

# A Comprehensive Bibliometric Analysis of Research Trends About Congenital Toxoplasmosis

## Konjenital Toksoplazmoz Hakkındaki Araştırma Eğilimlerinin Kapsamlı Bibliyometrik Analizi

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### ABSTRACT

**Objective:** *Toxoplasma gondii* is an obligate intracellular protozoan that infects approximately one-third of the human population. The parasite could transmit from mother to fetus in cases of acute infection during pregnancy and cause complications in the fetus. The bibliometric analysis is a popular research area that evaluates all the studies indexed in particular databases on a subject.

**Methods:** This article puts forth bibliometric review of the literature on maternal and congenital toxoplasmosis research indexed in the Web of Science database between 1945 and 2024. VOS viewer, Web of Science and MS Office Excel 17 programs were used in the study.

**Results:** The results of the search showed 1476 publications. The countries that most contributed to the literature were France (n=306, 20.73%), the USA (n=229, 15.52%), and Brazil (n=146, 9.89%). The most cited country was also France (n=10271, 35.52%), followed by the USA (n=9113, 31.51%), and England (n=2611, 9.03%). The top three countries by number of citations per document were Denmark (44.88), the USA (39.79) and France (33.57). The five departments with the most publications are Pediatrics (20.26%), General Internal Medicine (18.16%), Infectious Diseases (16.8%), Obstetrics (14.57%), and Immunology (11.86%). Wallon M. (n=57), Peyron F. (n=49), Thulliez P. (n=36) and Vilena I. (n=36) were the leading authors in terms of contribution to the literature. The five most published journals were Pediatric Infectious Disease Journal (3.66%), Journal of Clinical Microbiology (2.78%), Lancet (2.3%), Presse Medicale (1.76%), and American Journal of Obstetrics and Gynecology (1.63%).

**Conclusion:** France is one of the countries that pays the most attention to congenital toxoplasmosis and compatible with this, in our study, the country with the highest number of studies on congenital toxoplasmosis was France. It is thought that drawing more attention to this issue and conducting more studies in countries where the disease is common might yield successful results, as in France.

**Keywords:** *Toxoplasma gondii*, toxoplasmosis, congenital, pregnancy, bibliometric

### ÖZ

**Amaç:** *Toxoplasma gondii*, insan popülasyonunun yaklaşık üçte birini enfekte eden zorunlu hücre içi bir protozondur. Hamilelik sırasında akut enfeksiyon geçirilmesi durumunda parazit anneden fetüse geçebilir ve fetüste birtakım komplikasyonların ortaya çıkmasına neden olabilmektedir. Bibliyometrik analiz, bir konu hakkında veri tabanlarında indeklenen tüm yayınları araştıran popüler bir araştırma türüdür.

**Yöntemler:** Çalışmamız, 1945 ile 2024 yılları arasında Web of Science veri tabanında indekslenen maternal ve konjenital toksoplazmoz araştırmalarına ilişkin literatürün bibliyometrik bir incelemesini ortaya koymaktadır. Çalışmada VOS viewer, Web of Science ve MS Office Excel 17 programları kullanılmıştır.

**Bulgular:** Araştırmamız sonucunda 1945 ile 2024 yılları arasında maternal ve konjenital toksoplazmoz konularında toplam 1476 yayın saptanmıştır. Literatüre en çok katkı sağlayan ülkeler Fransa (n=306, %20,73), ABD (n=229, %15,52) ve Brezilya'dır (n=146, %9,89). Aynı zamanda en çok atıf yapılan ülke Fransa (n=10271, %35,52) olurken, bunu ABD (n=9113, %31,51) ve İngiltere (n=2611, %9,03) takip etmiştir. Yayın başına yapılan atıf sayısına göre ilk üç ülke Danimarka (44,88), ABD (39,79) ve Fransa'dır (33,57). En fazla yayın yapılan beş bölüm sırasıyla Çocuk (%20,26), Genel Dahiliye (%18,16), Enfeksiyon Hastalıkları (%16,8), Kadın Doğum (%14,57) ve İmmünolojidir (%11,86). Wallon M. (57), Peyron F. (49), Thulliez P. (36) ve Vilena I. (36) literatüre katkı



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açısından önde gelen yazarlardır. En fazla yayın yapılan beş dergi sırasıyla Pediatric Infectious Disease Journal (%3,66), Journal of Clinical Microbiology (%2,78), Lancet (%2,3), Presse Medicale (%1,76) ve American Journal of Obstetrics and Gynecology'dir (%1,63).

