

# A bibliometric analysis study on *Chlamydia trachomatis*

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## Abstract

**Aim:** *Chlamydia trachomatis*, is one of the most important sexually transmitted disease (STD) pathogens on a global scale. In this study we aimed to analyze the publication developments with bibliometric methods on *C. trachomatis* by examining the research articles published between January 1970–December 2021.

**Material and methods:** Herein, a bibliometric design was used to achieve the developments in *C. trachomatis* research. Research articles published in the Web of Science (WoS) database between January, 1970–December, 2021 were included in the study. The keywords selected for the search were '*Chlamydia trachomatis*, *Chlamydia*, and *C. trachomatis*'.

**Results:** The search of the WoS database for *C. trachomatis* research articles from 1970 to 2021 yielded 8133 results. Of the documents, 5696 were articles. 95.769% were published in Science Citation Index Expanded (SCI-EXPANDED) indexed journals. Most were published in English (94.803%). The articles were mostly from the Infectious Diseases (33.251%) research area. Most of the articles were from the USA. About 51% of the studies had funding organizations, with the United States Department of Health and Human Services provided the most financial support. Most of the articles (n=346, 6.074%) were published in the Journal of Sexually Transmitted Diseases. Although the number of publications seems to be irregular, it has not fallen below 80 articles per year, especially since 1980. The articles were cited 147,672 times (25.93 times per article) and the H-index was 133.

**Conclusion:** STDs are still an important public health problem in almost all parts of the world. We have found that the number of published articles and citations to articles on *C. trachomatis* has increased rapidly, especially in recent years. However, although the number of publications in developed countries has increased, the number of publications in developing and underdeveloped countries is below the expected level. Since *C. trachomatis* is a global public health problem, countries with a lower number of publications should be supported financially.

**Key words:** *Chlamydia trachomatis*, publications, bibliometric analysis, sexually transmitted diseases

## Introduction

*Chlamydia trachomatis* is a gram-negative obligate intracellular bacterium. Humans are the only natural hosts for *C. trachomatis* [1]. The principal etiological agents of avoidable blindness (serovars A to C), the most frequent bacterial sexually transmitted diseases (STDs) globally (serovars D to K), and lymphatic system infections (serovars D to K) are all chlamydial serovars (serovars L1 to L3) [1,2].

*Chlamydia trachomatis* is a common cause of urethritis in men and cervicitis in women [3]. The largely asymptomatic reservoir of infections provides a constant source of disease transmission, as well as the ability to spread the disease silently [4]. Moreover, this disease is predicted to be the most expensive non-viral sexually transmitted illness due to these outcomes [5]. This infection has become more common in the last 20 years. In recent years, novel features of *C. trachomatis*

infections have emerged, such as lymphogranuloma venereum proctitis in men who have sex with males and a variety with a deletion in the cryptic plasmid [6]. Screening programs that are well-organized are thought to play a key role in preventing the spread of the disease and its long-term effects [6].

The use of statistical tools to examine a wide range of literature in order to determine the historical evolution of a field of research, as well as qualitative and quantitative investigation of publications, is referred to as bibliometrics. The bibliometric method can also be used to determine the importance given to a topic and possible research areas by examining a field of scientific research [7–10]. In various fields of medicine, bibliometric research has been conducted. Web of Science (WoS), Scopus, and PubMed are often utilized in the international scientific literature for the bibliometric analysis of medical publications. Bibliometric analysis, on the other hand, evaluates the overall (absolute) number of publications while calculating relative indicators, their dynamics through time, and the amount of research funding. Content analysis, which involves recognizing research trends, is one of the topics of bibliometric analysis [8–10]. However, no similar study on *C. trachomatis* was found in the available literature.

In this study, it was aimed to analyze the developments in publications *C. trachomatis* by examining the research articles published between 1970 and 2021. We aimed to reveal the scientific map on this subject by examining many bibliometric parameters such as the distribution of publications by years, the countries with the most publications, the journals with the most publications, the authors with the most publications, the institutions with the most publications, the distribution of citations over the years, the institutions that fund scientific publications, scientific partnerships between institutions and countries.

