Infect Dis Trop Med 2022;8: e876

Bibliometric analysis of global *gonorrhea* research

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ABSTRACT:

— ***Objective:*** This study offers a systematic and comprehensive picture of the field, which researchers may use to assess the characteristics of articles involving *Neisseria gonorrhoeae*.

— ***Materials and Methods:*** In the current bibliometric analysis study, the Web of Science (WoS; formerly Web of Knowledge) database was used to accomplish the objective of the study. The keywords "*Neisseria gonorrhoeae*" "*gonorrhoeae*" or "*N. gonorrhoeae*" or "*gonorrhea*" were used in the search, using "title" as the search item. The article category was referred to as the document type in this study.

— ***Results:*** In the WOS database, 4,250 articles were retrieved for the entire study period. Most of the articles were published between the years 2010-2019 (27.506%). The articles were from 84 different study areas. Most of them from Microbiology (n= 1829, 43.035%), Infectious Diseases (n=1664, 39.153%) and Immunology (n=793, 18.659%) areas. The top-ranked country was the United State of America (USA) (n=1931, 45.435%) in this field. Also, England, Canada, Sweeden, and Australia were the most productive countries on this topic. Turkey ranked 46th. 4,250 articles were cited 106,469 times, H index average per item was 117. The number of citations increased over the years.

— ***Conclusions:*** Our findings revealed that current research on the subject of *gonorrhea* has increased dramatically, as expected, and has covered a wide range of specialties. With a focus on the USA, American and European institutions are by far the most influential regions of the globe in terms of study in this field.

— ***Keywords:*** *Neisseria gonorrhoeae*, Bibliometric analysis, Gonorrhea.

INTRODUCTION

Scholars perform bibliometric analysis for different purposes, including spotting recent trends in the quality of publications, collaboration trends, and research themes, as well as analyzing the essence of a certain topic in the current literature[1]. Through well-designed bibliometric analyses, scholars can acquire a one-stop overview, identify knowledge gaps, develop new research ideas, and establish the future contribution in the field, forming the basis for furthering a subject in innovative and creative ways[2,3].

Neisseria gonorrhoeae is an intracellular gram-negative diplococcus bacterium responsible for a sexually transmitted infection (STI) named gonorrhea, in humans. It was first isolated in 1979 by Albert Neisser[4]. After *Chlamydia trachomatis* infection, *gonorrhea* is the world's 2nd most frequent bacterial STI. In addition, multidrug-resistant *N. gonorrhoeae* strains have been detected worldwide[5].

The World Health Organization (WHO) currently recommends ceftriaxone-azithromycin dual therapy for this infection[6]. Nevertheless, azithromycin and ceftriaxone resistance is on the rise, and treatment failures are becoming more common. As a result, innovative approaches to reducing the development of antimicrobial-resistant *N. gonorrhoeae* by enhancing the detection and treatment of resistant infections are definitely needed. Molecular assays to predict resistance are being

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developed, greater doses of ceftriaxone are being used, older antibiotics are being repurposed, and newer antibiotics are being developed. Furthermore, due to the cross-protectivity of the *N. meningitidis* vaccine, the opportunity to produce a vaccine for *N. gonorrhoeae* has resurfaced in recent years, employing a range of techniques and targets. Despite tremendous advances, there is still substantial effort to be done internationally to prevent antimicrobial-resistant *N. gonorrhoeae*[5,7].

This study provides a systematic and comprehensive picture of the field that researchers can use to evaluate the characteristics of articles on gonorrhea.

MATERIALS AND METHODS

Database

In the current study, the Web of Science (WoS; formerly Web of Knowledge) database was used to accomplish the objective of the study. The WOS database provides subscribers with access to a number of databases that give detailed citation data for a variety of academic areas. It was created by the Institute for Scientific Information (ISI) in the first place. Clarivate (formerly Thomson Reuters' Intellectual Property and Science unit) currently owns it. Originally created by the Institute for Scientific Information (ISI), the service is now maintained by Clarivate Analytics. Six online databases make up the WOS Core Collection; [*Social Sciences Citation Index* (SSCI), *Science Citation Index Expanded* (SCIE), *Emerging Sources Citation Index* (ESCI), *Arts & Humanities Citation Index* (A&HCI or AHCI), *Book Citation Index* (BCI) and *Conference Proceedings Citation Index* (CPCI)][8].

This database has two search options: a simple search and an advanced search, which allows you to create complicated and extensive search queries to achieve your goal with high validity. Consumers can access terms in titles, abstracts, journal/authors names, and affiliations in this database.