**Sonuç:** Konjenital toksoplazmoz konusuna en çok önem veren ülkelerden biri olan Fransa, bununla uyumlu olarak en fazla çalışmanın yapıldığı ülke olmuştur. Hastalığın yaygın olduğu ülkelerde bu konuya daha fazla dikkat çekilmesinin ve daha fazla çalışma yapılmasının Fransa'da olduğu gibi başarılı sonuçlar verebileceği düşünülmektedir.

**Anahtar Kelimeler:** *Toxoplasma gondii*, toksoplazmoz, konjenital, gebelik, bibliyometrik

## INTRODUCTION

Toxoplasmosis is caused by the etiological agent *Toxoplasma gondii* (*T. gondii*), an obligate intracellular protozoon, that could infect all warm-blooded animals. The parasite infects approximately one-third of the human population during their lifespan (1). The Centers for Disease Control and Prevention reported that toxoplasmosis is the second most common cause of death due to foodborne illnesses and the fourth leading cause of hospitalizations based on foodborne diseases (2). The prevalence varies from 10% to 80% between countries across the globe and even between different communities within a country based on geographical changes and the eating habits of humans. Toxoplasmosis is most prevalent in Brazil (77.5%) and followed by Iran (63.9%), Colombia (63.5%), and Cuba (61.8%), respectively (3,4).

The protozoa have a complex life cycle, including cats as definitive hosts and other warm-blooded animals as intermediate hosts. The asexual life cycle occurs in the intermediate hosts, while the cats harbor both sexual and asexual life cycles. Humans could be intermediate hosts in the life cycle of the parasite, and they are most commonly infected by ingesting bradyzoites in undercooked or raw meat or ingesting oocysts in improperly washed vegetables and fruits (5). Many patients infected with *T. gondii* are asymptomatic. On the other hand, it could cause serious complications in immunosuppressed patients, and the parasite could transmit from mother to fetus in terms of acute infection gained during pregnancy. The rate of transmission is low in the first trimester due to the intact structure of the placenta. But in cases of transmission, the outcomes may be very serious, such as spontaneous abortion, stillbirth, or congenital anomalies, including hydrocephalus, intracranial calcification, and retinochoroiditis. Although transition rates increase towards the end of pregnancy, the severity of sequelae decreases (6).

Screening for toxoplasmosis before and during pregnancy and taking necessary precautions by making an early diagnosis in cases of acute infection is very important in preventing congenital toxoplasmosis cases. Therefore, some countries have included toxoplasmosis in their national screening programs. There are two preventive strategies against congenital toxoplasmosis, including prenatal and neonatal. Prenatal programs combine education with serological testing and aim to prevent acute infection during pregnancy, early diagnosis in cases of acute infection, and blockage of transmission from mother to fetus. Prenatal screening programs are conducted on a national scale in France, Austria, and Slovenia. In France, all pregnant women have been screened monthly until delivery since 1992, and a prominent decrease has been achieved in the prevalence of toxoplasmosis. The incidence of acute toxoplasmosis during pregnancy has decreased from 5.4 to 1.6 per 1000 susceptible women (6,7). Prenatal screening is cost-saving in countries where the incidence is high, and this situation also encourages efforts to perform these programs even in countries where the incidence is low (7).

The bibliometric analysis is a popular research area that evaluates all the studies indexed in particular databases and the research tendencies of countries and individuals on a subject. Therefore, by revealing the research tendencies on a subject, one can get an idea of its importance and the level of knowledge on that subject. There are few toxoplasmosis bibliometric analyses available in the literature (8). Nevertheless, bibliometric analysis of publications on congenital and maternal toxoplasmosis indexed in the Web of Science database has not been discovered in any study. With this study, we aim to put forth the research trends about maternal and congenital toxoplasmosis by evaluating all the studies indexed in the Web of Science database and detecting the contribution of countries, authors, or journals to this significant parasitic disease.

