IntroductIon

Toxoplasmosis is an infection caused by Toxoplasma gondii, a parasite infecting almost all homeothermic animals, such as humans. Toxoplasmosis is considered the most prevalent parasitic zoonotic disease worldwide.\(^1\) Approximately 35% of the world’s population has been estimated to be infected with T. gondii in their lifetime.\(^5\) In the parasite life cycle, humans can play the role of intermediate hosts. In humans, the infection usually occurs through eating raw or undercooked meat containing viable tissue cysts and drinking the water and food contaminated with feces of infected cats, moreover it can also be transmitted from the mother to the embryo.\(^3\) All felids can be the final hosts of T. gondii; infected cats excrete T. gondii oocytes through their feces.\(^6\) T. gondii infection is traditionally asymptomatic and self-limiting in immunocompetent people; however, it can cause a variety of life-threatening clinical complications in immunocompromised individuals.\(^7\)

Abstract

**Background:** Toxoplasmosis is a disease caused by Toxoplasma gondii, and one-third of the world’s population has T. gondii antibodies. Due to this issue, the aim of this study was to assess the mean prevalence and odds ratios of T. gondii infection and epidemiological features of neonatal infection worldwide.

**Materials and Methods:** We performed a meta-analysis and systematic review of published studies reporting T. gondii infection using the PubMed, MEDLINE, Web of Science, EMBASE, and Scopus electronic databases through January 1999 to December 2020, regarding diagnostic tests, and prevalence data of infection among the newborn population. The pooled prevalence of T. gondii with a 95% confidence interval (CI) was calculated using the random-effects models.

**Results:** A total of thirty eligible articles were included. The estimated global prevalence rate was 44% (95% CI: 29%–0.58%); the highest prevalence rate was in America 47% (95% CI: 30%–64%), followed by Europe 41% (95% CI: 26%–57%) and Asia 33% (95% CI: 4%–61%). In this study, despite our careful analysis of possible modifiers, the heterogeneity was significant \(P = 0.000\). The publication bias was not significant based on the results of Egger’s \(P = 0.918\) and Begg’s tests \(P = 0.230\).

**Conclusion:** Based on the results of this study, T. gondii infection can be a serious concern in newborns around the world. Therefore, further research is needed to provide better strategies to screen and diagnose T. gondii infection in neonates and determine the risk factors associated with the prevalence of infection in neonates worldwide.

Keywords: Meta-analysis, newborn, prevalence, systematic review, Toxoplasma gondii

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

How to cite this article: Akbari M, Azadi D, Habibi D, Khodashenas S, Shariatmadari F, Abedi B. Toxoplasmosis infection in newborn: A systematic review and meta-analysis. Adv Biomed Res 2022;11:75.
In pregnant women, the parasite can cross the placental barrier and infect the developing fetus, often causing miscarriage or severe abnormalities such as low birth weight, hydrocephaly, microcephaly, and retinochoroiditis, if it happens during the first and second trimesters of pregnancy.\(^{(8,9)}\) Infection in the third trimester of pregnancy is usually asymptomatic at birth, though intracranial calcification, hearing loss, and visual disturbances may occur in the later stages of life.\(^{(10)}\) Factors influencing the transmission of toxoplasmosis infection from mother to infant during pregnancy include the time of transmission during pregnancy, immunological status of mother, fetal age, and the pathogenicity level of parasites transmitted to the fetus.\(^{(11)}\) Therefore, the chance of exposure of fetus to Toxoplasma parasites depends on the socioeconomic, cultural, and health conditions.\(^{(12)}\) Toxoplasmosis infection in fetuses can be classified into acute and chronic forms. The parasite during the first and second trimesters of pregnancy can lead to severe symptoms, such as intracranial calcifications, abortion, low birth weight, hydrocephaly, and retinochoroiditis, which are recognizable at birth. In contrast, fetus infected in the third trimester of pregnancy does not show any symptoms of the disease at birth, however, they may develop intracranial calcifications, visual disorders, hearing impairments, and developmental delays later in life.\(^{(13–14)}\)

The seroprevalence rates of \(T.~gondii\) infection in general population and pregnant women worldwide have been reported to be 39.3% and 41.0%, respectively.\(^{(16,17)}\) Precise estimations of the seroprevalence rate of toxoplasmosis in specific populations can help health-care organizations to control this infection and its consequences. With regard to mentioned information, the aim of the present study is to accurately estimate the prevalence of toxoplasmosis in the neonatal population worldwide.

