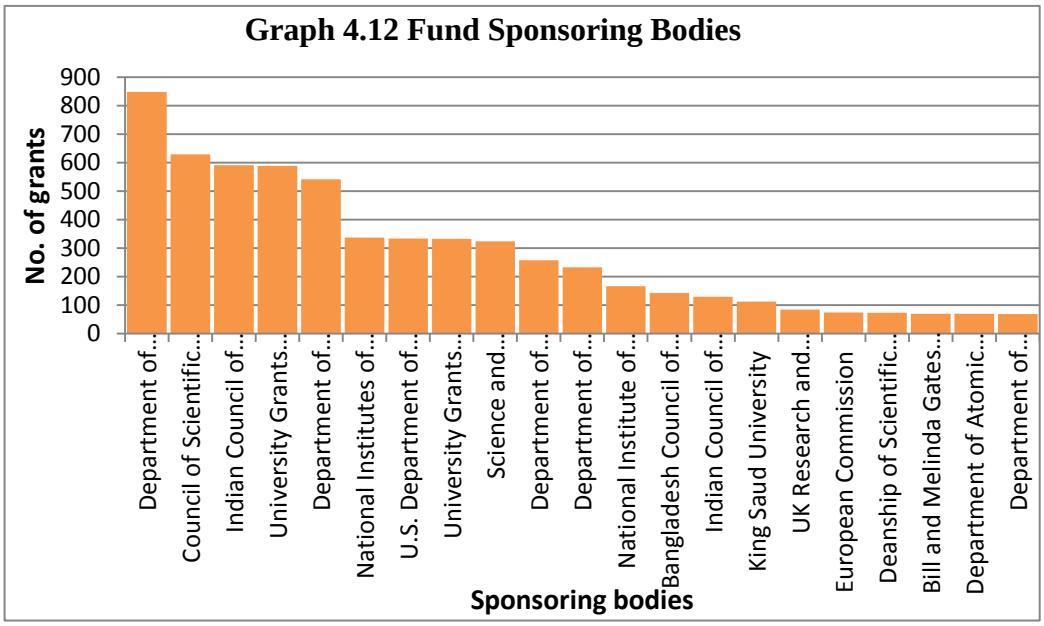


4.12 FUND SPONSORING BODIES

Table 4.12 shows the list of fund sponsoring bodies for antibiotics research in India. A total of 170 bodies have released funds to various institutes for conducting research in this area. It has been observed that the *Department of Science and Technology, Ministry of Science and Technology, India* has sponsored 848 times to various institutions, followed by *Council of Scientific and Industrial Research, India* with 629, and *Indian Council of Medical Research* with 591 times. The *University Grants Commission* has also given grants to 589 different institutes to promote research on this. Apart from this, it was also found that funding bodies of other countries other than India have also given grants to Indian scientists for research on this subject.

Table 4.12 Fund Sponsoring Bodies

S.N.	Sponsoring Bodies	No.
1.	Department of Science and Technology, Ministry of Science and Technology, India	848
2.	Council of Scientific and Industrial Research, India	629
3.	Indian Council of Medical Research	591
4.	University Grants Commission	589
5.	Department of Biotechnology, Ministry of Science and Technology, India	542
6.	National Institutes of Health	337
7.	U.S. Department of Health and Human Services	334
8.	University Grants Committee	332
9.	Science and Engineering Research Board	323
10.	Department of Science and Technology, Government of Kerala	257
11.	Department of Biotechnology, Government of West Bengal	232
12.	National Institute of Allergy and Infectious Diseases	166
13.	Bangladesh Council of Scientific and Industrial Research	143
14.	Indian Council of Agricultural Research	129
15.	King Saud University	112
16.	UK Research and Innovation	84
17.	European Commission	74
18.	Deanship of Scientific Research, King Saud University	73
19.	Bill and Melinda Gates Foundation	70
20.	Department of Atomic Energy, Government of India	69



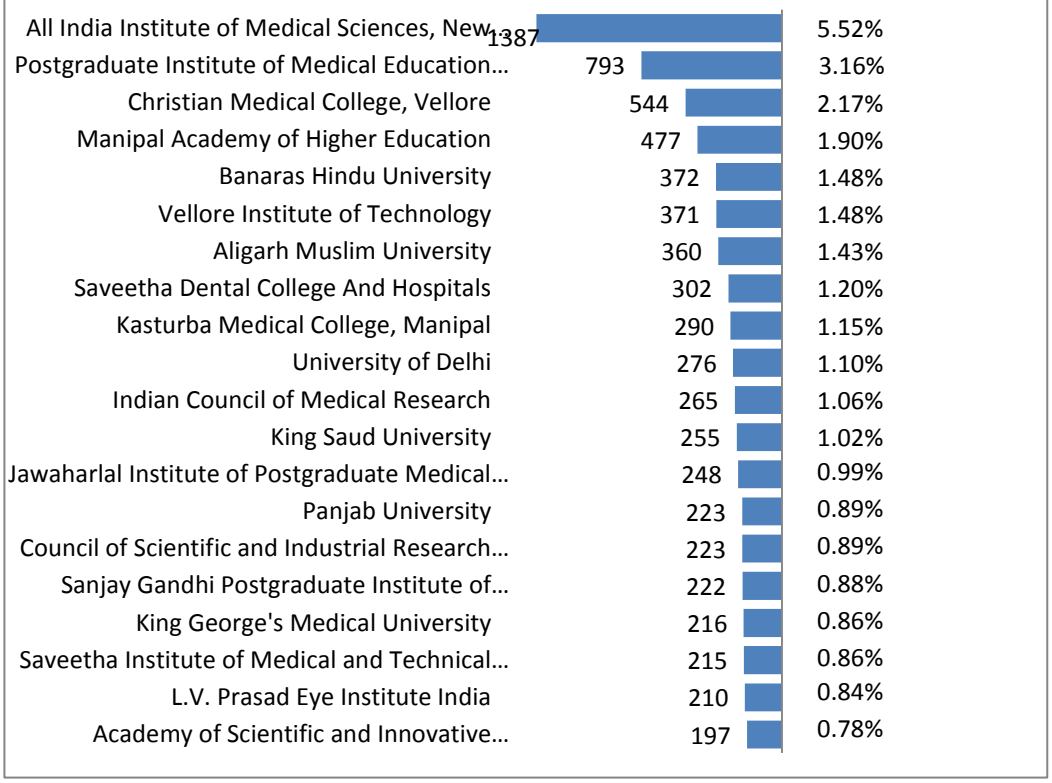
4.13 INDIA'S HIGHLY PRODUCTIVE INSTITUTIONS

Table and Graph 4.13 presents India's highly productive twenty institutions in antibiotics research. The study reveals that the *All India Institute of Medical Sciences, New Delhi* with 1387 (5.52%) papers has been observed as the most productive institution in the field of antibiotics research followed by the *Postgraduate Institute of Medical Education & amp; Research, Chandigarh* with 793 (3.16%) and *Christian Medical College, Vellore* with 544 (2.17%) papers. A detailed description of India's highly productive twenty institutions in antibiotics research along with the publication is shown in Table 4.13.

Table 4.13 Top 20 Productive Institutes

Rank	Affiliation/ Institute	No. of articles	% (N=25117)
1st	All India Institute of Medical Sciences, New Delhi	1387	5.52%
2nd	Postgraduate Institute of Medical Education & amp; Research, Chandigarh	793	3.16%
3rd	Christian Medical College, Vellore	544	2.17%
4th	Manipal Academy of Higher Education	477	1.90%
5th	Banaras Hindu University,Varanasi	372	1.48%
6th	Vellore Institute of Technology	371	1.48%
7th	Aligarh Muslim University	360	1.43%
8th	Saveetha Dental College And Hospitals	302	1.20%
9th	Kasturba Medical College, Manipal	290	1.15%
10th	University of Delhi, New Delhi	276	1.10%
11th	Indian Council of Medical Research	265	1.06%
12th	King Saud University	255	1.02%
13th	Jawaharlal Institute of Postgraduate Medical Education and Research	248	0.99%
14th	Panjab University, Panjab	223	0.89%
15th	Council of Scientific and Industrial Research India	223	0.89%
16th	Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow	222	0.88%
17th	King George's Medical University	216	0.86%
18th	Saveetha Institute of Medical and Technical Sciences	215	0.86%
19th	L.V. Prasad Eye Institute India	210	0.84%
20th	Academy of Scientific and Innovative Research AcSIR	197	0.78%

Graph 4.13 Top 20 Productive Institutes



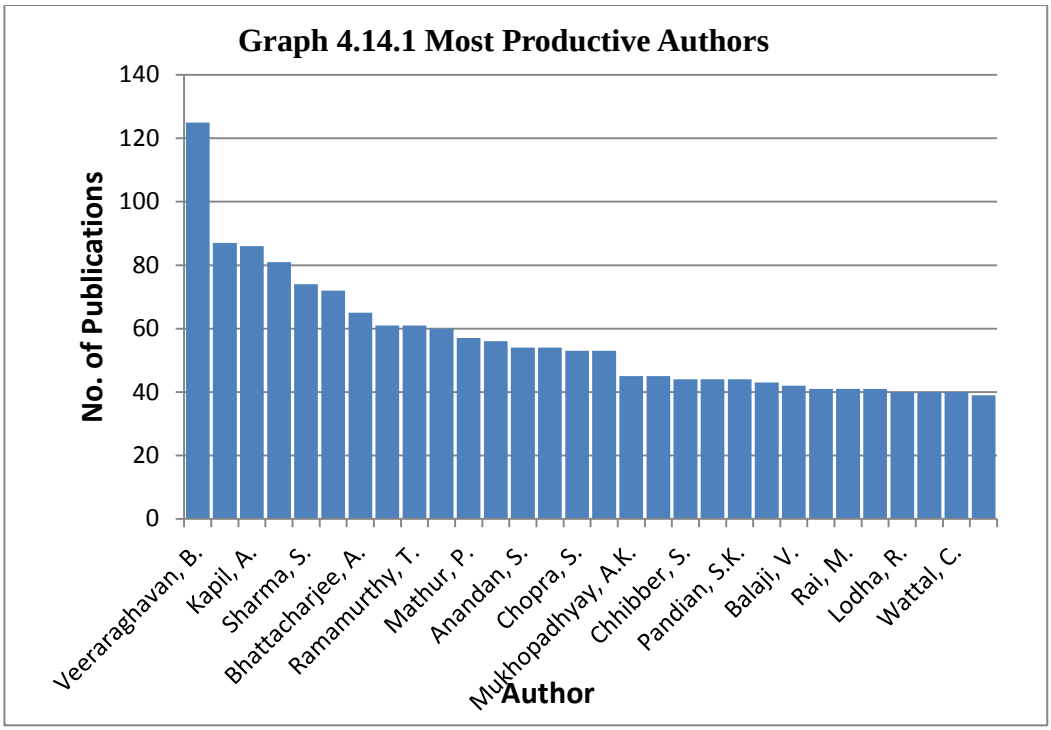
4.14 AUTHORSHIP PATTERN

4.14.1 Most Productive Authors

India's highly productive twenty authors in antibiotics research have been listed in table and graph 4.14.1. A total of 56815 authors have been contributed their research papers in antibiotics research. It is observed from the concerned table that *Veeraraghavan, B.* affiliated with Department of Clinical Microbiology, Christian Medical College, Vellore, India has been published the highest 125 (0.50%) articles on antibiotics research followed by *Rodrigues, C.* with 87 (0.35%) and *Kapil, A.* with 86 (0.34%) articles. During the study, it has also been found that *Shetty, A.* who is ranked 20th in the ranking list, has also published at least 39 articles in antibiotics research.