The keywords "*Neisseria gonorrhoeae*" or "gonorrhea" or "*N. gonorrhoeae*" were used in the search, using "title" as the search item. The article category was referred to as the document type in this study.

The search time range was up to December 31, 2021, which was the maximum time range of the WOS database. Finally, the collected literature was carefully reviewed for relevance to the current article's research.

Mapping

To visualize collaboration networks and keywords, the VOSviewer 1.6.18 for the Microsoft Windows systems program was used. We created co-occurrence networks from the obtained publications' bibliographic metadata.

RESULTS

General Information, Countries, Affiliations

Throughout the whole study period, the WOS database yielded 4250 articles on gonorrhea. Most of the articles were published between the years 2010-2019 (27.506%) (Figure 1).

The articles were mostly written in English (96.682%). French (1.388%), German (0.8%), and Spanish (0.471%) were the other most preferred languages. 2161 (50.847%) of the articles were published as Open Access (OA).

The articles were from 84 different study areas. Most of them from Microbiology (n= 1829, 43.035%), Infectious Diseases (n=1664, 39.153%) and Immunology (n=793, 18.659%) areas (Table 1).

Most of the articles were published in the SCI-EXPANDED indexed journals (Table 2).

The top-ranked country was the USA (n=1931, 45.435%) in this field. Also, England, Canada, Sweeden, and Australia were the most productive countries on this topic. Turkey ranked 46th (Table 3).

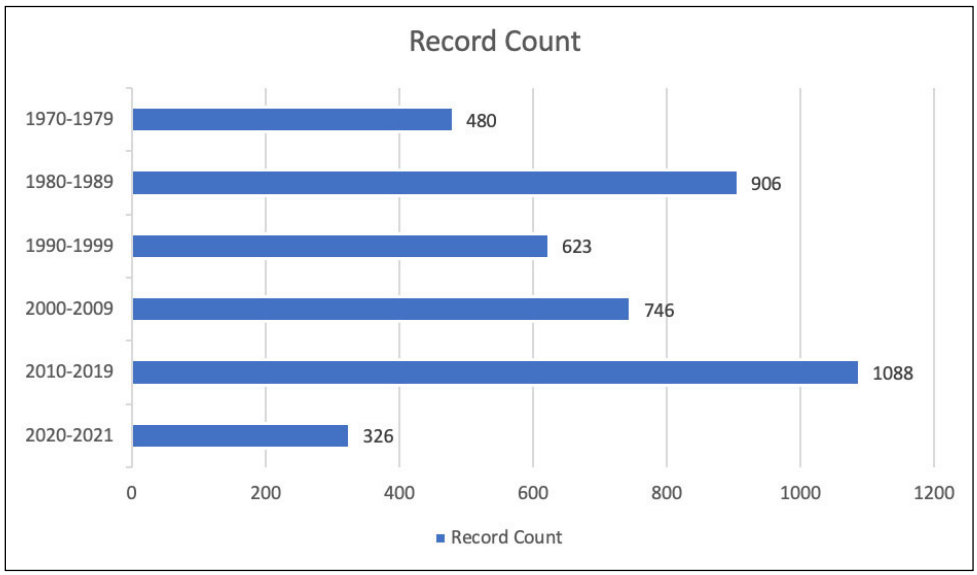

Figure 1. The number of articles according to time periods.

Table 1. Top 10 research areas of the articles.

The WOS categories	Record Count	% of 4.250
Microbiology	1829	43.035
Infectious Diseases	1664	39.153
Immunology	793	18.659
Pharmacology Pharmacy	461	10.847
Biochemistry Molecular Biology	348	8.188
Public Environmental Occupational Health	290	6.824
Medicine General Internal	187	4.400
Dermatology	176	4.141
Obstetrics Gynecology	123	2.894
Multidisciplinary Sciences	116	2.729

*Showing 10 out of 84 entries.

Table 2. The articles according to Web of Science Index.

The WOS Index	Record Count	% of 4.250
SCI-EXPANDED	4126	97.082
SSCI	139	3.271
ESCI	74	1.741
CPCI-S	56	1.318
BKCI-S	36	0.847
IC	3	0.071

**Social Sciences Citation Index* (SSCI), *Science Citation Index Expanded* (SCIE), *Emerging Sources Citation Index* (ESCI), *Arts & Humanities Citation Index* (A&HCI *or* AHCI), *Book Citation Index* (BCI) *and Conference Proceedings Citation Index* (CPCI).

Table 3. Top 15 countries.