**Materials and Methods**

**Search strategies and selection criteria**

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were used to conduct the current study.\(^{(17)}\) Five databases were searched (PubMed, MEDLINE, Web of Science, EMBASE, and Scopus) for all studies that probably contained data for \(T.~gondii\) prevalence in neonates during January 1999 to December 2020. There was no language limitation. The databases were searched utilizing the keywords including “Toxoplasma gondii,” “Toxoplasma,” “toxoplasmosis,” “epidemiology,” “prevalence,” “newborn,” “neonate,” and “incidence.”

**Inclusion and exclusion criteria**

Initially, repetitive articles were removed and then original studies and brief reports were evaluated according to the following inclusion criteria: (1) investigation of \(T.~gondii\) incidence in neonates worldwide, (2) evaluation of mothers and their infants, (3) diagnosis of toxoplasmosis by applying serological and molecular methods on the serum and cord blood, and (4) adoption of a cross-sectional design. The exclusion criteria were as follows: (1) publication in languages other than English or Persian, (2) inclusion of aborted fetuses, (3) irrelevancies, (4) lack of suitable data, and (5) review articles.

**Study selection and data extraction**

The review was authored by three independent authors. It includes studies which have been listed in the EndNote software (EndNote X9, Thomson Reuters, Boston, Massachusetts, USA) and screened based on the title, abstract, and full text. Finally, the search strategy results and the screening section briefly are shown in Figure 1.

**Data extraction**

The data from thirty selected articles were imported to Excel software. The extracted variables included the name of the first author, the publication date, the country where the investigation has been done, the study design, sample type, number of samples, prevalence rate, and the conducted study methods.

**Assessment of study quality**

We evaluated the quality of included observational studies with the Newcastle–Ottawa Quality Assessment Scale.\(^{(18)}\) The quality of each study was graded either low (0–3) or high (7–9) level based on three subscales: (1) selection, (2) comparability, and (3) outcome (for cohort studies) or exposure (for casecontrol studies). Studies that scored ≥7 were defined as high quality.\(^{(19)}\) The inter-rater agreement for each subscale was reasonably good (intraclase correlation coefficient valued between 0.75 and 0.93).\(^{(20)}\)

**Meta-analysis approach**

Meta-analysis was carried out using Stata software version 14 (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX, USA). Substantial heterogeneity was expected and considered the nature of the study. Heterogeneity was assessed by the Cochrane \(Q\)-test and \(I^2\) index among studies. When the heterogeneity was not significant \((P < 50\%\), a fixed-effects model was applied in all of the analyses; otherwise, a random-effects model was used. Publication bias was evaluated by Egger’s and Begg’s tests at a significance level of 0.05. Forest plot showed the prevalence in each study and the pooled prevalence with a confidence interval (CI) of 95\%. The size of each box indicated the weight of the study, and each horizontal line defined the reported 95\% CI. The subgroup analysis and meta-regression test were conducted according to continent, sample size, and the year in which the study has been carried out.