Table 4.14.1 Most Productive Authors

Rank	Name of the Author	No. of Articles	% (N=25117)
1st	Veeraraghavan, B.	125	0.50%
2nd	Rodrigues, C.	87	0.35%
3rd	Kapil, A.	86	0.34%
4th	Khan, A.U.	81	0.32%
5th	Sharma, S.	74	0.29%
6th	Ray, P.	72	0.29%
7th	Bhattacharjee, A.	65	0.26%
8th	Gautam, V.	61	0.24%
8th	Ramamurthy, T.	61	0.24%
9th	Swaminathan, S.	60	0.24%
10th	Mathur, P.	57	0.23%
11th	Chander, J.	56	0.22%
12th	Anandan, S.	54	0.21%
12th	Laxminarayan, R.	54	0.21%
13th	Chopra, S.	53	0.21%
13th	Haldar, J.	53	0.21%
14th	Mukhopadhyay, A.K.	45	0.18%
14th	Mukhopadhyay, C.	45	0.18%
15th	Chhibber, S.	44	0.18%
15th	Kabra, S.K.	44	0.18%
15th	Pandian, S.K.	44	0.18%
16th	Dhama, K.	43	0.17%
17th	Balaji, V.	42	0.17%
18th	Lundborg, C.S.	41	0.16%
18th	Rai, M.	41	0.16%
18th	Walia, K.	41	0.16%
19th	Lodha, R.	40	0.16%
19th	Mandal, S.M.	40	0.16%
19th	Wattal, C.	40	0.16%
20th	Shetty, A.	39	0.16%



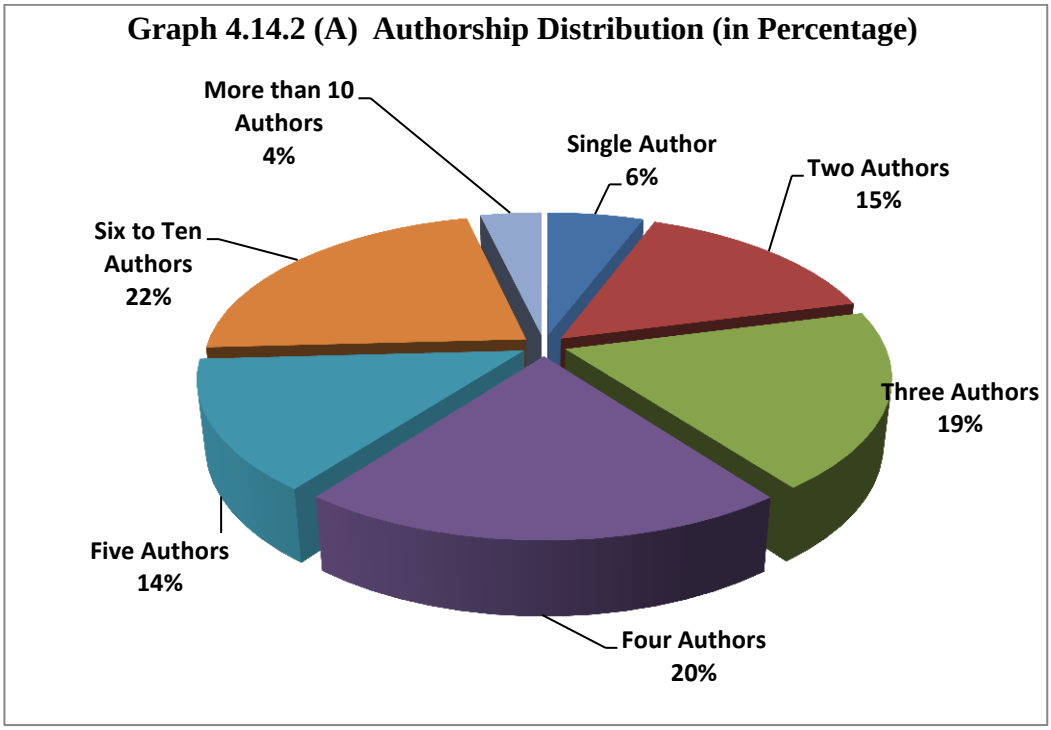
4.14.2 Authorship Distribution

Table 4.14.2 and graph 4.14.2 (A&B) present the authorship distribution of antibiotics research in India. The authorship patterns against a total of 25117 papers published on antibiotics research were analysed, of which it is found that only 1473 publications are published by single authors while 23644 papers were published by multi-authors. In the detailed study, it was also found that the highest 22.19% i.e. 5683 papers were written by six to 10 authors while 20.58% i.e. 5270 papers have been written by four authors followed by 18.81% i.e. 4817 papers have been published by three authors. Further, it is found that more than ten authors have published 3.67% i.e.941 papers, out of which the number of authors of some papers is up to 600 to 700 authors. A study of the authorship patterns revealed that only 5.75% of the papers have been published by single authors and the remaining 94.24% of papers were published by multiple authors. Other detailed description of authorship distribution of antibiotics research in India is shown in table 4.14.2.

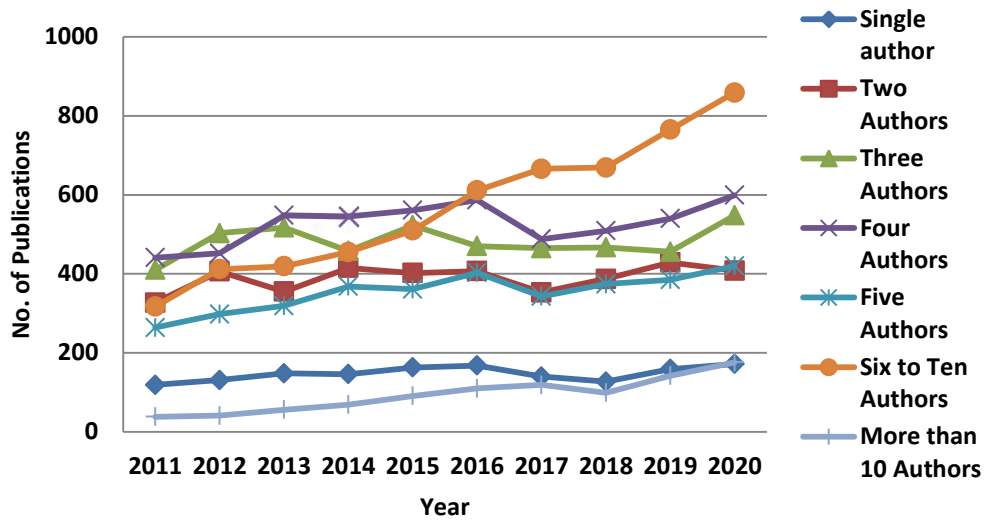
Table 4.14.2 Authorship Distribution

Year	Single Author	Two Authors	Three Authors	Four Authors	Five Authors	Six to Ten Authors	More than 10 Authors	Total	%
2011	119	327	410	441	264	305	38	1904	7.48%
2012	131	406	503	452	298	393	41	2224	8.76%
2013	148	355	517	548	319	380	56	2323	9.22%
2014	146	415	458	545	368	424	69	2425	9.59%
2015	163	402	523	561	361	477	91	2578	10.20%
2016	168	407	470	587	403	550	110	2695	11%
2017	140	353	465	488	343	610	119	2518	10.05%
2018	127	387	467	509	374	619	99	2582	10.28%
2019	159	429	456	540	385	697	142	2808	11.23%
2020	172	408	548	599	420	737	176	3060	12.43%
Total	**1473**	**3889**	**4817**	**5270**	**3535**	**5192**	**941**	**25117**	**100.00%**
%	**5.75%**	**15.19%**	**18.81%**	**20.58%**	**13.80%**	**22.19%**	**3.67%**	**100.00%**	

Graph 4.14.2 (A) Authorship Distribution (in Percentage)



Graph 4.14.2 (B) Authorship Distribution (Year-wise)



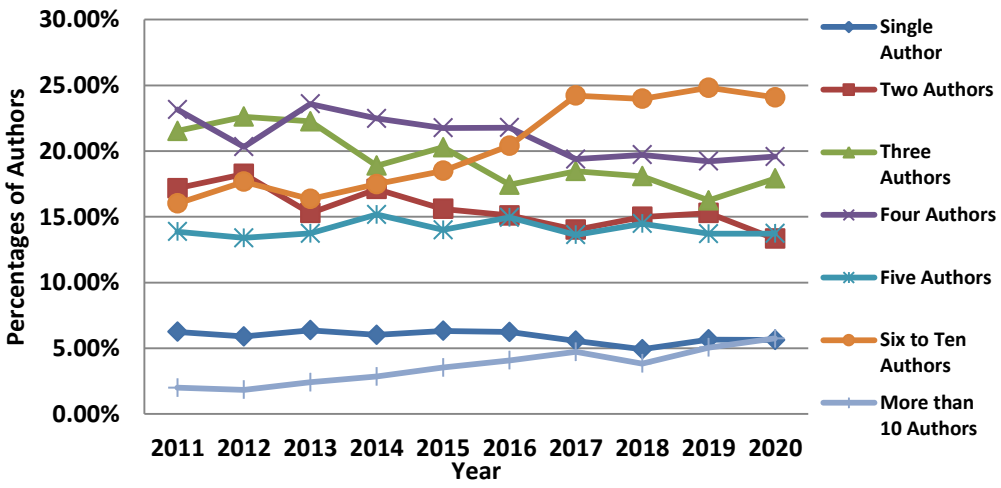
4.14.3 Authorship Pattern (Year-wise Percentage)

The year-wise authorship distribution with percentage is presented in table 4.14.3. It is observed from table that the highest 6.37% of papers have been published by single authors in the year 2013 followed by 6.32% of papers in the year 2015. The lowest 4.92% of papers were published by a single author in 2018. Further, the study revealed that 18.26% of the papers of the two authors were published in the year 2015 and the lowest 13.33% papers in the year 2020. The highest 22.62% papers written by three authors were published in 2012 and the lowest 16.24% in 2019. The highest 23.59% papers of four authors were published in 2013 and the lowest 19.23% in 2019. The highest 15.18% papers of five authors were published in 2014 while the lowest 13.40% in 2012. It is also observed that 24.42% of papers of 6 to 10 authors, were published in 2019 and the lowest 16.02%in 2011 while 5.75% papers of more than ten authors were published in 2020 and the lowest 1.24% in 2012.

Table 4.14.3 Authorship Pattern (Year-wise Percentage)

Year	Single Author	Two Authors	Three Authors	Four Authors	Five Authors	Six to Ten Authors	More than 10 Authors	Total
2011	119	327	410	441	264	305	38	1904
	6.25%	17.17%	21.53%	23.16%	13.87%	16.02%	2.00%	100.00%
2012	131	406	503	452	298	393	41	2224
	5.89%	18.26%	22.62%	20.32%	13.40%	17.67%	1.84%	100.00%
2013	148	355	517	548	319	380	56	2323
	6.37%	15.28%	22.26%	23.59%	13.73%	16.36%	2.41%	100.00%
2014	146	415	458	545	368	424	69	2425
	6.02%	17.11%	18.89%	22.47%	15.18%	17.48%	2.85%	100.00%
2015	163	402	523	561	361	477	91	2578
	6.32%	15.59%	20.29%	21.76%	14.00%	18.50%	3.53%	100.00%
2016	168	407	470	587	403	550	110	2695
	6.23%	15.10%	17.44%	21.78%	14.95%	20.41%	4.08%	100.00%
2017	140	353	465	488	343	610	119	2518
	5.56%	14.02%	18.47%	19.38%	13.62%	24.23%	4.73%	100.00%
2018	127	387	467	509	374	619	99	2582
	4.92%	14.99%	18.09%	19.71%	14.48%	23.97%	3.83%	100.00%
2019	159	429	456	540	385	697	142	2808
	5.66%	15.28%	16.24%	19.23%	13.71%	24.82%	5.06%	100.00%
2020	172	408	548	599	420	737	176	3060
	5.62%	13.33%	17.91%	19.58%	13.73%	24.08%	5.75%	100.00%
Total	**1473**	**3889**	**4817**	**5270**	**3535**	**5683**	**941**	**25117**
%	**5.75%**	**15.19%**	**18.81%**	**20.58%**	**13.80%**	**22.19%**	**3.67%**	**100.00%**

Graph 4.14.3 Authorship Pattern (Year-wise Percentage)



4.15 COLLABORATION PATTERN

The degree of collaboration (DC) for antibiotics research during the period of study has been calculated by using the following formula suggested by Subramanyam K (1983). "DC is easy to calculate and easily interpretable as a degree (for it lies between zero and one), gives zero weight to single-authored papers, and always ranks higher a discipline (or period) with a higher percentage of multiple-authored papers."

$$C = \frac{\mathrm{Nm}}{\mathrm{Nm+Ns}}$$

Where, C = Degree of Collaboration

Nm = Number of Multiple Authored Papers

Ns = Number of Single Authored Papers

According to Lawani, the collaborative index is "to measure the level of collaboration in two fields or to reveal the trend towards multiple authorships in a discipline, many studies have used the mean number of authors per paper."