Material and methods

Herein, a bibliometric design was used to achieve the developments in *C. trachomatis* research. The following search strategy was used:

- Selected database: The Web of Science database
- The keywords and search methodology: *Chlamydia trachomatis*, *Chlamydia*, and *C. trachomatis* were used in the Title section of the WOS database' search engine.
- Document type: Articles
- Timespan: January 1970–December 2021
- Editions: Web of Science Core Collection [Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (AHCI), Emerging Sources Citation Index (ESCI), Book Citation Index (BKCI) and Conference Proceedings Citation Index (CPCI)].

Data source

The keywords *Chlamydia trachomatis*, *Chlamydia*, and *C. trachomatis*, were used in the search. Only research articles were included in the study. On February 13th, 2022, all electronic searches were completed, and the year 2022 was excluded from the study because complete data for that year was unavailable.

Data collection

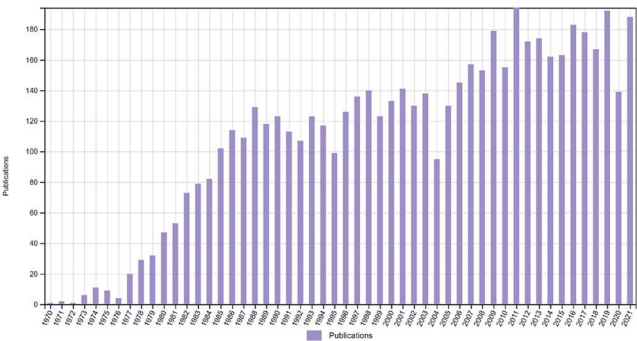
The WoS database was used to evaluate the bibliographic records. The authors' names, publication year, published journal, institution, country, and citation frequency were all retrieved for each publication. These were used to look into the worldwide knowledge domain of *C. trachomatis* research development patterns.

Visualization and mapping

The Vosviewer visualization tool (VOSviewer version 1.6.18) was used for visualizations. Thus, an international collaboration network map, citation network visualization map between links, and keyword visualization map of articles and authors with at least 5 publications and 100 citations were investigated.

Results

The search of the WoS database for *C. trachomatis* research articles from 1970 to 2021 yielded 8,133 results. Of these documents, 5,696 were articles. Moreover, 95.769% were published in Science Citation Index Expanded (SCI-EXPANDED) indexed journals. Most were published in English (94.803%). French (1.966%), German (1.141%), and Spanish (1.053%) were the other most preferred languages. While the number of research articles on *C. trachomatis* continued to increase from 1970 to 1985, it was determined that it did not decrease below 100 articles from 1986 onwards, except in 1995 and 2004. In other words, although the number of publications appears to be irregular, it has not fallen below 80 articles per year, especially since 1980 (Graphic 1).



Graphic 1 - The number of articles according to the years between 1970-2021.

Table 1      Research fields		
Research Fields	n = 5,696	%
Infectious Diseases	1,894	33.251
Microbiology	1,531	26.879
Immunology	1,129	19.821
Obstetrics Gynecology	564	9.902
General Internal Medicine	402	7.058
Public Environmental Occupational Health	372	6.531
Biochemistry Molecular Biology	308	5.407
Science Technology Other Topics	226	3.968
Pharmacology Pharmacy	219	3.845
Pathology	180	3.160
Research Experimental Medicine	163	2.862
Reproductive Biology	154	2.704
Pediatrics	118	2.072
Urology Nephrology	117	2.054
Cell Biology	115	2.019
Dermatology	108	1.896
Biotechnology Applied Microbiology	94	1.650
Tropical Medicine	81	1.422
Parasitology	72	1.264
Medical Laboratory Technology	60	1.053
Oncology	56	0.983
Genetics Heredity	53	0.93
Rheumatology	51	0.895
Virology	51	0.895
Ophthalmology	48	0.843

\*Showing 25 out of 82 entries: 3 record(s) (0.053%) did not contain data in the field being analyzed.

The articles were mostly from the fields of Infectious Diseases (33.251%), Microbiology (26.879%), and Immunology (19.821%) (Table 1).

The articles were from 136 countries globally. Most of the articles were from the USA (38.29%). Canada ranked 3rd. Apart from the USA and Canada, the top 7 countries were all European countries. China ranked 9th. India ranked 13th and Japan 14th. Brazil ranked 16th (Table 2).