**Results**

**Search results**

A total of 1290 articles were collected. The duplicates were removed prior to examination of article titles and abstracts. Finally, after review of the titles and abstracts, 30 (606,648 cases) articles were selected to be included in this systematic review and meta-analysis study [Figure 1]. The main characteristics in the results of literature searches are revealed in Table 1.
The total sample size was 606,648. The largest sample size belonged to Schmidt et al. (262,912),[31] Vasconcelos-Santos et al. (146,307),[37] and Paraguassú-Chaves et al. (114,793).[47] The smallest sample size belonged to Marangoni (n = 18),

| Table 1: The included studies for the prevalence of neonatal toxoplasmosis |
|---------------------------------------------------------------|
| **First author name** | **Country** | **Year** | **Sample size** | **Sample** | **Study design** | **Prevalence (%)** | **Methods** | **Reference** |
|------------------------|-------------|----------|-----------------|------------|-----------------|-------------------|-------------|--------------|
| Paul                   | Denmark     | 2000     | 27,516          | Serum      | C               | 61.8              | ELISA       | [21]         |
| Neto                   | Brazil      | 2000     | 47              | Serum      | C               | 17                | EIA-FEIA    | [22]         |
| Kwofie                 | Ghana       | 2016     | 106             | Serum      | C               | 57.5              | PCR/ELISA   | [23]         |
| Pinon                  | France      | 2001     | 50              | Serum      | C               | 70                | PCR         | [24]         |
| Paul                   | Denmark     | 2001     | 19              | Serum      | C               | 43.7              | ELISA       | [25]         |
| Rilling                | German      | 2003     | 175             | Serum      | C               | 52                | PCR         | [26]         |
| Sáfadi                 | Brazil      | 2003     | 43              | Serum      | C               | 88                | ELISA       | [27]         |
| Carvalheiro            | Brazil      | 2005     | 15,162          | Serum      | C               | 38.5              | PCR         | [28]         |
| Gallego-Marín          | Colombia    | 2005     | 200             | Serum      | C               | 45.4              | PCR/ELISA   | [29]         |
| Mehbod                 | Iran        | 2005     | 210             | Serum      | C               | 5.6               | ELISA       | [30]         |
| Schmidt                | Denmark     | 2006     | 262,912         | Serum      | C               | 14.9              | PCR         | [31]         |
| Gilbert                | London      | 2006     | 10,000          | Serum      | C               | 25                | PCR         | [32]         |
| Garas                  | London      | 2007     | 225             | Serum      | C               | 41                | ELISA       | [33]         |
| Guerina                | England     | 1994     | 100             | Serum      | C               | 40                | ELISA       | [34]         |
| Pinon                  | France      | 1996     | 103             | Serum      | C               | 80                | ELISA       | [35]         |
| Bessières              | France      | 2009     | 57              | Serum      | C               | 24                | PCR         | [36]         |
| Vasconcelos-Santos     | Brazil      | 2009     | 146,307         | Serum      | C               | 50                | ELISA       | [37]         |
| Röser                  | Denmark     | 2010     | 100             | Serum      | C               | 41                | PCR         | [38]         |
| Gómez-Marín            | Colombia    | 2011     | 15,333          | Serum      | C               | 51.7              | ELISA       | [39]         |
| Faucher                | France      | 2012     | 127             | Amniotic fluid | C | 18.9 | PCR | [40] |
| Lopes-Mori             | Brazil      | 2013     | 31              | Serum      | C               | 58.3              | ELISA       | [41]         |
| Noorbaksh              | Iran        | 2013     | 270             | Serum      | C               | 50                | ELISA       | [42]         |
| Marangoni              | Italy       | 2014     | 18              | Serum      | C               | 26.8              | PCR         | [43]         |
| Gontijo da Silva       | Brazil      | 2015     | 487             | Serum      | C               | 63                | PCR/ELISA   | [44]         |
| Rasti                  | Iran        | 2015     | 798             | Serum      | C               | 42.7              | PCR/ELISA   | [45]         |
| Contopoulos-Ioannidis  | California  | 2015     | 233             | Serum      | C               | 36                | ELISA       | [46]         |
| Paraguassú-Chaves      | Brazil      | 2019     | 114,793         | Serum      | C               | 90                | PCR/ELISA   | [47]         |
| Bischoff               | Brazil      | 2016     | 10,000          | Serum      | C               | 14.3              | ELISA       | [48]         |
| Carral                 | Argentina   | 2018     | 67              | Serum      | C               | 18.3              | PCR         | [49]         |
| Storchiolo             | Brazil      | 2019     | 11,59         | Serum      | C               | 43.9              | PCR/ELISA   | [50]         |