Table 4.15 and graph (4.15 A) present the year-wise degree of collaboration of authors. Degree of collaboration has been calculated between 0.94 to 0.95 with an average of 0.94. It is evident from the calculation that the Average value of DC is about 1 so it is clear that the percentage of multiple authors is more than single authors and the trend of collaborative research is increasing with time.

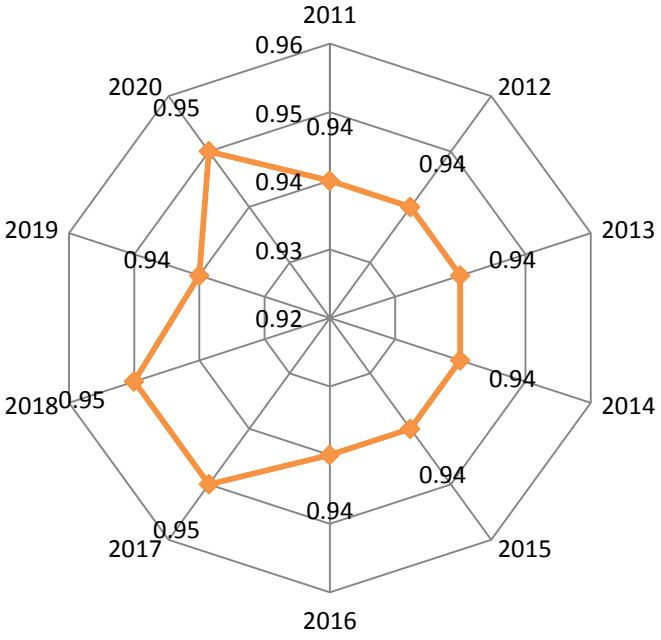
Table 4.15 and graph (4.15 B) display the collaborative index of the authors. It is found that the value for CI has been increased from 4.37 in 2011 to 5.82 in 2016. It is clear from the table that the CI value was higher during the period 2016-2020 with 5.82, 5.47, 5.29, 5.69, and 5.86 respectively. The average CI value during the period 2011 to 2020 has been observed 5.16 which imply that the collaborative level falls between 5 and 6 and the trend towards multiple authorships is increasing.

Table 4.15 Degree of Collaboration / Collaboration Index

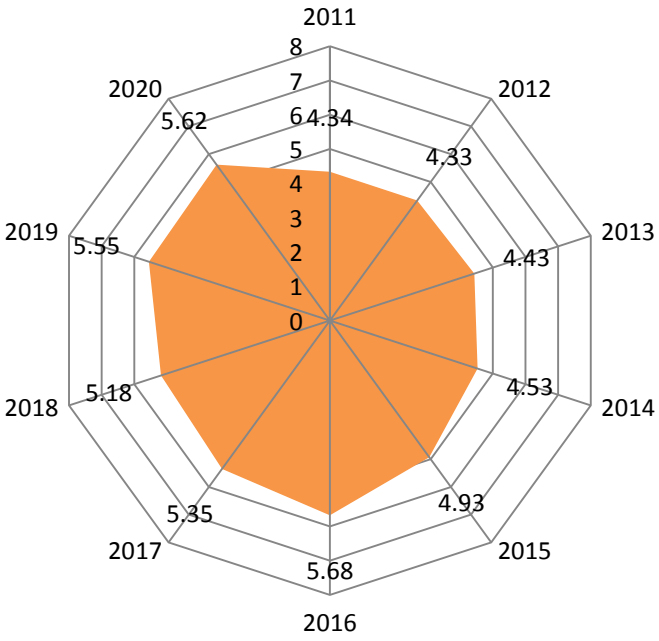
Year	SAP	SA	TP	MAP	TA	TMA	DC	CI
2011	119	119	1904	1785	7926	7807	0.94	4.37
2012	131	131	2224	2093	9278	9147	0.94	4.37
2013	148	148	2323	2175	9963	9815	0.94	4.51
2014	146	146	2425	2279	10614	10468	0.94	4.59
2015	163	163	2578	2415	12232	12069	0.94	5.00
2016	168	168	2695	2527	14863	14695	0.94	5.82
2017	140	140	2518	2378	13150	13010	0.94	5.47
2018	127	127	2582	2455	13105	12978	0.95	5.29
2019	159	159	2808	2649	15236	15077	0.94	5.69
2020	172	172	3060	2888	17085	16913	0.94	5.86
Total	**1473**	**1473**	**25117**	**23644**	**123452**	**121979**	**0.94**	**5.16**

SAP-Single authored paper — SA -Single author
TP- Total paper — MAP- Multiple authored paper
TA – Total author — TMA - Total multiple author
DC- Degree of collaboration — CI- Collaboration index

Graph 4.15 (A) Degree of Collaboration



Graph 4.15 (B) Collaboration index



4.16 AUTHOR(S)-WISE DISTRIBUTION OF ARTICLES

Table 4.16 presents the distributions of articles by the author. A total of 56815 authors have been identified, who have contributed 25117 papers in antibiotics research during 2011-2020. It is observed that 39750 (69.96%) authors have been contributed only one each paper in antibiotics research while 8128 (14.30%) authors have published two papers each. Further, it is observed that about 3320 (6%), 1752 (3.08%), 1006 (1.77%) authors have been contributed three; four, and five papers respectively. It is also observed that the highest 125 papers have been published by only one author followed by 87 papers, 86papers, 81 papers contributions by one author each. A detailed list of the distributions of articles based on the author is presented in table 4.16.

Table 4.16 Author(s)-wise Distribution of Articles

S.No.	No. of Authors	Documents Written	Proportion of Authors	Total Authors
1.	1	125	0.0018%	125
2.	1	87	0.0018%	87
3.	1	86	0.0018%	86
4.	1	81	0.0018%	81
5.	1	74	0.0018%	74
6.	1	72	0.0018%	72
7.	1	65	0.0018%	65
8.	2	61	0.0035%	122
9.	1	60	0.0018%	60
10.	1	57	0.0018%	57
11.	1	56	0.0018%	56
12.	2	54	0.0035%	108
13.	2	53	0.0035%	106
14.	2	45	0.0035%	90
15.	3	44	0.0053%	132
16.	1	43	0.0018%	43
17.	1	42	0.0018%	42
18.	3	41	0.0053%	123
19.	3	40	0.0053%	120
20.	1	39	0.0018%	39
21.	2	38	0.0035%	76
22.	4	37	0.0070%	148
23.	1	36	0.0018%	36
24.	3	35	0.0053%	105
25.	1	34	0.0018%	34
26.	5	32	0.0088%	160
27.	7	31	0.0123%	217
28.	3	30	0.0053%	90

Table Contd…

S.No.	No. of Authors	Documents Written	Proportion of Authors	Total Authors
29.	3	29	0.0053%	87
30.	3	28	0.0053%	84
31.	6	27	0.0106%	162
32.	3	26	0.0053%	78
33.	7	25	0.0123%	175
34.	9	24	0.0158%	216
35.	10	23	0.0176%	230
36.	17	22	0.0299%	374
37.	19	21	0.0334%	399
38.	38	20	0.0669%	760
39.	46	19	0.0810%	874
40.	54	18	0.0950%	972
41.	49	17	0.0862%	833
42.	65	16	0.1144%	1040
43.	74	15	0.1302%	1110
44.	91	14	0.1602%	1274
45.	120	13	0.2112%	1560
46.	126	12	0.2218%	1512
47.	178	11	0.3133%	1958
48.	182	10	0.3203%	1820
49.	263	9	0.4629%	2367
50.	348	8	0.6125%	2784
51.	479	7	0.8431%	3353
52.	613	6	1.0789%	3678
53.	1006	5	1.7707%	5030
54.	1752	4	3.0837%	7008
55.	3320	3	5.8435%	9960
56.	8128	2	14.3061%	16256
57.	39750	1	69.9639%	39750
Total	**56815**		**100.0000%**	**108258**

4.17 LOTKA'S LAW ON ANTIBIOTICS RESEARCH

Table 4.17 presents the distributions of articles based on Lotka's law. A total of 56522 authors have been calculated based on Lotka's formula, who has contributed up to 20 papers. It is observed that 39750 (69.58%) authors have been contributed only one each paper in antibiotics research while 8127 (13%) authors have published two papers each. Further, it is observed that about 3211 (5%), 1661 (3%), 997 (2%) authors have been contributed three; four, and five papers respectively. A detailed list of the distributions of articles based on the author is presented in table 4.17.

For the calculation of expected value, two simplest formula of Lotka's law are used:

$x^n Xy = c$ (Equation 1) and $1/n^2$.

Where, x is number of contribution, here as NC

y is number of authors, here as NO

c is a constant.

For the value of 'c' and 'n' Lotka's equation "$x^n Xy = c$" are used. The Data for calculations are retrieved from Table 4.17. When the values of (x) and (y), as given in the row 1 of the Table 4.17, the equations will be as follows:

$1^n X\ 39750 = c$

$c = 39750$

When the data put in equation from second row of Table 4.17, the value of n has been found as follows:

$2^n X 8128 = 39750$

$2^n = 39750/8128$

$2^n = 4.890$, Taking log at both sides

$n \log 2 = \log(4.890)$

$n\ (0.301) = 0.689$

$n = 2.289$

$n = 2.29$

Table 4.17 Lotka's Law on Antibiotics Research
(Up to 20 Publications)

NC	NO	NOP	TA	NE	NEP	NO-NE
1	39750	69%	39750	39750	63%	0
2	8128	14%	16256	8127	13%	1
3	3320	6%	9960	3211	5%	109
4	1752	3%	7008	1661	3%	91
5	1006	2%	5030	997	2%	9
6	613	1%	3678	656	1%	-43
7	479	1%	3353	461	1%	18
8	348	1%	2784	340	1%	8
9	263	0%	2367	259	0%	4
10	182	0%	1820	204	0%	-22
11	178	0%	1958	164	0%	14
12	126	0%	1512	134	0%	-8
13	120	0%	1560	112	0%	8
14	91	0%	1274	94	0%	-3
15	74	0%	1110	81	0%	-7
16	65	0%	1040	69	0%	-4
17	49	0%	833	60	0%	-11
18	54	0%	972	53	0%	1
19	46	0%	874	47	0%	-1
20	38	0%	760	42	0%	-4
	56682		103899	56522		

NC – Number of contribution 'n' NO – Observed number of authors
NOP – Percentage of observed authors TA – total authorship
NE – Expected number of authors NEP - Percentage of expected authors

Lotka's law of scientific productivity estimated that "out of all the authors in a given field, 60 percent will have just one publication each; 15 percent will have just two publications each, whereas 7 percent of the authors will have three publications each. Only about 6 percent of authors in any bibliography in any field would produce up to ten papers each." It is evident from table 4.17 that the distribution of observed author productivity is confirm to estimated Lotka's law of scientific productivity, So Lotka's law is applicable in this study.