## METHODS

### Data Collection

This research is a bibliometric publication in the fields of maternal and congenital toxoplasmosis, including all the documents indexed in the Web of Science Core Collection database between 1945 and 2024. Using OR between the terms, the advanced search function of the database examined the titles of the documents containing the following terms: "*Toxoplasma* pregnancy", "toxoplasmosis pregnancy", "*T. gondii* pregnancy", "maternal toxoplasmosis", "congenital *Toxoplasma*", and "congenital toxoplasmosis". All the document types were included in the analysis. Excluded from consideration were documents with titles that contained animal names like murine, mouse, cats, rat, pig, etc.

### Statistical Analysis

The documents were downloaded to the computer in plain text format as full records, cited references, and transferred to VOSviewer program 1.6.20 for forward analysis (9). Visualizations and graphics were made in both the VOSviewer program and Web of Science. MS Office Excel 2017 was used for the preparation of the tables and calculation of data frequencies and percentages. The Spearman and Pearson correlation tests were utilized to assess the association between research data using the IBM SPSS Statistics 23 Program.

Ethical approval and informed consent are not required because neither humans nor animals are included in the study.

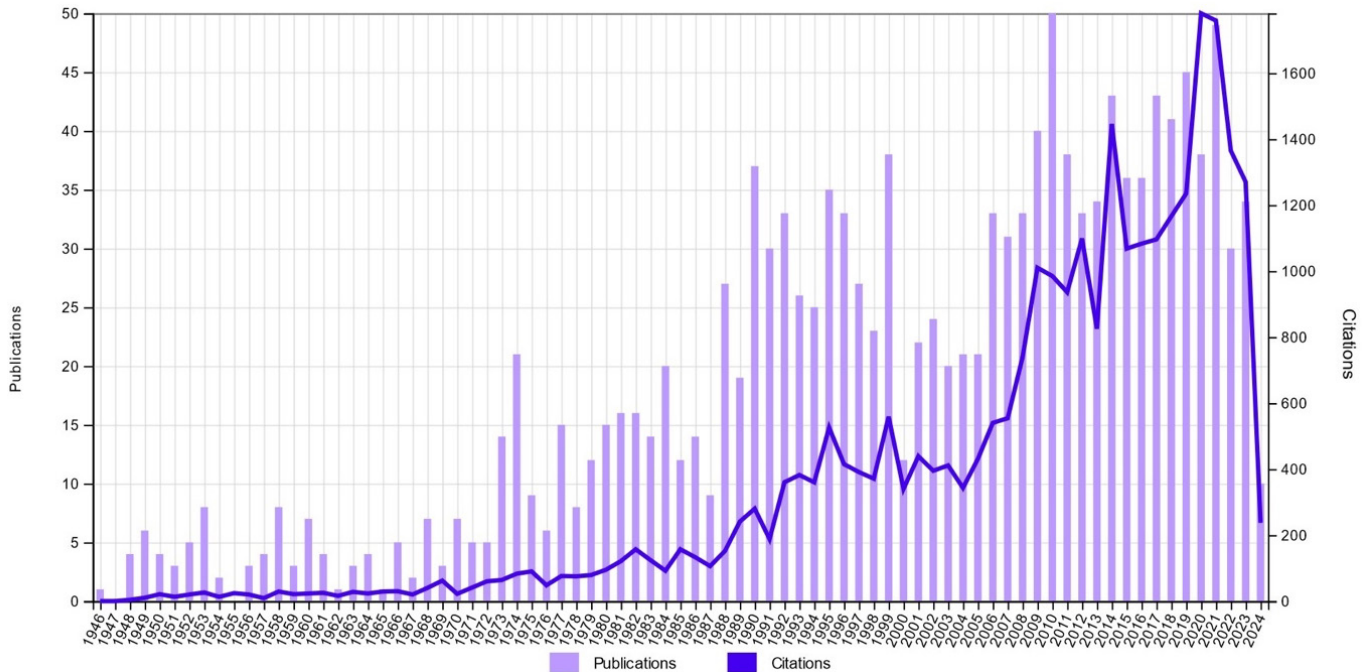
## RESULTS

The results of the search in the Web of Science database showed 1476 publications about maternal and congenital toxoplasmosis between 1945 and 2024. Although the number of publications showed a fluctuating trend since 1945, it gradually increased and peaked in 2010 with 50 documents, followed by 2021 and 2019 with 49 and 45 documents, respectively. One thousand four hundred and seventy six publications have been cited 28917 times by 10135 publications. When self-citations were excluded, the

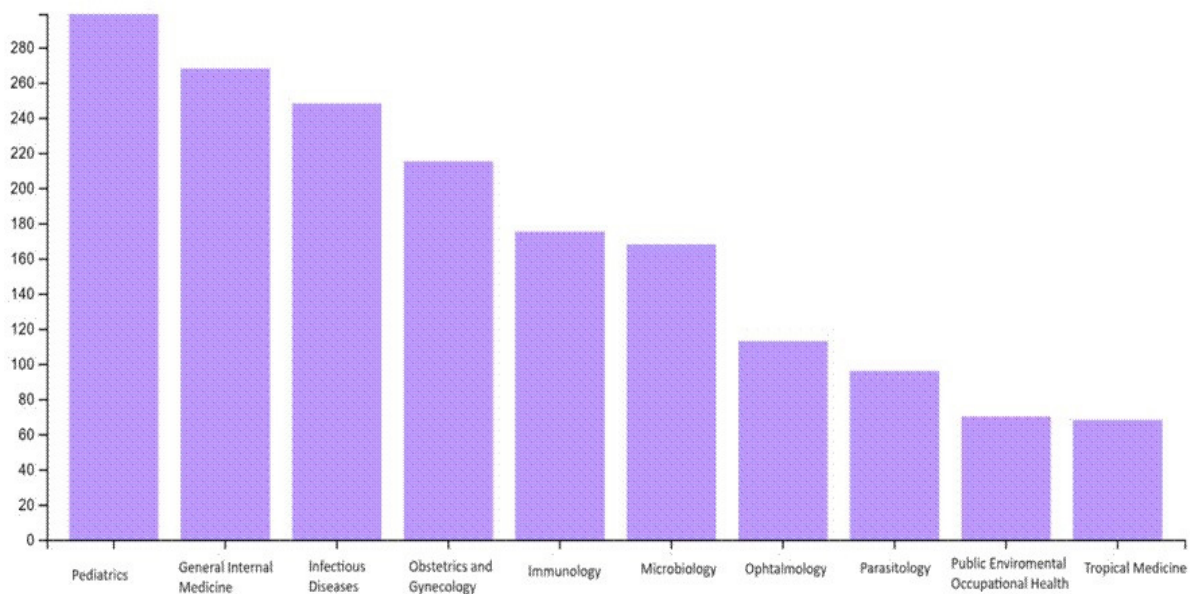
number of citations was 19707, made by 9044 publications. The average number of citations per publication was 19.59 (Figure 1). The first document was about congenital toxoplasmosis and was conducted by Ricci HN in 1946 (10). The most indexed document type was the original article (67.07%), followed by letter (9.69%), meeting abstract (8.94%), and review article (6.1%). Most of the publications were published in Science Citation Index Expanded (SCI-E) journals (90.65%), while 6.78% in Emerging Sources Citation Index (ESCI), and 6.03% in Conference Proceedings Citation Index-Science (CPCI-S) journals. The most contributor five departments were Pediatrics (20.26%), General Internal

Medicine (18.16%), Infectious Diseases (16.8%), Obstetrics Gynecology (14.57%) and Immunology (11.86%), respectively (Figure 2).