C: Cohort, PCR: Polymerase chain reaction, ELISA: Enzyme-linked immunosorbent assay, FEIA: Fluorometric enzyme immunoassay.
Paul (n = 19), and Capobiango (n = 31). In addition, the highest and lowest prevalence rates of *T. gondii* were observed in studies conducted by Paraguassú-Chaves *et al.* as 90% (95% CI: 90%–90%) and Mehbod *et al.* as 6% (95% CI: 2%–9%).

**Prevalence of neonatal toxoplasmosis**

The result of the *Q*-test (Chi-squared = 4.6e+ 0.5, df = 29, *P* = 0.0001) and *F* index (*F* = 100%) presented that the prevalence of neonatal toxoplasmosis is strongly heterogeneous among thirty studies. Therefore, the random-effects models were used to estimate the prevalence. The total prevalence of toxoplasmosis in neonates was 44% (95% CI: 29%–0.58%) [Figure 2]. Furthermore, the results of the subgroups revealed that the pooled prevalence is different among the continents [Figure 3], and the highest prevalence rates are in America with the prevalence of 47% (95% CI: 30%–64%), followed by Europe with the prevalence of 41% (95% CI: 26%–57%) and Asia with the prevalence of 33% (95% CI: 4%–61%). The meta-analysis revealed that the prevalence of neonatal toxoplasmosis decreases in coordination with sample size and the publication year of articles, but they were not significant [Table 2].

**Publication bias**

Publication bias was assessed using Egger’s (*P* = 0.918) and Begg’s tests (*P* = 0.230). No publication bias was observed.

**Discussion**

*T. gondii* is one of the most common infectious agents worldwide that can be transmitted from mothers to their newborn and cause congenital toxoplasmosis. Therefore, adequate knowledge about epidemiology and incidence of toxoplasmosis in neonates in different parts of the world is essential for effective control and prevention of this infection and its related complications in an infected mother and her child. Due to this issue, we designed this systematic review and meta-analysis to assess the pooled prevalence of this infection in newborns across the world.

The prevalence of toxoplasmosis in different parts of the world relies on different climatic conditions, cats’ population, and local lifestyles. In this study, a meta-analysis was performed including 30 articles (606,648 cases) which were found as a result of searching from 5 databases. According to the results of the search, the prevalence of toxoplasmosis ranged from 5.6% to 88%.

We explain the prevalence of toxoplasmosis infection due to continental segregation below:

**America**

The lowest and highest prevalence rates of toxoplasmosis were observed in the United States and Brazil, respectively. Neto *et al.*, in 2000, reported the lowest prevalence of newborn toxoplasmosis in Brazil over a 3-year period. They found...
that out of every 3000 live births, one infant has the parasitic infection; in this investigation, out of 140,914 samples, 66,320 (47%) had come from the state of Rio Grande do Sul, and 74,684 (53%) had come from the rest of the country.\[22\] The clinical symptoms of the patients included in the study were as follow: two infants with intracranial calcification, four infants with retinal ulcers, one infant with intracranial calcification and retinal ulcers, and one infant with hepatosplenomegaly and lymphadenopathy. Overall, in this investigation, the reported prevalence of toxoplasmosis was 17\%\[22\].