4.17(A) Chi-Square Test for Check Applicability of Lotka's Law

Chi-square test has been applied to check whether the author productivity distribution follows the Lotka's law or not. The formula for the calculation of $\chi 2$ value is as follows:

$$\chi 2 = \sum \frac{(Observed\ value - Expected\ value)^2}{Expected\ Value}$$

It is observed from table 4.15 that the calculated $\chi 2$ value for all author productivity distribution up to twenty publications are

$\chi 2$ (Calculated value)=20.50

The critical value of chi-square at the 5% level of significance at degree of freedom (20-1) =19 is

$\chi 2$ (Tabulated value)=30.14

Hence 20.50<30.14

$\chi 2$ (Calculated value)< $\chi 2$ (Tabulated value)

On comparing, it is found that the calculated value of chi-square is less than the critical value of chi-square. Thus, it is conclude that the Lotka's law is fit in the observed given all author productivity distribution.

Table 4.17 (A) Chi-square Test for Check Applicability of Lotka's Law

NC	NO(O1)	NE(E1)	O1-E1	(O1-E1)2	$\frac{(Obs.value - Exp.value)^2}{Exp.Value}$
1	39750	39750	0	0	0
2	8128	8127	1	1	0.0
3	3320	3211	109	11899	3.7
4	1752	1661	91	8195	4.9
5	1006	997	9	81	0.1
6	613	656	-43	1849	2.8
7	479	461	18	324	0.7
8	348	340	8	64	0.2
9	263	259	4	16	0.1
10	182	204	-22	484	2.4
11	178	164	14	196	1.2
12	126	134	-8	64	0.5
13	120	112	8	64	0.6
14	91	94	-3	9	0.1
15	74	81	-7	49	0.6
16	65	69	-4	16	0.2
17	49	60	-11	121	2.0
18	54	53	1	1	0.0
19	46	47	-1	1	0.0
20	38	42	-4	16	0.4
Total	56682	56522			χ^2 =20.5

NC – Number of contribution 'n' NO – Observed number of authors

NE – Expected number of authors

4.18 AUTHOR KEYWORD OCCURRENCES

The VOSviewer software has been used for the construction of the co-occurrence bibliometric map, using the author's keywords from the database obtained in antibiotics research. According to Zhanget "Keywords have as their main objective to provide rapid access to scientific works and are highly effective in terms of bibliometric analysis when investigating the knowledge structure of scientific fields."

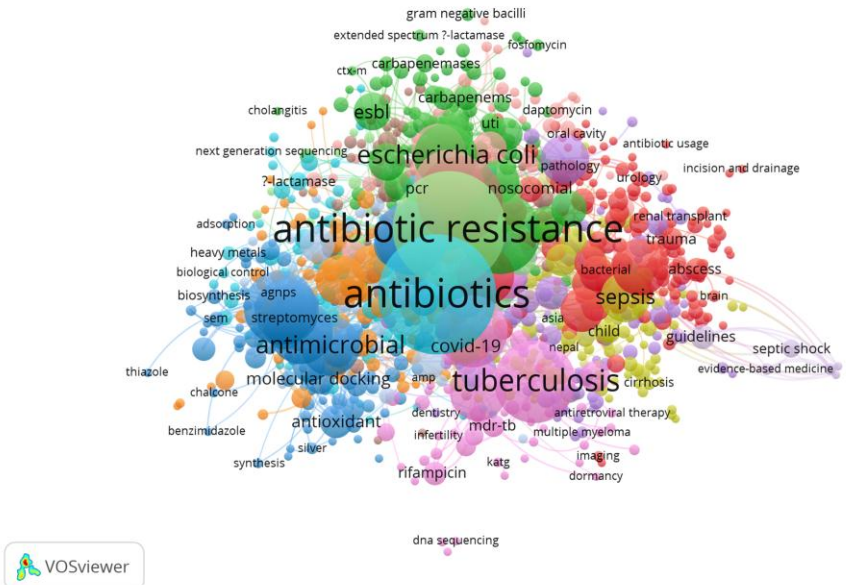
A total of 17392 keywords have been used for the 25117 antibiotics research papers, in which, 976 key words have been found when minimum

occurrences were selected five times. The size of each circle is proportional to the co-occurrence. Frequency of the term depends upon its size. A larger circle denotes a larger frequency and a smaller circle denotes a lower frequency. Table 4.18 shows the twenty most used author keywords in the *antibiotics*. It is observed from table 4.18 and graph 4.17 that *antibiotics* is the most recurring keyword (395) with 638 links, followed by *antibiotics resistance* (281) with 554 links, *antimicrobial resistance* (181) with 349 links. A detailed list of twenty most used author key words has been presented in table 4.18. Additionally, the table shows information related to total link strength, which denotes the importance of a keyword in the field, since a higher value means that it has been linked with others and many times.

Table 4.18 Author Keyword Occurrences in Indian Antibiotics Research

S.No.	Keyword	Occurrences	Total Link Strength
1.	Antibiotics	395	638
2.	Antibiotic resistance	281	554
3.	Antimicrobial resistance	181	349
4.	Tuberculosis	167	252
5.	Biofilm	140	295
6.	Antibacterial activity	139	223
7.	Drug resistance	133	295
8.	Staphylococcus aureus	133	304
9.	Antimicrobial activity	116	171
10.	Antibacterial	112	227
11.	Escherichia coli	112	267
12.	Multidrug resistance	111	263
13.	Pseudomonas aeruginosa	104	224
14.	Antimicrobial	100	223
15.	Mycobacterium tuberculosis	95	150
16.	Infection	92	210
17.	MRSA	87	207
18.	Resistance	80	202
19.	Probiotics	77	157
20.	Sepsis	76	173

Figure 4.18 Author Keyword Occurrences in Indian Antibiotics Research



4.19 CITATION IN INDIAN ANTIBIOTICS RESEARCH LITERATURE

Citation is an important tool for determining an author's, journal's, or article's impact because it allows for the quick recognition of key works in the field. Since not all research publications have the same scholarly relevance, this measure is needed. The following tables examine the citations in the proposed area of research.

4.19.1 Year-Wise and Average Article Citations

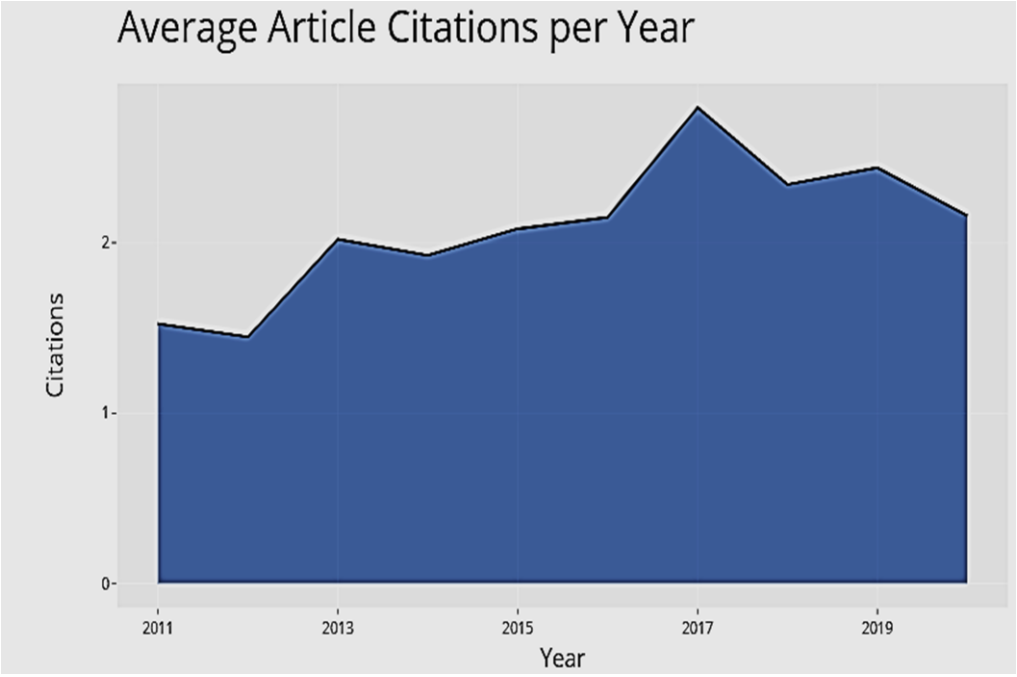
The number of citations is the main factor to reflect the quality of a paper. According to the analysis of the data from Scopus from 2011 to 2020, all antibiotics research publications were cited 255975 times. The total number of citations per year for retrieved documents is shown in Table 4.19.1. The highest citations 37529 have been received in 2013 followed by 32695 in the year 2014 while the lowest 6604 citations were counted in 2020. The number of citations per document was highest for documents published in 2013 (16.15 citations per

document) while the lowest was for those published in 2020 (2.1 citations per document) due to the short time elapsed since publications. The highest average article citations per year have been received in 2017 (2.79 citations) while the lowest article citations per year recorded in 2014 (1.44 citations).

Table 4.19.1 Year-Wise and Average Article Citations

Year	N	TC	Mean TC Per Articles	TC Per Year	Average Article C Per Year	Citable Years
2011	1904	29029	15.246	2903	1.525	10
2012	2224	28982	13.031	3220	1.448	9
2013	2323	37529	16.155	4691	2.019	8
2014	2425	32695	13.482	4671	1.926	7
2015	2578	32198	12.490	5366	2.082	6
2016	2695	28962	10.747	5792	2.149	5
2017	2518	28133	11.173	7033	2.793	4
2018	2582	18141	7.026	6047	2.342	3
2019	2808	13701	4.879	6850	2.440	2
2020	3060	6604	2.158	6604	2.158	1

Graph 4.19.1 Year-Wise Average Article Citations Per Year



4.19.2 Author-Based Citations

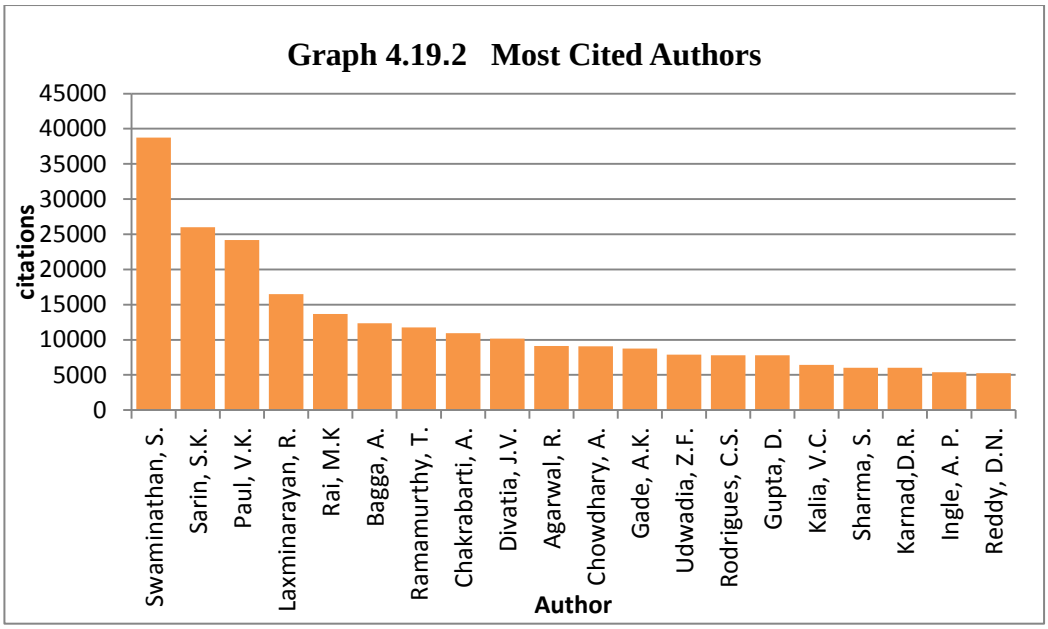
Table and graph 4.19.2 presents the top 20 cited authors on antibiotics research, along with their number of documents and citations per article. A total of 25117 documents have been written by 57128 authors and received 255975 citations till 2020. Out of these, some of the authors have not received any number of citations. It is observed from the analysis that *Swaminathan, S.* affiliated to Department of Clinical Research, Tuberculosis Research Centre, Indian Council of Medical Research (ICMR), Chennai, India has been received the highest 38744 citations followed by *Sarin, S.K* affiliated to Institute of Liver and Biliary Sciences, New Delhi, India with 25985 citations for and *Paul, V.K* affiliated to All India Institute of Medical Sciences (AIIMS), New Delhi, India with 24178 citations. A detail of top twenty cited author along with their citations are shown in table 4.19.2.