Countries/Regions	Record Count	% of 4.250
USA	1931	45.435
England	488	11.482
Canada	330	7.765
Sweden	288	6.776
Australia	242	5.694
Germany	151	3.553
Peoples Republic of China	138	3.247
Japan	130	3.059
France	121	2.847
Netherlands	118	2.776
India	93	2.188
South Africa	68	1.600
Belgium	62	1.459
Norway	62	1.459
Scotland	61	1.435

48 record(s) (1.129%) do not contain data in the field being analyzed.

2.426 articles (57.082%) of the articles did not have a funder sponsor. The United States Department Of Health and Human Services (24.824 %) funded most of the studies (Table 4).

Table 4. Distrubition of main funding agencies.

Funding Agencies	Record Count	% of 4.250
United States Department of Health Human Services	1055	24.824
National Institutes of Health USA	990	23.294
National Institute of Allergy Infectious Diseases	855	20.118
European Commission	108	2.541
National Institute of General Medical Sciences	105	2.471
Wellcome Trust	63	1.482
National Health And Medical Research Council of Australia	61	1.435
National Center For Research Resources	60	1.412
Centers For Disease Control Prevention USA	55	1.294
United States Public Health Service	55	1.294

*Showing 10 out of 1.217 entries.

The University of North Carolina and the Centers For Disease Control Prevention (CDC) were the lead affiliations on *gonorrhea* research (Table 5).

The authors who published most of the articles on gonorrhea were Magnus Unemo (n=168, 3.953), William M. Shafer (n=85, 2%), and H. Steven Seifert (n=74, 1741). Most of the articles were published in the 'Sexually Transmitted Diseases' and 'Infection and Immunity' journals (Table 6).

Citing Analysis

4.250 articles were cited 106,469 times, H index average per item was 117. The number of citations increased over the years (Figure 2).

The top cited articles, the average and total number of citations were given in Table 7.

Table 5. Distrubition of main funding agencies.

Affiliations	Record Count	% of 4.250
University of North Carolina	248	6.964
Centers for Disease Control Prevention, USA	244	5.741
University of California System	170	4.000
Orebro University	165	3.882
University of Washington	128	3.012
University of Washington Seattle	128	3.012
US Department Veterans Affairs	122	2.871
Veterans Health Administration	122	2.871
Emory University	114	2.682

Showing 10 out of 2.826 entries; 49 record(s) (1.153%) do not contain data in the field being analyzed.

Table 6. Distrubition of main funding agencies.

Journals	Record Count	% of 4.250
Sexually Transmitted Diseases	331	7.788
Infect Immun	286	6.729
J Clin Microbiol	258	6.071
Antimicrob Agents Chemother	191	4.494
J Bacteriol	188	4.424
J Antimicrob Chemother	144	3.388
Br J Vener Dis	119	2.800
J Infect Dis	115	2.706
Sexually Transmitted Infections	102	2.400
Mol Microbiol	97	2.282

*Showing 10 out of 621 entries.

Mapping

The mapping of the authors minimum 25 documents were given in Figure 3. The mapping of the collabaraitons between top affiliations were given in Figure 4.

DISCUSSION

Gonorrhea is a highly prevalent disease, particularly among young people between the ages of 15 and 24 in the USA and globally. The most comprehensive picture of STIs in the USA to date comes from the CDC. According to the CDC data, over 20% of the USA population – or one for every five persons – had an STI on almost any particular day in 2018, with STIs costing the American healthcare system approximately $16 billion in healthcare costs alone. *Gonorrhea* infection is also the second-leading cause of STIs[20].

The importance of research in a country's development and advancement cannot be overstated. The publication of an investigator's project allows the knowledge to be shared with the scientific community, and original publications allow investigators to communicate their scientific observations. Publications are frequently used to assess the success of research projects. In recent years, there has been a rise in interest in developing scientific metrics that might assist with the analysis of study results[9]. This study aims to make a systematic and comprehensive picture of the articles on gonorrhea. No similar bibliometric study on the *gonorrhea* topic was found in the published literature. The articles regarding *gonorrhea* in English were collected from the WoS database between 1970 and 2021 for statistical and bibliometric analysis. After text mining operations, effective organizations, authors, and countries on the *gonorrhea* topic were shown using graphs. Figures were also used to depict the distribution of publication numbers according to the number of authors and the change in publication numbers over time from 1970 to 2021. The top cited articles in this field were listed in a table at the conclusion of the data analysis.

The WOS database is a commonly used bibliometric database that provides free output for visualization or mapping using various visualization programs. In this study, we also used visualization or mapping technologies.