Paraguassú-Chaves et al., in 2008 in the USA, reported the highest prevalence (91\%) of toxoplasmosis in a study performed with the aim of clinical presentation and follow-up of patients with congenital toxoplasmosis. Due to the fact that Amazon is a region with a hot and humid climate, the production of parasite eggs is higher, and therefore, the prevalence of toxoplasmosis infection in this region is higher in comparison to the other regions.\[51\]

In the study of Paraguassú-Chaves et al., in 2019, the number of live births was 114,793, a total of 126 children out of 102,963 screened children with congenital toxoplasmosis were treated and followed up.\[47\]

Another study in 2011 by Gomez Marin found that 51.7\% of infants were confirmed by toxoplasmosis by Western blotting and retesting, of which 0.39\% by IgM-specific parasites were considered infected.\[39\]

### Asia

The lowest prevalence of newborn toxoplasmosis in Asia was in Iran. According to the study of Mehbod et al., with the aim

### Figure 3: Forest plot of the prevalence of neonatal toxoplasmosis according to the continent

### Table 2: Result of meta-regression, the effect of sample size, and year on the prevalence of neonatal toxoplasmosis

| Coefficient | SE    | t     | P>|t|  | Lower | Upper         |
|-------------|-------|-------|-------|-------|----------------|
| Year        | −0.0030501 | 0.0060553 | −0.50 | 0.619  | −0.0154745 | 0.0093743 |
| Sample size | −1.20e-07   | 7.31e-07   | 0.16  | 0.871  | −1.62e-06 | 1.38e-06 |
| Cons        | 6.565077     | 12.16182    | 0.54  | 0.594  | −18.38891 | 31.51906 |

SE: Standard error
of investigating the seroepidemiology of toxoplasmosis in newborns, the prevalence of toxoplasmosis was reported to be 5.6% in Iran. A 2013 study by Noorbakhsh et al. found that 50% of IgM-positive infants had eye problems and 50% had neurological problems, of which 1.5% were positive for toxoplasmosis. Timely treatment of this parasite is considered a medical measure.[22]

Europe
In a study conducted by Schmidt et al., with a screening program for congenital toxoplasmosis in Denmark, 14.9% of eye lesions were detected by screening, which according to the findings, despite early treatment, may also be healthy. The lesion is more common in people with immunodeficiency.[31]
In another study performed by Pinon et al., with the aim of the early diagnosis of toxoplasmosis in newborns, the result revealed that during the 1st month of life (newborn period), the prevalence of toxoplasmosis is 70%–81%.[24]

Africa
The study, which was conducted to determine the risk of transmitting toxoplasmosis from mother to infant, found that of the 106 samples, the prevalence of toxoplasmosis was 57.5% in infants born from mothers with toxoplasmosis. According to this study, the presence of tissue cysts carries the risk of congenital transmission due to reactivation. So that with the release of bradyzoite in the bloodstream, it is transformed into tachyzoite and transferred.[27]