Table 2 Top 20 countries on Chlamydia research

Ranking	Countries/Regions	n	%
1	USA	2,181	38.290
2	England	635	11.148
3	Canada	318	5.583
4	Sweden	312	5.478
5	Netherlands	302	5.302
6	France	258	4.529
7	Germany	252	4.424
8	Australia	225	3.950
9	China	215	3.775
10	Denmark	159	2.791
11	Italy	150	2.633
12	Finland	123	2.159
13	India	121	2.124
14	Japan	116	2.037
15	Switzerland	107	1.879
16	Brazil	88	1.545
17	Scotland	77	1.352
18	Norway	67	1.176
19	Iran	65	1.141
20	Spain	62	1.088

\*Showing 20 out of 136 entries: 24 record(s) (0.421%) did not contain data in the field being analyzed.

Nearly 51% of the studies had funding agencies. The United States Department of Health and Human Services and the National Institutes of Health funded most of the articles (21.752%, and 20.681%, respectively) (Table 3).

Most of the articles (n = 346, 6.074%) were published in the Journal of Sexually Transmitted Diseases (Table 4).

Table 3 Top 10 funding agencies on Chlamydia research

Funding Agencies	n	%
United States Department of Health Human Services	1,239	21.752
National Institutes of Health USA	1,178	20.681
National Institute of Allergy Infectious Diseases	906	15.906
European Commission	223	3.915
National Eye Institute	120	2.107
National Institute of General Medical Sciences	87	1.527
United Kingdom Research Innovation	87	1.527
Wellcome Trust	86	1.510
Medical Research Council United Kingdom	85	1.492
Eunice Kennedy Shriver National Institute of Child Health Human Development	82	1.440

\*Showing 10 out of 1,690 entries: 3,370 record(s) (59.164%) did not contain data in the field being analyzed

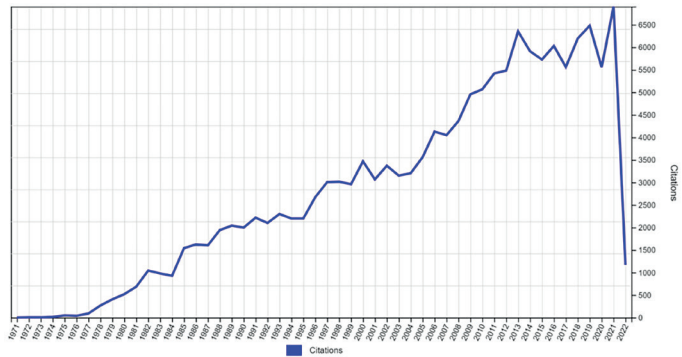
Citing analysis

The articles were cited 147,672 times (25.93 times per article) and the H-index was 133. The number of citations has increased over the years (Graphic 2).

Table 4 Journals publishing the most articles on C. trachomatis

Journals	n = 5,696	%
Sexually Transmitted Diseases	346	6.074
Infection And Immunity	323	5.671
Journal of Clinical Microbiology	287	5.039
Sexually Transmitted Infections	185	3.248
International Journal of STD Aids	142	2.493
Journal of Infectious Diseases	127	2.230
PloS One	114	2.001
Journal of Bacteriology	87	1.527
Genitourinary Medicine	74	1.299
American Journal of Obstetrics and Gynecology	73	1.282
Antimicrobial Agents and Chemotherapy	61	1.071
Journal of Medical Microbiology	61	1.071
BMC Infectious Diseases	57	1.001
European Journal of Clinical Microbiology Infectious Diseases	53	0.930
Diagnostic Microbiology and Infectious Disease	50	0.878
Journal of Immunology	50	0.878
Journal of Clinical Pathology	46	0.808
Obstetrics and Gynecology	46	0.808
FEMS Microbiology Letters	45	0.790
Molecular Microbiology	44	0.772
British Journal of Venereal Diseases	42	0.737
Human Reproduction	40	0.702
Fertility and Sterility	39	0.685
Clinical Infectious Diseases	38	0.667
Journal of General Microbiology	38	0.667

\*Showing 25 out of 986 entries

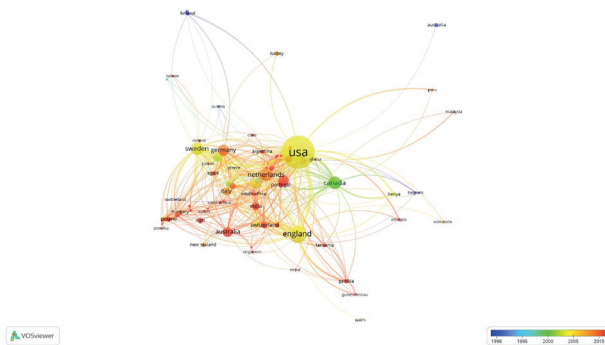


Graphic 2 - Number of citations by year.