Table 4.19.2 Most Cited Authors

Rank	Author	Affiliation	Citations
1st	Swaminathan, S.	Department of Clinical Research, Tuberculosis Research Centre, Indian Council of Medical Research, Chennai, India	38744
2nd	Sarin, S.K	Institute of Liver and Biliary Sciences, New Delhi, India	25985
3rd	Paul, V.K	All India Institute of Medical Sciences, New Delhi, New Delhi, India	24178
4th	Laxminarayan, Ramanan	Public Health Foundation of India, New Delhi, India	16479
5th	Rai, M.K	Department of Biotechnology, Sant Gadge Baba Amravati University, Amravati, Maharashtra, India	13650
6th	Bagga, Arvind	All India Institute of Medical Sciences, New Delhi, New Delhi, India	12341

Table Contd…

Rank	Author	Affiliation	Citations
7th	Ramamurthy, Thandavarayan	Translational Health Science and Technology Institute, Faridabad, India	11763
8th	Ramamurthy, Thandavarayan	Translational Health Science and Technology Institute, Faridabad, India	11763
9th	Chakrabarti, Arunaloke	Postgraduate Institute of Medical Education & Research, Chandigarh, Chandigarh, India	10953
10th	Divatia, Jigeeshu Vasishtha	Tata Memorial Hospital, Mumbai, India	10172
11th	Agarwal, Ritesh	Postgraduate Institute of Medical Education & Research, Chandigarh, Chandigarh, India	9098
12th	Chowdhary, Anuradha	Vallabhbhai Patel Chest Institute, New Delhi, India	9053
13th	Gade, Aniket Krishnarao	Sant Gadge Baba Amravati University, Amravati, India	8752
14th	Udwadia, Zarir Farokh	Breach Candy Hospital, Mumbai, India	7883
15th	Rodrigues, Camilla S.	P.D. Hinduja National Hospital and Medical Research Centre, Mumbai, India	7808
16th	Gupta, Dheeraj	Postgraduate Institute of Medical Education & Research, Chandigarh, Chandigarh, India	7786
17th	Kalia, V.C.	Microbial Biotechnology and Genomics, CSIR-Institute of Genomics and Integrative Biology (IGIB), Delhi University Campus, Mall Road, Delhi-110007, India	6442
18th	Sharma, Savitri	L.V. Prasad Eye Institute India, Hyderabad, India	6044
19th	Karnad, Dilip R.	Jupiter Hospital, Thana, India	6008
20th	Ingle, A. P.	Sant Gadge Baba Amravati University, Amravati, India	5385



4.19.3 Document-Based Citations

The impact of a publication is assessed in terms of the number of citations that it has received. To identify the most influential papers in the field of antibiotics, here are listed the top 20 papers with the most citations. The period of the most cited articles were selected from 2011 to 2020. There are more than one authors in papers, then only the first author to be shown in the following table. Table 4.19.3 show the top twenty highly cited papers in terms of title, Authors, publication year, journal, DOI, and citation numbers that have been retrieved from the Scopus database. It is observed from the table that the title *Surviving Sepsis Campaign: International Guidelines for the Management of Severe Sepsis and Septic Shock: 2012* by Dellinger RP et al. has been received the highest 4037 (average citations per year 448.6) citations followed by *Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016* by Rhodes A et al. with 2318 (average citations per year 463.60) citations and title *Antibiotic Resistance-the Need for Global Solutions* by Laxminarayan R, with 1882 (average citations per year 209.11) citations. The other details on the top 20 document title by citation number are shown in table 4.19.3.

Table 4.19.3 Most Cited Document-title

Rank	Document Title	Author, Year and Source	DOI	Total Citations	TC /Average C per Year	Normalized TC
1st	Surviving sepsis campaign: International guidelines for management of severe sepsis and septic shock: 2012	DELLINGER RP, 2013, CRIT CARE MED	0.10197/CCM.0b013e31827e83af	4037	448.56	248.8951
2nd	Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016	RHODES A, 2017, INTENSIVE CARE MED	10.1007/s00134-017-4683-6	2318	463.60	203.1728
3rd	Antibiotic resistance-the need for global solutions	LAXMINARAYAN R, 2013, LANCET INFECT DIS	10.1016/S1473-3099(13)70318-9	1882	209.11	115.4413
4th	Expanding consensus in portal hypertension Report of the Baveno VI Consensus Workshop: Stratifying risk and individualizing care for portal hypertension	DE FRANCHIS R, 2015, J HEPATOL	10.1016/j.jhep.2015.07.001	1407	201.00	110.7328

Table Contd…

Rank	Document Title	Author, Year and Source	DOI	Total Citations	TC /Average C per Year	Normalized TC
5th	Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016	RHODES A, 2017, CRIT CARE MED	10.1097/CCM.0000000000002255	1366	273.20	119.8451
6th	Global trends in antimicrobial use in food animals	VAN BOECKEL TP, 2015, PROC NATL ACAD SCI U S A	10.1073/pnas.1503141112	1110	158.57	87.113
7th	Global antibiotic consumption 2000 to 2010: An analysis of national pharmaceutical sales data	VAN BOECKEL TP, 2014, LANCET INFECT DIS	10.1016/S1473-3099(14)70780-7	1060	132.50	78.1756
8th	Clinical epidemiology of the global expansion of Klebsiella pneumoniae carbapenemases	MUNOZ-PRICE LS, 2013, LANCET INFECT DIS	10.1016/S1473-3099(13)70190-7	903	100.33	55.5851
9th	A Review of Coronavirus Disease-2019 (COVID-19)	SINGHAL T, 2020, INDIAN J PEDIATR-a	10.1007/s12098-020-03263-6	787	393.50	345.2137
10th	Silver nanoparticles: The powerful nanoweapon against multidrug-resistant bacteria	RAI MK, 2012, J APPL MICROBIOL	10.1111/j.1365-2672.2012.05253.x	748	74.80	56.7856

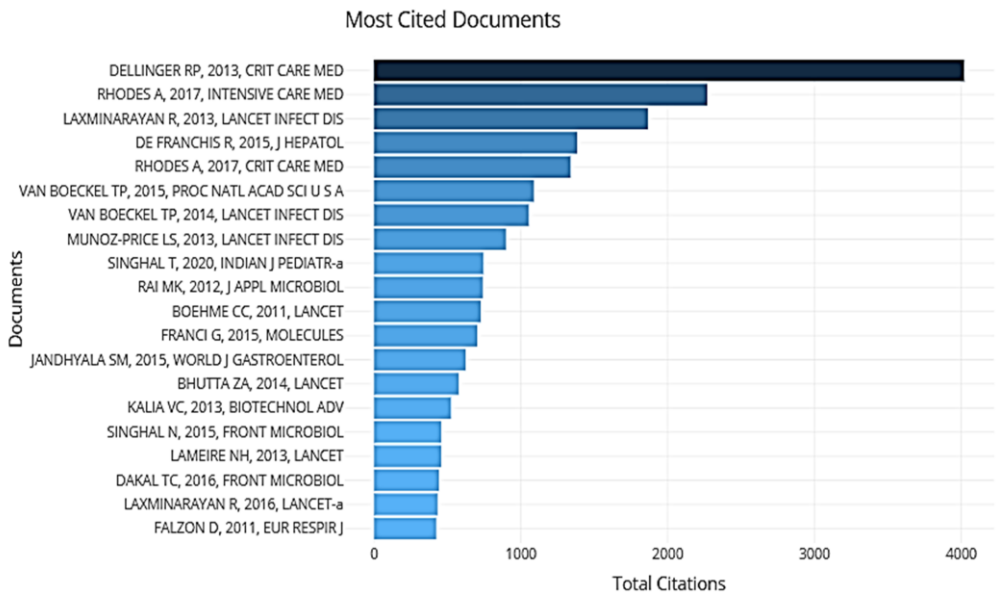
Table Contd…

Rank	Document Title	Author, Year and Source	DOI	Total Citations	TC /Average C per Year	Normalized TC
11th	Feasibility, diagnostic accuracy, and effectiveness of decentralised use of the Xpert MTB/RIF test for diagnosis of tuberculosis and multidrug resistance: A multicentre implementation study	BOEHME CC, 2011, LANCET	10.1016/S0140-6736(11)60438-8	729	66.27	47.6836
12th	Silver nanoparticles as potential antibacterial agents	FRANCI G, 2015, MOLECULES	10.3390/molecules20058856	713	101.86	56.2872
13th	Role of the normal gut microbiota	JANDHYALA SM, 2015, WORLD J GASTROENTEROL	10.3748/wjg.v21.i29.8787	642	91.71	49.9619
14th	Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost?	BHUTTA ZA, 2014, LANCET	10.1016/S0140-6736(14)60792-3	583	72.88	42.7963
15th	Quorum sensing inhibitors: An overview	KALIA VC, 2013, BIOTECHNOL ADV	10.1016/j.biotechadv.2012.10.004	527	58.56	32.435

Table Contd…

Rank	Document Title	Author, Year and Source	DOI	Total Citations	TC /Average C per Year	Normalized TC
16th	MALDI-TOF mass spectrometry: An emerging technology for microbial identification and diagnosis	SINGHAL N, 2015, FRONT MICROBIOL	10.3389/fmicb.2015.00791	463	66.14	36.6707
17th	Acute kidney injury: An increasing global concern	LAMEIRE NH, 2013, LANCET	10.1016/S0140-6736(13)60647-9	463	51.44	28.2878
18th	Mechanistic basis of antimicrobial actions of silver nanoparticles	DAKAL TC, 2016, FRONT MICROBIOL	10.3389/fmicb.2016.01831	454	75.67	41.0364
19th	Access to effective antimicrobials: A worldwide challenge	LAXMINARAYAN R, 2016, LANCET-a	10.1016/S0140-6736(15)00474-2	439	73.17	40.1989
20th	WHO guidelines for the programmatic management of drug-resistant tuberculosis: 2011 update	FALZON D, 2011, EUR RESPIR J	10.1183/09031936.00073611	424	38.55	27.7444