The USA (n=1931, 45.435%) like in prior bibliometric analysis[21-23] has by far the most publications on *gonorrhea* research. Also, the most productive countries on this topic were England, Canada, Sweden, and Australia. In addition, developed countries were in the first place. This may be due to both advanced scientific activities and the high number of reported cases of *gonorrhea* in these developed countries. Furthermore, the vast majority of the most referenced publications are from American or European institutions, with only a few from other continents. The University of North Carolina (USA) and CDC (USA) have published most of the articles.

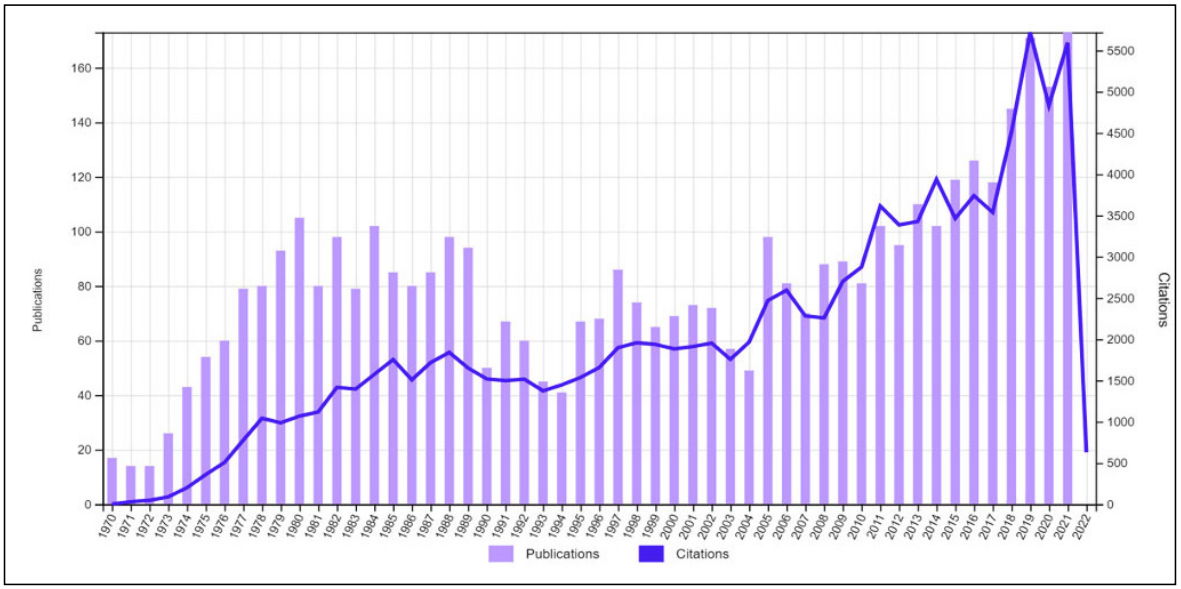

Figure 2. The number of articles and citations over the years.

Table 7. Top cited articles, the avarage and total number of citations[10-19].

Author, Article, Year, Journal, Reference number	Average citations per year	Total
Pohlner J, Halter R, Beyreuther K, Meyer TF. Gene structure and extracellular secretion of *Neisseria gonorrhoeae* IgA protease. Nature 1987; 325: 458-462.	14.86	535
Ohnishi M, Golparian D, Shimuta K, Saika T, Hoshina S, Iwasaku K, Nakayama S, Kitawaki J, Unemo M. Is *Neisseria gonorrhoeae* initiating a future era of untreatable gonorrhea?: detailed characterization of the first strain with high-level resistance to ceftriaxone. Antimicrob Agents Chemother 2011; 55: 3538-3545.	38.58	463
Unemo M, Golparian D, Nicholas R, Ohnishi M, Gallay A, Sednaoui P. High-level cefixime-and ceftriaxone-resistant *Neisseria gonorrhoeae* in France: novel penA mosaic allele in a successful international clone causes treatment failure. Antimicrob Agents Chemother 2012; 56: 1273-1280.	38.91	428
Stern A, Brown M, Nickel P, Meyer TF. Opacity genes in *Neisseria gonorrhoeae*: control of phase and antigenic variation. Cell 1986; 47: 61-71.	9.22	341
Brotman RM, Klebanoff MA, Nansel TR, Yu KF, Andrews WW, Zhang J, et al. Bacterial vaginosis assessed by gram stain and diminished colonization resistance to incident gonococcal, chlamydial, and trichomonal genital infection. J Infect Dis 2010; 202: 1907-1915.	16.4	328
Ram S, Sharma AK, Simpson SD, Gulati S, McQuillen DP, Pangburn MK, et al. A novel sialic acid binding site on factor H mediates serum resistance of sialylated *Neisseria gonorrhoeae*. J Exp Med 1998; 187: 743-752.	12.56	314
Penicillinase-producing *Neisseria gonorrhoeae*. Lancet 1976; 2: 793.	6.66	313
Shafer WM, Qu X, Waring AJ, Lehrer RI. Modulation of *Neisseria gonorrhoeae* susceptibility to vertebrate antibacterial peptides due to a member of the resistance/nodulation/division efflux pump family. Proc Natl Acad Sci U S A 1998; 95: 1829-1833.	12.44	311
Goodman SD, Scocca JJ. Identification and arrangement of the DNA sequence recognized in specific transformation of *Neisseria gonorrhoeae*. Proc Natl Acad Sci U S A 1988; 85: 6982-6986.	8.34	292
Poole K. Efflux-mediated resistance to fluoroquinolones in gram-negative bacteria. Antimicrob Agents Chemother 2000; 44: 2233-2241.	10.21	286