Conclusion
The results of our study showed that the toxoplasmosis infection has high prevalence worldwide; this high prevalence of toxoplasmosis in the world, if not diagnosed in time, can affect the growth and development of the child in the future, which can disrupt the various functions of the child, such as intelligence, physical, and psychological. However, the prevalence rate of this disease based on geographical area, socioeconomic condition, and lifestyle varies. Furthermore, different diagnostic methods such as enzyme-linked immunosorbent assay and polymerase chain reaction tests and laboratory diagnosis of IgG and IgM can measure the incidence of this parasitic infection in different people, particularly newborns, and by early detection of the disease and appropriate treatment, complications of toxoplasmosis infection can be prevented.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References
1. Pappas G, Roussos N, Falagas ME. Toxoplasmosis snapshots: Global status of Toxoplasma gondii seroprevalence and implications for pregnancy and congenital toxoplasmosis. Int J Parasitol 2009;39:1385-94.
2. Gelaye W, Kebede T, Haïlu A. High prevalence of anti-toxoplasma antibodies and absence of Toxoplasma gondii infection risk factors among pregnant women attending routine antenatal care in two Hospitals of Addis Ababa, Ethiopia. Int J Infect Dis 2015;34:41-5.
3. Kahan Y, Avidar M, Gottesman BS, Riklis I, Dveyrin Z, Dalal I, et al. Characterization of congenital toxoplasmosis in Israel: A 17-year Nationwide Study Experience. Pediatr Infect Dis J 2020;39:553-9.
4. Cortina-Borja M, Tan HK, Wailoo M, Paul M, Prusa A, Buffolano W, et al. Prenatal treatment for serious neurological sequelae of congenital toxoplasmosis: An observational prospective cohort study. PLoS Med 2010;7:e1000351.
5. Soares JA, Carvalho SF, Caldeira AP. Profile of pregnant women and children treated at a reference center for congenital toxoplasmosis in the northern state of Minas Gerais, Brazil. Rev Soc Bras Med Trop 2012;45:55-9.
6. Abbas M, Nasir A, Kashif M, Hussain K, Bano N, Raza MA, et al. Serodiagnosis of Toxoplasma gondii, associated risk factors in domesticated cats: Preventing zoonosis in humans and implications for livestock extension. Int J Agric Ext 2021;9:13-8.
7. Ahmadpour E, Daryani A, Shariif M, Sarvii S, Aarabi M, Mizani A, et al. Toxoplasmosis in immunocompromised patients in Iran: A systematic review and meta-analysis. J Infect Dev Count 2020;10:e0003525.
8. Song KJ, Shin JC, Shin HJ, Nam HW. Seroprevalence of toxoplasmosis in Korean pregnant women. Korean J Parasitol 2005;43:69.
9. Jasim RA, Salih TA, Al-Kubaisi S. Non enzymatic method to isolation Toxoplasma gondii from placental tissue and effect on lipid peroxidation in pregnant women in Al-Ramadi City. Ann Romanian Soc Cell Biol 2021:28:11859-65.
10. Jung SY, Kim BG, Kwon D, Park JH, Youn SK, Jeon S, et al. An outbreak of joint and cutaneous infections caused by non-tuberculous mycobacteria after corticosteroid injection. Int J Infect Dis 2015;36:62-9.
11. Sarvi S, Chegeni TN, Shariif M, Montazeri M, Hosseini SA, Amouei A, et al. Congenital toxoplasmosis among Iranian neonates: A systematic review and meta-analysis. Epidemiol Health 2019;41:1-9.
12. de Melo Inagaki AD, Carvalheiro CG, Cipolotti R, Gurgel RQ, Rocha DA, Pinheiro KS, et al. Birth prevalence and characteristics of congenital toxoplasmosis in Sergipe, North-East Brazil. Trop Med Int Health 2012;17:1349-55.
13. Shieh M, Didehdar M, Hajhossein R, Ahmadi F, Eslamirad Z. Toxoplasmosis: Seroprevalence in pregnant women, and serological and molecular screening in neonatal umbilical cord blood. Acta Trop 2017;174:38-44.
14. Chaudhry SA, Gad N, Koren G. Toxoplasmosis and pregnancy. Can Fam Physician 2014;60:334-6.
15. Arora N, Sadovsky Y, Dermody TS, Coyne CB. Microbial vertical transmission during human pregnancy. Cell Host Microbe 2017;21:561-7.
16. Murat JB, Dard C, Hidalgo HF, Dardé ML, Brenier-Pinchart MP, Pelloux H. Comparison of the Vidas system and two recent fully automated assays for diagnosis and follow-up of toxoplasmosis in pregnant women and newborns. Clin Vaccine Immunol 2013;20:1203-12.
17. Ngoougou EB, Bialla D, Nzoghe A, Dardé ML, Preux PM. Toxoplasmosis and epilepsy – systematic review and meta-analysis. PLoS Negl Trop Dis 2015;9:e0003525.
18. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol 2010;25:603-5.
19. Zhong X, Guo L, Zhang L, Li Y, He R, Cheng G. Inflammatory potential of diet and risk of cardiovascular disease or mortality: A meta-analysis. Sci Rep 2017;7:1-6.
20. Cicchetti DV. Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. Psychol Assess 1994;6:284.
21. Paul M, Petersen E, Pavloowski ZS, Szczupa J. Neonatal screening for congenital toxoplasmosis in the Poznań region of Poland by analysis of Toxoplasma gondii-specific IgM antibodies eluted from filter paper blood spots. Pediatr Infect Dis J 2000;19:30-6.
22. Neto EC, Anele E, Rubim R, Brites A, Schulte J, Becker D, et al. High prevalence of congenital toxoplasmosis in Brazil estimated in a 3-year prospective neonatal screening study. Int J Epidemiol 2000;29:941-7.
23. Kwofie KD, Ghansah A, Osei JH, Frempong KK, Obad S, Frimpong EH, et al. Indication of risk of mother-to-child Toxoplasma gondii transmission in the Greater Accra Region of Ghana. Maternal Child Health J 2016;20:2581-8.