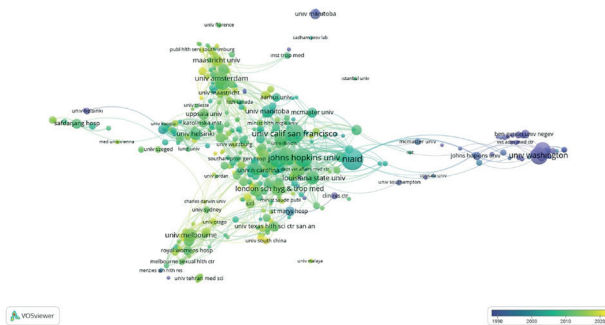
Discussion

STDs are among the important public health problems that are increasing rapidly and in need of solutions worldwide. C. trachomatis is the bacteria with the highest prevalence among STDs. The USA has the highest prevalence of STDs among developed countries. C. trachomatis is the most common STD agent in the USA with an estimated 1.8 million cases annually [11–13]. Due to the fact that the disease poses a serious threat to the USA as well as all over the world, a treatment guide has been published by the Centers for Disease Control and Prevention (CDC) covering the approach to these patients, their treatments, preventive measures for patients and their partners, risky behaviors related to diseases, and preventive measures from diseases [3, 14, 15]. In this bibliometric analysis, it is not surprising that the USA is the country that publishes the most articles on C. trachomatis (38.29%) and provides the most support to research it, due to the widespread prevalence of this disease and its economic power. The USA is followed by England (11.148%). Canada ranked 3rd. Apart from the USA and Canada, the top 7 countries were all European countries. China ranked

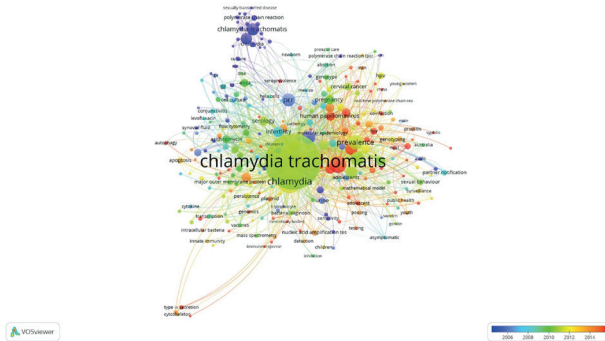




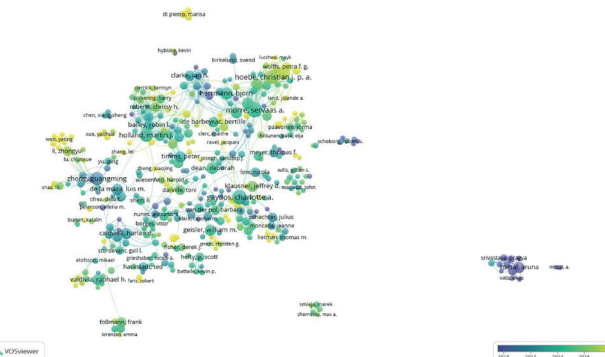
**Figure 1** - International collaboration network map.



**Figure 2** - Citation network visualization map among affiliations with at least 5 publications  
 \*\*Collaboration is shown with lines linking institutions. Stronger cooperation is indicated by thicker lines. Countries with a bigger circle or text size had a higher level of international cooperation.



**Figure 3** - Keyword visualization map of articles with at least 5 occurrences.  
 \*\*Connecting lines are indicative of occurrence relations in the articles. Keywords represented by a larger circle size or font size had a relatively higher occurrence in the articles.



**Figure 4** - Authors with at least 5 publications and 100 citations are shown on the map.  
 \*\*Citations are shown by lines linking the authors. Authors with a greater circle size or font size had a higher number of citations.

9th. India ranked 13th and Japan 14th. Brazil ranked 16th. Iran, a developing country, ranked 19th. Nearly 51% of the studies had funding agencies. Most of the financial support to research article institutions was the *United States Department of Health Human Services and the National Institutes of Health USA*. In addition, it was determined that research cooperation between countries and continents was carried out comprehensively with the participation of 136 countries. To summarise in general, the USA and European countries took the lead in the number of publications.