Graph 4.19.3 Most Cited Document-title



4.19.4 Source-Based Citations

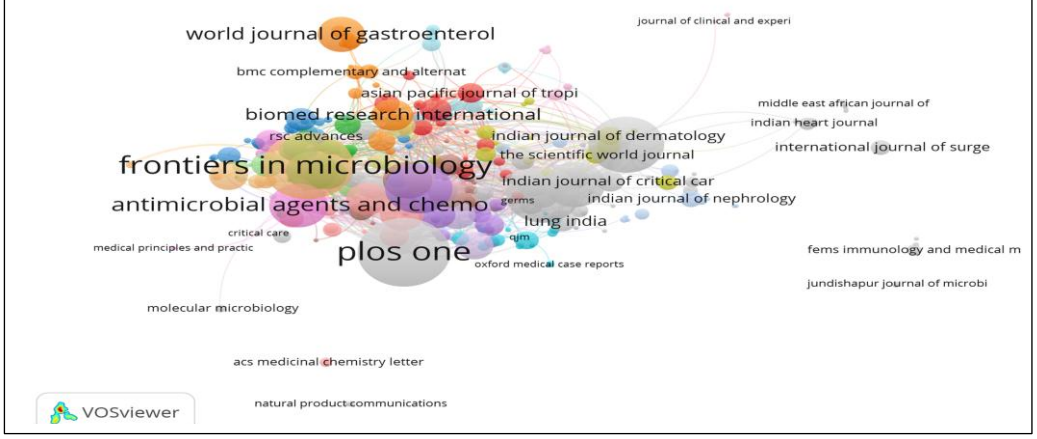
Based on VOSviewer, there were found 1627 sources with their citations. However, when a filter was applied to sources with at least five document and at least five citations, 456 sources met the threshold in which 50 most cited journals were listed with citations, documents, and total link strength as shown in table 4.19.4. The node colours refer to the different clusters that were allocated. The number of citations obtained by the sources is represented by the size of a node. The closeness and frequency of the relationship between the nodes are demonstrated by the thickness of the ties and the distance between the nodes. More frequent and deeper relationships are shown by thicker nodes and closer distances. Table 4.19.4 presents the list of 50 most-cited journals along with no of documents in antibiotics research. As shown in table and Fig. 4.19.4, the most commonly cited journal by authors was the *Plos One* with 11148 citations of 486 documents along with total link strength of 312. *The Frontiers in Microbiology* placed second with 10529 citations of 362 documents along with total link strength of 362 followed by *The Journal of Clinical and Diagnostic Research* with 7408 citations of 1228 documents, and it had total link strength of 324. The other details on the top 50 sources by citation number are shown in Table 4.19.4.

Table 4.19.4 Most Cited Source Journals

S.N.	Source	Citations	All Documents	Total Link Strength
1.	Plos One	11148	486	312
2.	Frontiers In Microbiology	10529	362	251
3.	Journal of Clinical and Diagnostic Research	7408	1228	324
4.	Intensive Care Medicine	6971	18	7
5.	The Lancet Infectious Diseases	5925	24	113
6.	Indian Journal of Medical Microbiology	4881	688	494
7.	Antimicrobial Agents And Chemotherapy	4442	161	200
8.	Scientific Reports	3518	218	120
9.	Journal of Antimicrobial Chemotherapy	3168	83	121
10.	World Journal of Gastroenterology	2903	32	8
11.	Clinical Infectious Diseases	2589	59	54
12.	Proceedings of the National Academy of Sciences of the United States of America	2385	12	50
13.	Biomed Research International	2301	78	17
14.	Journal of Applied Microbiology	2193	41	74
15.	Molecules	2031	21	18
16.	European Respiratory Journal	1868	19	14
17.	Indian Journal of Medical Research	1756	272	258
18.	Plos Medicine	1734	18	49
19.	Journal of Clinical Microbiology	1732	59	69
20.	Bmc Microbiology	1688	76	71
21.	International Journal of Nanomedicine	1630	52	19
22.	Microbiological Research	1522	37	13
23.	Journal of Biological Chemistry	1434	53	27
24.	Veterinary World	1400	192	38
25.	Journal of Infection in Developing Countries	1358	136	110
26.	Asian Pacific Journal of Tropical Biomedicine	1285	55	44
27.	Fems Microbiology Reviews	1263	7	2
28.	World Journal of Emergency Surgery	1216	30	18
29.	Asian Pacific Journal of Tropical Medicine	1182	79	40

S.N.	Source	Citations	All Documents	Total Link Strength
30.	BMC Infectious Diseases	1166	72	116
31.	Evidence-Based Complementary And Alternative Medicine	1149	9	7
32.	International Journal of Environmental Research and Public Health	1147	47	69
33.	Journal of Medical Microbiology	1146	77	132
34.	Journal of Global Infectious Diseases	1132	162	66
35.	The Lancet	1095	12	24
36.	Lung India	1084	220	33
37.	Clinical Microbiology and Infection	1036	24	24
38.	Virulence	987	19	16
39.	Indian Journal of Critical Care Medicine	983	195	81
40.	Indian Journal of Pathology and Microbiology	982	238	88
41.	Nucleic Acids Research	982	14	16
42.	3 Biotech	950	70	36
43.	Asian Pacific Journal of Tropical Disease	888	82	58
44.	Saudi Journal of Biological Sciences	860	38	18
45.	Annals of Clinical Microbiology and Antimicrobials	816	44	36
46.	Mbio	810	22	18
47.	Indian Journal of Dermatology	800	170	16
48.	Emerging Infectious Diseases	776	40	44
49.	Indian Journal of Pediatrics	768	40	11
50.	BMJ Case Reports	758	330	17

Figure 4.19.4 Most Cited Source Journals



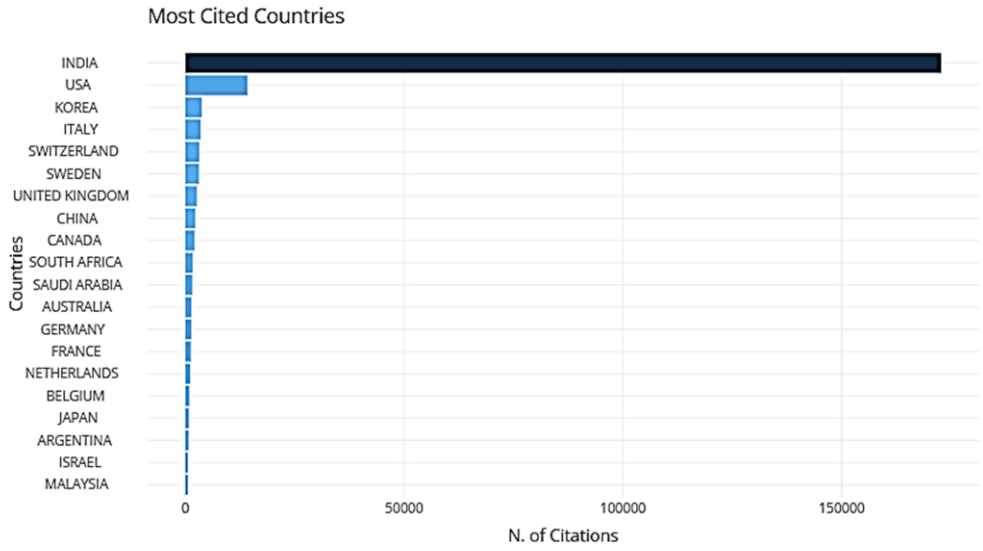
4.19.5 Country-Based Citations

Table and graph 4.19.5 illustrates the 20 most cited countries along with no. of citations in antibiotics research. It is observed from table 4.19.5, that the most commonly cited countries by authors was the *India* with 172703 citations (average citations 8.57 per article) followed by The *USA* with 14179 citations (average citations 30.56 per article) and *Korea* with 3757 (average citations 33.85 per article) citations. The other details of the 20 most cited countries by citation number are shown in Table 4.19.5.

Table 4.19.5 Most Cited Countries

S.N.	Country	Total Citations	Average Article Citations
1.	India	172703	8.57
2.	USA	14179	30.56
3.	Korea	3757	33.85
4.	Italy	3496	61.33
5.	Switzerland	3166	113.07
6.	Sweden	3108	47.82
7.	United Kingdom	2612	21.77
8.	China	2294	22.49
9.	Canada	2088	44.43
10.	South Africa	1724	49.26
11.	Saudi Arabia	1579	13.16
12.	Australia	1411	21.71
13.	Germany	1356	27.12
14.	France	1270	29.53
15.	Netherlands	1114	53.05
16.	Belgium	951	43.23
17.	Japan	789	25.45
18.	Argentina	747	83.00
19.	Israel	584	48.67
20.	Malaysia	580	10.74

Graph 4.19.5 Most Cited Countries



4.20 TESTING OF HYPOTHESES

In order to implement the f test, t-test, z test, and chi-square test, the hypotheses have been mathematically formulated in this section. It has been tested on the basis of data obtain and analysed in the thesis's earlier chapters.

4.20.1 Hypothesis : 1

India is the leading country in Antibiotics publication in the World

Mathematically:

H_0: Mean of India ≥Mean of top five countries

H_1: Mean of India < Mean of top five countries

Testing of Hypothesis

In order to fit the data to test whether *India is the leading country in Antibiotics or not*, the mean values of countries have been calculated on the basis of table 4.1(A).

Table 4.20.1 Descriptive Statistics of Top 5 Countries

	India	USA	China	UK	Germany
Mean	2511.7	8391.4	3879.8	2467.22	1769.7
Median	2548	8393.5	3480	2426	1769
Standard Deviation	320.86	1101.737	1855.31	297.68	210.72
Sample Variance	102955.34	1213825	3442184	88614.94	44404.45
Range	1156	3262	5908	908	728
Minimum	1904	6748	1747	2114	1449
Maximum	3060	10010	7655	3022	2177
Sum	25117	83914	38798	24672	17697

Mean of India (2511.7) > Mean of UK (2467.22)
> Mean of Germany (1769.7)
< Mean of USA (8391.4)
< Mean of China (3879.8)

The results of the mean values indicate that the calculated mean value of India is less than the mean value of USA and China but higher than Germany and UK. India is the 3rd top most productive country in world. Hence, the ***hypothesis 1 has been accepted*** and it is concluded that the India is leading country in antibiotics publication in the world.

4.20.2 Hypothesis : 2

USA is the most productive country in antibiotic research.

Mathematically:

H_0: Mean of USA ≥Mean of other any countries

H_1: Mean of USA < Mean of other any countries

Testing of Hypothesis

In order to fit the data to test whether ***USA is the most productive country*** *or not*, the mean values of countries have been calculated on the basis of table 4.1(A).

Table 4.20.2 Descriptive statistics of leading countries (mean value)

	India	**USA**	**China**	**UK**	**Germany**
Mean	2511.7	8391.4	3879.8	2467.22	1769.7

Mean of USA (8391.4) > Mean of UK (2467.22)
> Mean of India (2511.7)
> Mean of Germany (1769.7)
> Mean of China (3879.8)

The results of the mean values indicate that the calculated mean value of USA is higher than another country. Hence, the ***hypothesis 2 has been accepted*** and it is concluded that the ***USA is the most productive country in*** antibiotics publication entire the world.

4.20.3 Hypothesis : 3

English is most preferred language.

Mathematically:

H0: Publications of English language ≥ Publications of other language

H1: Publications of English language < Publications of other language

Testing of Hypothesis

In order to fit the data to test whether the *English is most preferred language* or not, t-Test: Two-Sample Assuming Unequal Variances has been calculated on the basis of table 4.10.

Table 4.20.3 t-Test: Two-Sample Assuming Unequal Variances

	Others	*English*
Mean	6.25	25106
Variance	12.78571429	1
Observations	8	2
Hypothesized Mean Difference	0	
Df	1	
t Stat one tail	0.25006658	
t Critical one-tail	6.313751515	

T (Tabulated value) > t (Calculated value) 6.3137 > 0.2500

The above table reveals that the t (tabulated value) is higher than the critical t (calculated value) at 1 degrees of freedom (df) at 0.05 level of significance. Hence, the ***hypothesis 3 has been accepted*** and it is concluded that the English is most preferred language for research publication.

4.20.4 Hypothesis : 4

The proportional growth rate on antibiotics is almost the same in India and the world.