The researches were conducted in 106 different countries. France was the leading country with 306 documents, consisting of 20.73% of all the publications and followed by the USA (15.52%), Brazil (9.89%), Italy (6.1%), and England (5.29%). The most cited country was also France (35.52%), followed by the USA (31.51%), England (9.03%), Brazil (6.54%), and Italy (5.78%). The leading country was Denmark (44.88%), taking into consideration the number of citations per document, followed by the USA (39.79%)



**Figure 1.** The distribution of publications and citations about maternal and congenital toxoplasmosis between 1945 and 2024



**Figure 2.** The most contributor 10 departments to the literature about maternal and congenital toxoplasmosis

and France (33.57%), respectively (Table 1). While a strong linear positive correlation was detected between the number of documents published from different countries and the total number of citations ( $r=0.912$ ,  $p=0.01$ ), there was no correlation between the number of documents and the average number of citations ( $p=0.242$ ).

A total of 5065 authors contributed to 1476 publications. The most contributor author was Wallon M with 57 documents, followed by Peyron F, Thulliez P and Vilena I with 49, 36, and 36 documents, respectively (Figure 3). The most published five journals were

Pediatric Infectious Disease Journal (3.66%), Journal of Clinical Microbiology (2.78%), Lancet (2.3%), Presse Medicale (1.76%), and American Journal of Obstetrics and Gynecology (1.63%), respectively (Figure 4).

The most cited document was an original article titled “Toxoplasmosis snapshots: Global status of *T. gondii* seroprevalence and implications for pregnancy and congenital toxoplasmosis” conducted by Pappas et al. (3) published in 2009 in the International Journal for Parasitology, with a total number of 672 citations and followed by Desmots G and Couvreur J, 1974

**Table 1.** The countries that published at least 23 publications about maternal and congenital toxoplasmosis

Countries	Documents		Citations		Without self-citations		Average citations per document	H-index
	N	%	N	%	N	%		
France	306	20.73	10271	35.52	8636	43.82	33.57	53
USA	229	15.52	9113	31.51	8499	43.13	39.79	50
Brazil	146	9.89	1891	6.54	1539	7.81	12.95	22
Italy	90	6.1	1670	5.78	1591	8.07	18.56	20
England	78	5.29	2611	9.03	2469	12.53	33.47	27
Germany	48	3.25	493	1.70	480	2.44	10.27	12
Switzerland	48	3.25	1204	4.16	1164	5.91	25.08	16
Austria	33	2.24	955	3.30	913	4.63	28.94	15
Denmark	33	2.24	1481	5.12	1420	7.21	44.88	21
Belgium	29	1.97	834	2.88	803	4.07	28.76	15
China	29	1.97	382	1.32	325	1.65	13.17	13
Japan	23	1.56	148	0.51	133	0.67	6.43	6
Scotland	23	1.56	450	1.56	432	2.19	19.57	12

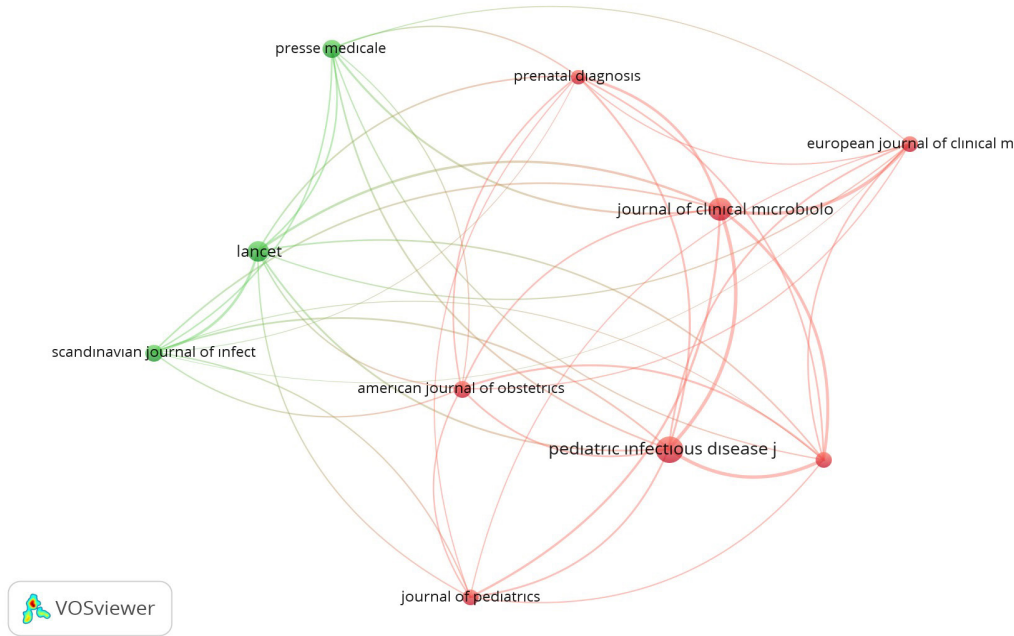
N: Number, percentages are calculated based on total numbers documents (n=1476), citations (n=28917), and without self-citations (n=19707) in WOS database