The times cited count is used to determine the H-index value, which is based on a list of articles ranked in descending order. An index of h indicates that there are h papers in the collection, each of which has been cited at least H times. The H-index is calculated using the number of years of your product subscription and the time period you choose. Items that are not included in your subscription will be excluded from the calculation[24]. The number of articles and citations has increased numerically over the years.

LIMITATIONS

However, there are some limitations to this research. Some articles may have been missing and the number of citations was overestimated because the data were gathered from a single database (WOS), although the authors believe this is improbable. The content analyses were not enough implemented.

CONCLUSIONS

To the author's knowledge, this is the first study to assess *gonorrhea* research with the bibliometric method. Our findings revealed that current research on the subject of *gonorrhea* has increased dramatically, as expect-

Figure 3. Authors minimum 25 documen

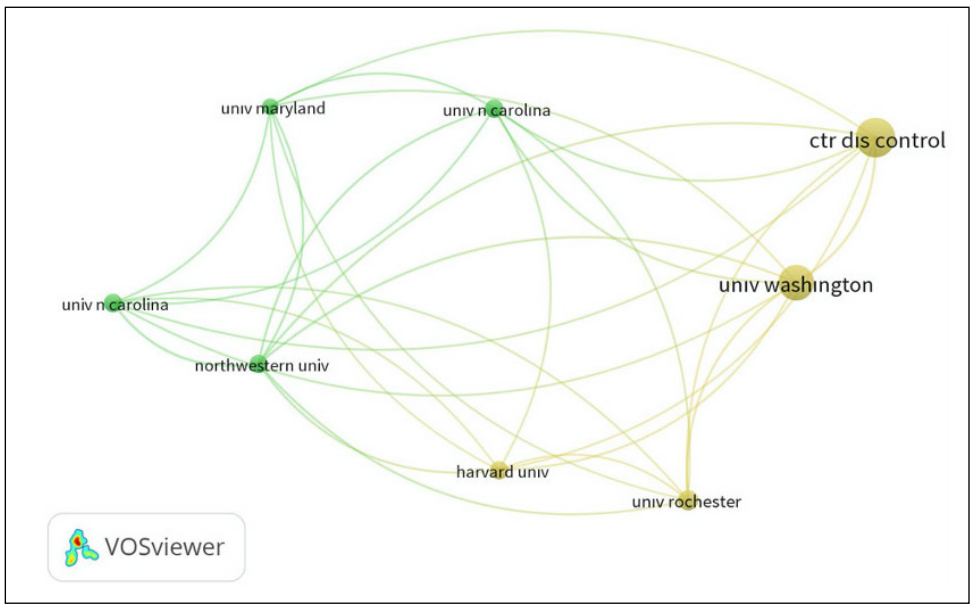

Figure 4. Collaborations between top affiliations.

ed, and has covered a wide range of specialties. With a focus on the United States, American and European institutions are by far the most significant in terms of research on this topic.

Conflicts of Interest:
No conflict of interest was declared by the authors.

Ethical Consideration:
As there is no human or animal involvement in most bibliometric investigations, no ethical approval was necessary.

Informed consent:
Not applicable.

Availability of Data and Materials:
Data were retrieved from Web of Science bibliometric database. We used Çanakkale Onsekiz Mart University's online library and digital resources to access information.

Funding:
None.

Author Contributions:
Authors have equal contributions.

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