Mathematically:

H0: Proportional growth of India = Proportional growth of world

H1: Proportional growth of India ≠ Proportional growth of world

Testing of Hypothesis

In order to fit the data to test whether the *proportional growth rate on antibiotics is almost the same* or not, the z-Test: Two Sample for Means has been calculated on the basis of table 4.2.

Table 4.20.4 z-Test: Two Sample for Means

	India	*World*
Mean	10.24971065	10.26883076
Known Variance	10	10
Observations	9	9
Hypothesized Mean Difference	0	
z(Calculated value)	-0.012826159	
P(Z<=z) one-tail	0.494883243	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.989766486	
z Critical two-tail (Tabulated value)	1.959963985	

z (Tabulated value) > z (Calculated value)

1.9599 > -0.0128

The above table reveals that the z (tabulated value) is higher than the critical z (calculated value) at 9 degrees of freedom (df) at 0.05 level of significance. Hence, the ***hypothesis 4 has been accepted*** and it is concluded that the proportional growth rate on antibiotics is almost the same in India and the world.

4.20.5 Hypothesis : 5

The activity index of India is high in research publications..

Mathematically:

H0: Activity index $mean \geq 0.2308$

H1: Activity index $mean < 0.2308$

Testing of Hypothesis

In order to fit the data to test whether the *activity index of India is high* or not, the t value has been calculated on the basis of table 4.5.

Table 4.20.5 Descriptive statistics of activity index for t-test

Mean	1.834
Median	1.851296115
Standard Error	0.100113843
Standard Deviation	0.30
Sample Variance	0.090205034
Count	9
Confidence Level (95.0%)	0.230862937

On the basis of above t value is calculated as follows:

$$t = \frac{x - \mu}{sd/\sqrt{n}}$$

$$t = \frac{mean - hypo.mean\ or\ (cl\ 95\%)}{sd\ error}$$

$$t = \frac{1.83 - 0.23}{0.30/\sqrt{9}}$$

$$t = \frac{1.60}{0.10}$$

t (calculated value) = -47.20

t (tabulated value) on 0.05 significance level for degree of freedom 9= 1.83

Now, t (tabulated value) > t (calculated value)

1.83 > -47.20

The t (tabulated value) is higher than the critical t (calculated value) at 9 degrees of freedom (df) at 0.05 level of significance. Hence, the ***hypothesis 5 has been accepted*** and it is concluded that the activity index of India is high.

4.20.6 Hypothesis : 6

Journals are most preferred communication channels for research publication

Mathematically:

H0: Number of journals articles ≥ number of books, conference articles

H1: Number of journals articles < number of books, conference articles

Testing of Hypothesis

In order to fit the data to test whether the *Journals are most preferred communication channels* or not, t-Test: Two-Sample Assuming Unequal Variances has been calculated on the basis of table 4.7.

Table 4.20.6 t-Test: Two-Sample Assuming Unequal Variances

	Conferences articles ,books etc.	***Journals articles***
Mean	58.5	24294
Variance	3369.667	
Observations	4	1
Hypothesized Mean Difference	0	
df	2	
t calculated	0.50430828	
t Critical tabulated	2.92	

t (Tabulated value) > t (Calculated value)

2.92 > 0.5043

The above table reveals that the t (tabulated value) is higher than the critical t (calculated value) at 2 degrees of freedom (df) at 0.01 level of significance. Hence, the ***hypothesis 6 has been accepted*** and it is concluded that the Journals are most preferred communication channels for research publication.

4.20.7 Hypothesis : 7

Joint authorship publications are preferred for research publication

Mathematically:

H0: Articles of joint authorship ≥ articles of single authorship

H1: Articles of joint authorship < articles of single authorship

Testing of Hypothesis

In order to fit the data to test whether the *Joint authorship publications are preferred* or not, t-Test: Two-Sample Assuming Equal Variances has been calculated on the basis of table 4.14.2 and 4.15.

Table 4.20.7 t-Test: Two-Sample Assuming Equal Variances

	Single author	**Joint authorship**
Mean	147.3	2364.4
Variance	328.4556	93897.16
Observations	10	10
Pooled Variance	47112.81	
Hypothesized Mean Difference	0	
df	9	
t (calculated value)	-22.8402	
t (tabulated value)	1.734064	

t (Tabulated value) > t (Calculated value)

1.7340 > -22.84

The above table reveals that the t (tabulated value) is higher than the critical t (calculated value) at 9 degrees of freedom (df) at 0.01 level of significance. Hence, the ***hypothesis 7 has been accepted*** and it is concluded that the *Joint authorship publications are preferred.*

4.20.8 Hypothesis : 8

Collaboration between 2 to 4 authors is more prevalent among authors.

Mathematically:

H_0: Mean $n_{j2\text{-}4} \geq n_{j5}$ or n_{j6}

H_1: Mean $n_{j2\text{-}4} < n_{j5}$ or n_{j6}

Testing of Hypothesis

In order to fit the data to test whether *Collaboration between 2 to 4 authors is more prevalent among authors or not*, the mean values of joint authors publications have been calculated on the basis of table 4.14.2.

Table 4.20.8 Descriptive Statistics of Joint Authors

	2to 4 authors	***1 author***	***5 authors***	***6-10 authors***
Mean	1397.6	147.3	353.5	519.2
Standard Error	32.96772833	5.731104218	15.25432543	45.97482
Median	1419	147	364.5	513.5
Standard Deviation	104.2531108	18.12334284	48.23841254	145.3852
Sample Variance	10868.71111	328.4555556	2326.944444	21136.84
Kurtosis	1.378054864	-1.264260203	-0.233948584	-1.29227
Skewness	-0.799877779	-0.147966155	-0.583261511	0.101756
Range	377	53	156	432
Minimum	1178	119	264	305
Maximum	1555	172	420	737
Sum	13976	1473	3535	5192
Count	10	10	10	10

mean $n_{j2\text{-}4(1397.6)} > n_{j5(353.5)}$ or $n_{j6(519.2)}$

The mean values of 2 to 4 authors are less than the mean value of 5 authors or 6 authors. Hence, the ***hypothesis 8 has been accepted*** and it is concluded that the collaboration between 2 to 4 authors is more prevalent among authors.

4.20.9 Hypothesis : 9

Degree of Collaboration (DC) is high in research publications

Mathematically:

H0: $DC \geq 0.93$

H1: $DC < 0.93$

Testing of Hypothesis

In order to fit the data to test whether the ***Degree of Collaboration (DC) is high*** or not, t-Test for a mean has been calculated on the basis of table 4.15.

Table 4.20.9 t-test: two sample for means

Descriptive statistics for Degree of Collaboration (DC)	
Mean	0.941535027
Standard Error	0.001379317
Median	0.941225792
Standard Deviation	0.004361784
Sample Variance	1.90252E-05
Confidence Level (95.0%)	0.003120232
t (calculated value)	-1.320
t (tabulated value)	1.833

t (Tabulated value) > t (Calculated value)

1.833> -1.320

The above table reveals that the t (tabulated value) is higher than the critical t (calculated value) at 9 degrees of freedom (df) at 0.05 level of significance. Hence, the ***hypothesis 9 has been accepted*** and it is concluded that *the Degree of Collaboration (DC) is high.*

4.20.10 Hypothesis : 10

Bradford's law of scattering of articles in journals is applicable in this research.

Mathematically:

H0: Bradford's law of scattering of articles in journals is applicable

H1: Bradford's law of scattering of articles in journals is not applicable

Testing of Hypothesis

In order to fit the data to test whether the ***Bradford's law of scattering of articles in journals is applicable*** or not, Chi–Square test has been calculated on the basis of table 4.8.2 and 4.8.2(A).

Table 4.20.10 Chi-square test

Zone	Expected Value of Journals	Observed Value of Journals	Obs-Exp	(Obs-Exp)2	$\frac{(\mathbf{Obs.}-\mathbf{Exp.})^2}{\mathbf{Exp}}$
Zone I	50	50	0	0	0
Zone II	408	287	-121	14641	35.88
Zone III	3337	3040	-297	88209	26.43
Total	3795	3377			$\chi\mathbf{2}$ =62.32

χ2 (Tabulated value @ Df 2 and .5 % level of significance) =5.99

Hence 62.32>5.99

χ2 (Calculated value)> χ2 (Tabulated value)

The above table reveals that the χ2 (tabulated value) is less than the critical χ2 (calculated value) at 2 degrees of freedom (df) at 5% level of significance. Hence, the ***hypothesis 10 has been rejected*** and it is concluded that the Bradford's law of scattering of articles in journals is not applicable in the research.

4.20.11 Hypothesis : 11

Lotka's law of scientific productivity is applicable in this research.

Mathematically:

H0: Lotka's law of scientific productivity is applicable

H1: Lotka's law of scientific productivity is not applicable

Testing of Hypothesis

In order to fit the data to test whether the ***Lotka's law of scientific productivity is applicable*** or not, Chi –Square test has been calculated on the basis of table 4.17 and 4.17(A).

Table 4.20.11 Chi-square value calculated

NC	NO(O1)	NE(E1)	O1-E1	(O1-E1)2	$\frac{(Obs.value - Exp.valu}{Exp.Value}$
1	39750	39750	0	0	0
2	8128	8127	1	1	0.0
3	3320	3211	109	11899	3.7
4	1752	1661	91	8195	4.9
5	1006	997	9	81	0.1
6	613	656	-43	1849	2.8
7	479	461	18	324	0.7
8	348	340	8	64	0.2
9	263	259	4	16	0.1
10	182	204	-22	484	2.4
11	178	164	14	196	1.2
12	126	134	-8	64	0.5
13	120	112	8	64	0.6
14	91	94	-3	9	0.1
15	74	81	-7	49	0.6
16	65	69	-4	16	0.2
17	49	60	-11	121	2.0
18	54	53	1	1	0.0
19	46	47	-1	1	0.0
20	38	42	-4	16	0.4
Total	56682	56522			χ^2 =20.5

$\chi 2$ (Calculated value)=20.50

The critical value of chi-square at the 5% level of significance at degree of freedom (20-1) =19 is

$\chi 2$ (Tabulated value)=30.14

Hence 20.50<30.14

$\chi 2$ (Calculated value)< $\chi 2$ (Tabulated value

The above table reveals that the $\chi 2$ (tabulated value) is higher than the critical $\chi 2$ (calculated value) at 19 degrees of freedom (df) at 5% level of significance. Hence, the ***hypothesis 11 has been accepted*** and it is concluded that the Lotka's law of scientific productivity is applicable in the research.

CHAPTER-5

FINDINGS, CONCLUSION AND SUGGESTIONS

This chapter summarizes significant findings, conclusions, and suggestions as a result of data analysis and interpretation. In addition, the area for further research has also been stated in this chapter. It is an objective approach to research conducted in antibiotic research in the Indian context in terms of publication productivity based on scholarly publications indexed by the Scopus database during 2011-2020. Data related to publications have been downloaded, sorted, organized, and analysed using various software and analysis tools to fulfil the purpose of the study. Based on the data analysis the significant findings are as follows:

5.1 FINDINGS

5.1.1 Year-wise Distribution

A total of 25117 and 344452 records were extracted from the database of antibiotic research for India and the world, respectively from 2011 to 2020. The highest productivity of Indian publications has been observed in the year 2020 and lowest in the year 2011. The Indian publication has been increased from 7.58% (2011) to 12.18% (2020) while the highest world research output in antibiotics recorded in the year 2020 (13.21%) and lowest in 2011(7.75%). There is a steady growth of publication for India (except 2017-2018), while in the world, it has been increased consistently. The average publications were recorded 2511.7 and 34445.2 documents per year in India and the world, respectively.