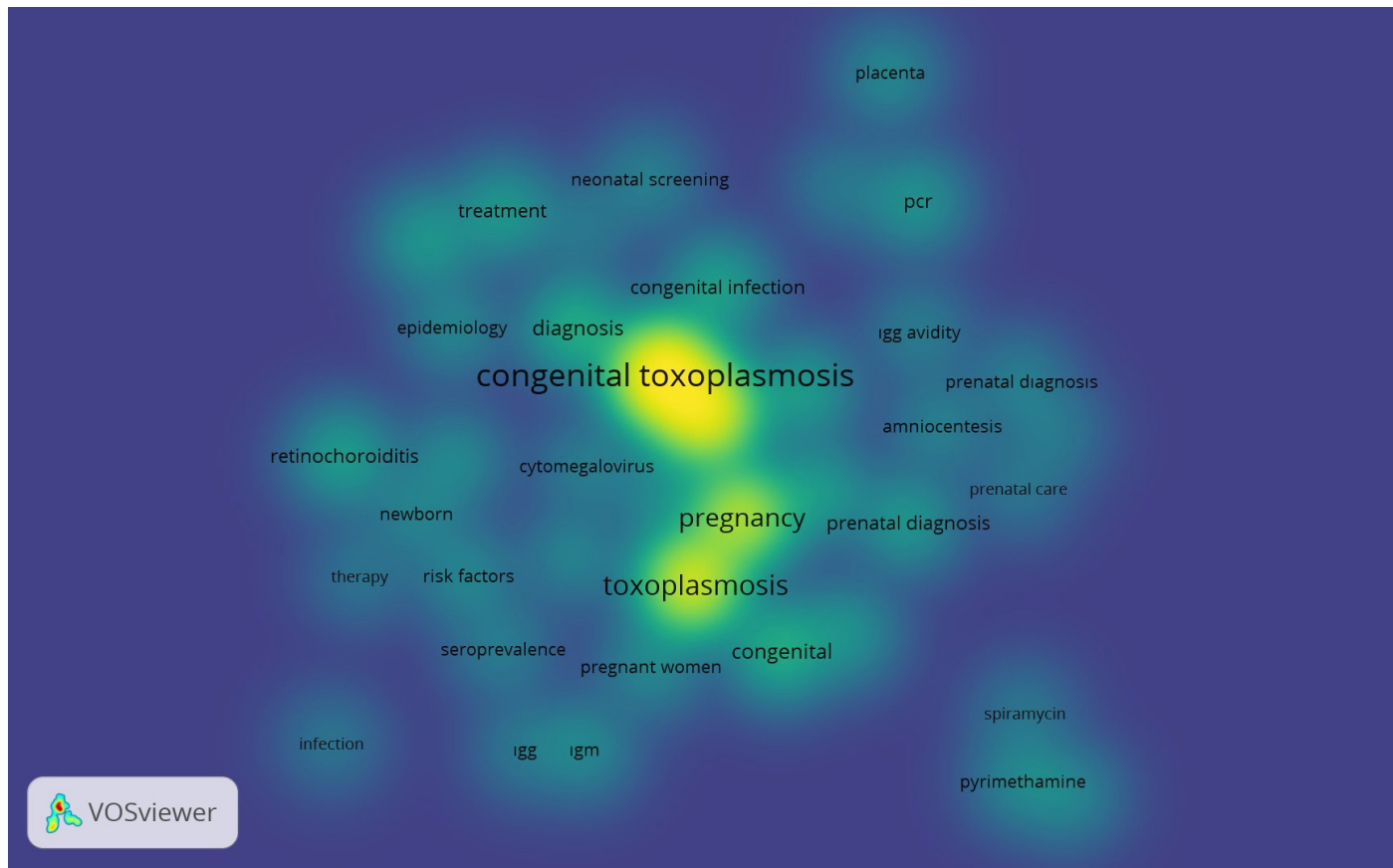
**Figure 3.** The most contributor 10 authors in the literature about maternal and congenital toxoplasmosis