*C. trachomatis* is the most reported sexually transmitted bacterial infection in the USA. According to the PubMed database search herein, it was detected that the first reports were in 1969. However, there were no similar bibliometric studies on *C. trachomatis*. In this study, 5,696 articles on *C. trachomatis* were identified and published between 1970-2021 by using the WoS database. While the number of research articles on *C. trachomatis* continued to increase from 1970 to 1985, it was determined that it did not decrease below 100 articles from 1986 onwards, except in 1995 and 2004. The increasing number of papers published and citations since its identification shows that *C. trachomatis* is still an important issue for humans and a topic of interest for researchers [16, 17].

In order to understand the biology of infectious diseases, it is necessary to examine the host-pathogen relationship and their interaction with the environment, as well as to characterize the characteristics of the agent. Using epidemiology, immunology, and genomic tools helps to examine the biology of infectious diseases. Lots of research has been done on the epidemiology, immunology, and genomics of *C. trachomatis* [11, 18–25]. In this study, it was shown that the studies on *C. trachomatis* were mostly related to the disease in the fields of Infectious Diseases, Microbiology, and Immunology.

The H-index is frequently used today to measure the quality and impact of scientific research by researchers, countries, institutions, and journals [7, 9, 10]. In a previous study [10], researchers analyzed the articles published on gonorrhea, one of the STD agents, with a similar approach. In this article, like our study, the USA ranked first in the ranking of published articles and the average H-index of the articles was determined as 117. In current study, the average H-index of the articles was determined as 133. *C. trachomatis* is the most common infectious disease, especially in the USA according to CDC case reports, and it is a public health crisis because it threatens reproductive health, especially in young women [3, 26]. Also, studies on the involvement of *C. trachomatis* in the etiology of cancer have revealed the severity of the disease; therefore, vaccine studies continue to be conducted [11, 26]. Therefore, the high number of citations of the publications may be related to the public health importance of *C. trachomatis* infection. In our study, despite the number of citations seeming to be irregular, there has been a rapid increase since the 1980s, and especially since 2010, it has not fallen below 5,000 citations per year.

The term "keyword co-occurrence analysis" describes the number of works where they co-occur and how often they do so. It may be easier for researchers to notice research hotspots and trends in a field and perhaps get the idea for a new research project if two keywords co-occur often in a single publication since they may have a tighter link to one another than other terms [27]. Figure 3 shows the keyword visualization map of articles mentioned at least five times. Accordingly, words related to the prevalence of the disease, other concomitant STDs (e.g. Human Papilloma Virus), treatment, and diagnosis were the most preferred keywords. The largest circles in Figure 3 indicate the highest number of occurrences.

Co-authorship analysis is the process of determining how closely related different products are by counting the number of papers they have in common. For instance, author co-authorship analysis exposes collaborative relationships among authors, which may assist new researchers in better understanding current collaborations and locating future colleagues in a field [27]. Figure 1 shows a map of the international cooperation network and reveals that the USA cooperates closely with European countries. The largest circle shows the largest number of publications and the thickest line the largest number of collaborations. In addition, the same colors indicate the links between the cooperating countries.

## Conclusion

STDs continue to be an important public health problem almost everywhere in the world. Research on the subject is important in controlling STDs, which are increasing in frequency. As a result of this bibliometric analysis, we found that the USA is the country that publishes the most articles and supports the most research on *C. trachomatis*. It was observed that the number of articles published on *C. trachomatis* increased over the years and the citations to the articles increased rapidly. Our study showed that although the number of publications from developed countries increased, the number of publications

from developing and underdeveloped countries was low. Since *C. trachomatis* continues to be a growing global public health problem, it is necessary to support all countries, especially those countries where the number of cases is increasing, scientifically on issues such as prevention, spread, and vaccination studies.

## Limitations

In this study, only the WOS database was selected as the bibliometric database and only articles were selected as the document type. Since other databases were not selected, this study may not reflect the entire scientific literature. This may have caused a bias. Different databases and comparisons can be made in the future. This is only an initial bibliometric study on *C. trachomatis*. Therefore, our study is valuable. It can also guide the next bibliometric researchers.

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