5.1.2 Lorenz Curve

The low dispersion has visible on the Lorenz curve in India and world publications on antibiotic research. The cumulative proportion for both India and the world is almost equal. The trend line is almost fitted to data from 2011 to

2020 for both India and world publications and little extended for 2015 -18 as a dashed line.

5.1.3 Publication Share of India in World

Overall, Publications share of Indian contribution in world output during 2011-2020 in antibiotic research was found 7.29 %. The *USA* was sharing the highest 24.36 % publications followed by china with (11.26 %) and the *United Kingdom* with 7.16 %. It has also been seen that *India* secured third position among top five countries in world.

5.1.4 Most Collaborative Country by Corresponding Author

A total of 168 countries have collaborated with Indian authors, in which the highest collaboration on antibiotic research is mainly with the *USA* followed by the *United Kingdom and Saudi Arabia*. It has been marked from citation analysis that India has profited from international collaboration in attracting and receiving more citations**.**

5.1.5 Activity Index for India

The average Indian publications share on antibiotics was greater than world publication share. Average activity index has been calculated 180.24 which is greater than 100, means research activities of Indian contribution to antibiotics research are strong in the world.

5.1.6 Annual Growth Rate

The annual growth rate (AGR) of the Indian publications on antibiotic has been decreased from the year 2012 to 2018 and again it is increased, means a fluctuating trend has been observed for India during the study period.

5.1.7 Relative Growth Rate and Doubling Times

The Relative Growth Rate has been decreased from 0.16 in 2012 to -0.07 in 2017 and again it is increased to 0.09 in 2020. The value of doubling time has been found fluctuated.

5.1.8 Communication Channels

Most of the publications, around 94.46% have been categorized under *journal articles*. Other communication channels such as books, conference proceedings, and reports, etc. have been hardly used.

5.1.9 Bradford's Law of Scattering of Articles in Journals

The 1.48% (50 journals) of the total journals that published articles are scattered in zone-1 while 8.50% (287 journals) in zone-2 and 90.02% (3040 journals) in zone-3.

Expected values are calculated by formula 1: n: n2 that is 50: 408: 3337 journals scattered in Zone-I, Zone-II, and Zone-III respectively.

Finding is that there is too much difference between expected values and observed values so that Bradford's law of scattering of articles in journals is not applicable in antibiotic research.

5.1.10 Sources (Journals) Dynamics

A total of 3377 journals have been found for the Indian contribution to antibiotics. *Journal of Clinical and Diagnostic Research* published from India was the most preferred journal ranked at the first position. The highest publication growth has been found in this journal. It has not published the highest number of papers only in the study period 2011-2020, but it has also published a maximum of 136 articles on antibiotics in one year. Among the top twenty leading journals, five journals are published from other countries like the USA, United Kingdom, Switzerland, and the Netherlands.

5.1.11 Communication Language

The 99.8 % of publications on antibiotic research have been published in the *English language* and the remaining in other languages such as *Turkish, French, Spanish*, etc. Every year, the *English language* dominance was found in total productivity on the subject during the study period.

5.1.12 Subject-wise Distribution

Around 35 subjects published papers on antibiotics, of which the highest 12573 (33.2%) papers were published under *Medicine* subject, followed by *Biochemistry, Genetics and Molecular Biology* with 6188 (15.9%) and *Pharmacology, Toxicology,* and *Pharmaceuticals* with 5373 (13.8%). The study reveals that it has a multi-disciplinary scope, not only in medicine but also in other subjects also published many papers on this topic.

5.1.13 India's Highly Productive Institutions

All India Institute of Medical Sciences, New Delhi with 5.52% papers has been observed as the most productive institution followed by the Postgraduate Institute of Medical Education & amp; Research, Chandigarh with 3.16% and Christian Medical College, Vellore with 544 2.17% papers.

5.1.14 Authorship Pattern

- A total of 56815 authors have been contributed their research papers on antibiotics. In which, *Veeraraghavan, B.* affiliated to Department of Clinical Microbiology, Christian Medical College, Vellore, India has been published the highest 125 articles on antibiotics followed by *Rodrigues, C.* with 87 articles and *Kapil, A.* with 86 articles.
- Only 5.75% of the papers have been published by single authors and the remaining 94.24% of papers were published by joint authors. The papers of four authors have published the highest number of joint authors.
- Degree of collaboration (DC) and collaborative index (CI) also support the high collaboration pattern. Average value of DC is about 1, so it is clear that the percentage of multiple authors is more than single authors and the trend of collaborative research is increasing with time.CI falls between 5 and 6 and the trend towards multiple authorships is increasing.

5.1.15 Lotka's law on Antibiotic Research

Observed author productivity has found 69% for one article each,14% for two articles, and 6% for three articles which is about to confirm to estimated Lotka's law of scientific productivity, So Lotka's law is applicable in this study.

5.1.16 Author Keyword Occurrences

'*Antibiotics*' was the most recurring author keyword followed by *antibiotic resistance* and *antimicrobial resistance*. It has high link strength which denotes the importance of a keyword in the field.

5.1.17 Citation Count of Indian Antibiotics Research Literature

5.1.17.1 Year-wise Total Citation and Average Article Citations

A total of 255997 citations were received, in which the highest 37529 citations (16.15 citations per document) counted in *2013* and lowest in *2020* (2.1 citations per document). The highest average article citations per year have been received in *2017* (2.79 citations) while the lowest article citations per year recorded in *2014* (1.44 citations).

5.1.17.2 Author-Based Citations

Swaminathan, S. affiliated to Department of Clinical Research, Tuberculosis Research Centre, Indian Council of Medical Research, Chennai, India has been received the highest 38744 citations Followed by *Sarin, S.K* affiliated to Institute of Liver and Biliary Sciences, New Delhi, India with 25985 citations for and *Paul, V.K* affiliated to All India Institute of Medical Sciences, New Delhi, New Delhi, India with 24178 citations.

5.1.17.3 Document-Based Citations

Surviving sepsis campaign: international guidelines for the management of severe sepsis and septic shock: 2012 written by Dellinger RP et al. has been received the highest 4037 (average citations per year 448.6) citations followed by *Surviving Sepsis Campaign: International Guidelines for Management of*

Sepsis and Septic Shock: 2016 by Rhodes A et al. with 2318 (average citations per year 463.60) citations and title *Antibiotic resistance-the need for global solutions* by Laxminarayan R, with 1882 (average citations per year 209.11) citations.

5.1.17.4 Source-Based Citations

The most commonly cited journal by authors was the *Plos One* with 11148 citations of 486 documents along with total link strength of 312. The *Frontiers in Microbiology* placed second with 10529 citations of 362 documents along with total link strength of 362 followed by the *Journal of Clinical and Diagnostic Research* with 7408 citations of 1228 documents, and it had total link strength of 324.

5.1.17.5 Country-Based Citations

The most commonly cited countries by authors was the *India* with 172703 citations (average citations 8.57 per article) followed by The *USA* with 14179 citations (average citations 30.56 per article) and *Korea* with 3757 (average citations 33.85 per article) citations.

5.2 CONCLUSION

The scientometric technique is the most powerful technique for conducting a quantitative study of research production and technological progress of any subject, person, and institution, etc. Before the discovery of antibiotics not only in India but in the world there were a large number of deaths from infections and bacterial diseases. Antibiotics are considered to be the biggest milestone of the twentieth century in the field of science and medicine. These medicines have been used primarily to reduce the mortality and morbidity rates of infectious and anti-bacterial diseases, including pneumonia, tuberculosis, and childhood communicable diseases. Antibiotics are used to fight diseases in humans and animals.

India is the second-largest populated country in the world so that an attempt was made in the present study to measure the trends in various aspects of published literature in the field of antibiotics research at the Indian level as well as global. In order to better understand a study of the Indian contribution to antibiotics has been conducted and analysed. The study is based on 25117 research papers published during 2011-2020 as indexed in the Scopus database. Scopus is one of the most comprehensive databases covering all subjects. The data were collected, tabulated, and analysed with the help of various bibliometrics laws and statistical software such as SPSS, biblioshiny, R packages, and VOsviewer. The study reveals some factual factorial data through bibliometric analysis. Research articles have been analysed for finding the publications growth trend, authorship pattern, relative growth rate, doubling time, collaborative pattern, applicability of bibliometric laws and examining the citations on different base. A total of 25117 and 344452 records were extracted from the database of antibiotic research for India and the world, respectively from 2011 to 2020. The outcome of the present study shows that there is a steady growth of publications for India (except 2017-18) and a consistent publications growth in the world during the study period. Averages of 2511.7 papers were published per year at the India level and 34445.2 papers at the global level. The maximum Indian contribution is observed during 2020 (3060 publications). The research in the field of antibiotics in India has increased over a period of time from 7.58% (2011) to 12.18% (2020. The cumulative proportion for both India and the world is almost equal. India was the third topmost contributor after the USA and China. USA and United Kingdom was the most collaborative country. The fluctuating trend was observed for relative growth rate and doubling time during the study period. Journal of Clinical and Diagnostic Research was the most preferred journal at the India level and Plos one at the global level. All India Institute of Medical Sciences, New Delhi with 5.52% papers has been marked as the most productive institution. Veeraraghavan, B. affiliated to Department of Clinical Microbiology, Christian Medical College, Vellore, India has been ranked at first position with 125 (0.50%) publications followed by Rodrigues, C. with 87 (0.35%) and Kapil, A. with 86 (0.34%) publications.

Swaminathan, S. affiliated to Department of Clinical Research, Tuberculosis Research Centre, Indian Council of Medical Research, Chennai, India has received the highest 38744 citations and Plos one journal was the Top most cited source journal. A joint authorship trend has been found. Articles published in journals on antibiotics do not follow Bradford's law of scattering article in journal. However, author productivity follows Lotka's law. The study concludes that there has been a steady trend towards the growing development of research literature in the field of antibiotics.

5.3 SUGGESTIONS

Based on the findings of the study, the following suggestions are recommended:

5.3.1 In order to improve the quality of antibiotics research, additional financial support should be given to specialized research institutes, universities, and other research institutes/organizations in the form of research grants and complex tools to the researchers.

5.3.2 Funding agencies, health research organizations and other institutions in India should be encouraged to provide for research projects on antibiotics and their infrastructure facilities.

5.3.3 Antibiotics research and discovery are tough and time-consuming, thus scientists must be provided the appropriate care and protection under the effects of professional exposure and external pressures so that they may dedicate their whole focus to study, leading to increased development and final publication.

5.3.4 Indian contributions to foreign journals are basically non-existent. Some of the most prestigious journals do not have contributions. There is a need to develop a national plan to encourage institutions with low publishing productivity to publish in international journals. They can collaborate with larger universities in their geographic area to publish their papers together.

5.3.5 From the inference of this study, the capability of the author could be acknowledged. Therefore, the individual scientist may be inspired to issue more contributions as an alternative to team contributions.

5.3.6 During the study, it became known that international collaboration with other countries in antibiotic research is very less, so universities and institutes should continuously organize conferences and workshops at the national and international levels and motivate them to research with other countries.

5.4 AREA FOR FURTHER RESEARCH

5.4.1 The present study is based on the Scopus database, but antibiotics are mainly related to medical science. Therefore, there is a need for a comprehensive and comparative bibliometric study on antibiotics research with different databases, such as PubMed, EMBASE (Excerpta Medica Database), UpToDate, and Web of Science.

5.4.2 The present scientometric study is based on the Indian point of view, but the field of antibiotics is very wide, therefore, a global level bibliometric study on this subject may be done.

5.4.3 Today, antibiotics resistance is a very big problem and we all are getting affected by it, so a scientometric study on this subject can be done at the Indian and global level.

5.4.4 Altmetrics may provide more immediate engagement data in online tools and environments, it includes the number of article downloads, citation of research, and citation counts in scholarly information sources via social media sources, etc. therefore an altmetric study can be done on this topic.

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