(n=479), Montoya and Remington, 2008 (n=424), Torgerson and Mastroiacovo, 2013 (n=396) and Brown et al. (14) (n=356) (Table 2) (3,11-14). The most recurring keywords in the documents were

“congenital toxoplasmosis” with 253 repetitives, followed by “*T. gondii*”, “toxoplasmosis” and “pregnancy” with 167, 161 and 114 repetitives, respectively (Figure 5).



**Figure 4.** The network visualization of the journals that published at least 17 documents about maternal and congenital toxoplasmosis



**Figure 5.** The density visualization of the most repetitive keywords in the literature about maternal and congenital toxoplasmosis

**Table 2.** The characteristics of the most cited 10 documents about maternal and congenital toxoplasmosis

No	Document title	Authors	Journal	Publication year	Number of citations	Average citations per year	Ref.
1	Toxoplasmosis snapshots: Global status of <i>Toxoplasma gondii</i> seroprevalence and implications for pregnancy and congenital toxoplasmosis	Pappas G, Roussos N, Falagas ME	International Journal for Parasitology	2009	672	42	3
2	Congenital toxoplasmosis. A prospective study of 378 pregnancies	Desmonts G, Couvreur J	The New England Journal of Medicine	1974	479	9.39	11
3	Management of <i>Toxoplasma gondii</i> infection during pregnancy	Montoya JG, Remington JS	Clinical Infectious Diseases	2008	424	24.94	12
4	The global burden of congenital toxoplasmosis: a systematic review	Torgerson PR, Mastroiacovo P	Bulletin of the World Health Organization	2013	396	33	13
5	Maternal exposure to toxoplasmosis and risk of schizophrenia in adult offspring	Brown AS, Schaefer CA, Quesenberry CP Jr, Liu L, Babulas VP, Susser ES	American Journal of Psychiatry	2005	356	17.8	14
6	Prenatal management of 746 pregnancies at risk for congenital toxoplasmosis	Daffos F, Forestier F, Capella-Pavlovsky M, Thulliez P, Aufrant C, Valenti D, Cox WL	The New England Journal of Medicine	1988	345	9.32	15
7	Genotype of 86 <i>Toxoplasma gondii</i> isolates associated with human congenital toxoplasmosis, and correlation with clinical findings	Ajzenberg D, Cogné N, Paris L, Bessières MH, Thulliez P, Filisetti D, Pelloux H, Marty P, Dardé ML	The Journal of Infectious Diseases	2002	336	14.61	16
8	Development of adverse sequelae in children born with subclinical congenital <i>Toxoplasma</i> infection	Wilson CB, Remington JS, Stagno S, Reynolds DW	Pediatrics	1980	333	7.4	17
9	Effectiveness of prenatal treatment for congenital toxoplasmosis: a meta-analysis of individual patients' data	SYROCOT (Systematic Review on Congenital Toxoplasmosis) study group; Thiébaud R, Leproust S, Chêne G, Gilbert R	Lancet	2007	304	16.89	18
10	Neonatal serologic screening and early treatment for congenital <i>Toxoplasma gondii</i> infection	Guerina NG, Hsu HW, Meissner HC, Maguire JH, Lynfield R, Stechenberg B, Abroms I, Pasternack MS, Hoff R, Eaton RB, Grady GF, and the New England Regional Toxoplasma Working Group	The New England Journal of Medicine	1994	299	9.65	19

## DISCUSSION

*T. gondii*, which infects approximately one-third of the world's population, is an important parasitic agent, especially for patients with suppressed immune systems and pregnant women. In cases of acute infection acquired during pregnancy, there is a risk of the agent passing to the fetus through the placenta and affecting the fetus at varying degrees of severity depending on the week of pregnancy. In this study, a bibliometrical analysis was performed on the maternal and congenital toxoplasmosis publications between 1945 and 2024. The present study may be beneficial

for determining the present status of studies on congenital toxoplasmosis around the world.

Some countries have a national screening program to fight against congenital toxoplasmosis, and one of the countries that pays the most attention to this issue is France. There are countries where prenatal screening for toxoplasmosis is compulsory, such as Austria, Belgium, France, Greece, Slovenia, and Slovakia. Screening programs in countries such as Bulgaria, Czechia, Germany, and Hungary are implemented voluntarily. The prenatal screening program that has been organized in France at a national scale, including the implementation of serological

screening of pregnant women starting in the first trimester and follow-up of seronegative women during pregnancy, could be one of the most comprehensive programs in the world (6). While 204 congenital toxoplasmosis cases were diagnosed in 2012, this number decreased to 110 in 2020 in France (20,21). In our study, the country with the highest number of studies on maternal and congenital toxoplasmosis was France, with 306 publications, confirming the importance given to this issue in France. Wallon M. with 57 publications and Peyron F. with 49 publications, both of them from Lyon, France, were the researchers who published the most on congenital toxoplasmosis. France's leadership in publications about maternal and congenital toxoplasmosis may be due to the importance given to national screening programs as well as research funding, infrastructure, and public health policies of the country.

In a bibliometric study investigating toxoplasmosis publications around the world between 2000 and 2016, the country where the most studies were conducted was found to be the USA (8). In another study examining congenital toxoplasmosis publications in the Web of Science database between 1900 and 2012, the USA ranked first in terms of the number of documents and citations, and the number of institutions supporting the studies (22). However, in our study examining congenital toxoplasmosis studies, France ranked first. The difference between the leading countries in terms of the number of studies may be due to the studies covering different time periods and the selection of different keywords.

The USA, where toxoplasmosis causes hundreds of deaths and thousands of hospitalizations and there are an estimated 300-4000 cases of congenital toxoplasmosis each year, is placed in the second rank after France in terms of the total number of publications with 229 documents (23). Brazil placed in the third rank after the USA. The dominance of the two countries could be explained by the fact that the disease is of great interest in both countries, as France has the highest prevalence in Europe due to the habit of consuming undercooked meat, and tropical areas of South America such as Brazil have the highest burden of the parasitic disease worldwide due to the high numbers of infected cats, the presence of highly virulent toxoplasma genotypes, and suitable climatic conditions for oocyst survival (24,25). France (35.52%) and the USA (31.51%) have been the most cited countries for maternal and congenital toxoplasmosis.

### Study Limitations

One study limitation might be that only papers indexed in the WOS database were assessed. A publication bias may result from the WOS database's status of only including journals with high impact factors and indexes in SCI-E, ESCI, CPCI-S, Social Science Citation Index, and Book Citation Index-Science.

### CONCLUSION

Many studies have been carried out on congenital toxoplasmosis in the world, especially in France, and very important steps have been taken in the fight against toxoplasmosis. Studies in this field have found toxoplasmosis screenings during pregnancy cost-saving when compared with the cost burden of the disease. For this reason, it is thought that it would be beneficial to make more studies about maternal and congenital toxoplasmosis and implement screening programs in other countries.

### \*Ethics

**Ethics Committee Approval:** Ethical approval and informed consent are not required because neither humans nor animals are included in the study.

**Informed Consent:** Ethical approval and informed consent are not required because neither humans nor animals are included in the study.

### \*Authorship Contributions

Surgical and Medical Practices: M.B., Ö.U.B., Concept: M.B., Ö.U.B., Design: M.B., Ö.U.B., Data Collection or Processing: M.B., Analysis or Interpretation: Ö.U.B., Literature Search: M.B., Ö.U.B., Writing: M.B., Ö.U.B.

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

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