24. Pinon JM, Dumon H, Chemla C, Franck J, Petersen E, Lebech M, et al. Strategy for diagnosis of congenital toxoplasmosis: Evaluation of methods comparing mothers and newborns and standard methods for postnatal detection of immunoglobulin G, M, and A antibodies. J Clin Microbiol 2001;39:2267-71.

25. Paul M, Petersen E, Szczapa J. Prevalence of congenital Toxoplasma gondii infection among newborns from the Poznan region of Poland: Validation of a new combined enzyme immunoassay for Toxoplasma gondii-specific immunoglobulin A and immunoglobulin M antibodies. J Clin Microbiol 2001;39:1912-6.

26. Rilling V, Dietz K, Krczal D, Knocket F, Enders G. Evaluation of a commercial IgG/IgM Western blot assay for early postnatal diagnosis of congenital toxoplasmosis. Eur J Clin Microbiol Infect Dis 2003;22:174-80.

27. Sáfadi MA, Berezin EN, Farhat CK, Carvalho ES. Clinical presentation and follow up of children with congenital toxoplasmosis in Brazil. Braz J Infect Dis 2003;7:325-31.

28. Carvalheiro CG, Mussi-Pinhata MM, Yamamoto AY, De Souza CB, Maciel LM. Incidence of congenital toxoplasmosis estimated by neonatal screening: Relevance of diagnostic confirmation in asymptomatic newborn infants. Epidemiol Infect 2005;133:485-91.

29. Gallego-Marin C, Henao AC, Gomez-Marin JE. Clinical validation of a western blot assay for congenital toxoplasmosis and newborn screening in a hospital in Armenia (Quindio) Colombia. J Trop Pediatr 2005;52:107-12.

30. Mehbod S, Shad DM, Ghorban K, Karami M. Seroepidemiology assay immunological profiles and anti-Toxoplasma gondii infection among pregnant women and vertical transmission of toxoplasmosis in pregnant women and associated risk factors. Braz J Infect Dis 2013;17:405-9.

31. Schmidt DR, Hogh B, Anderson O, Fuchs J, Fledelius H, Petersen E. The prevalence of congenital toxoplasmosis: Feasible, but benefits are not established. Arch Dis Child 2006;91:629-31.

32. Faucher B, Garcia-Meric P, Franck J, Minodier P, Francois P, Gonnet S, et al. Long-term oculat outcome in congenital toxoplasmosis: A prospective cohort of treated children. J Infect Dis 2012;64:104-9.

33. Gómez-Marin JE, De-La-Torre A, Angel-Muller E, Rubio J, Arenas J, Osorio E, et al. First Colombian multicentric newborn screening for congenital toxoplasmosis. PLoS Negl Trop Dis 2011;5:e1195.

34. Carvalheiro CG, Mussi-Pinhata MM, Yamamoto AY, De Souza CB, Maciel LM. Incidence of congenital toxoplasmosis estimated by neonatal screening: Relevance of diagnostic confirmation in asymptomatic newborn infants. Epidemiol Infect 2005;133:485-91.

35. Pinon JM, Dumon H, Chemla C, Franck J, Petersen E, Lebech M, et al. Strategy for diagnosis of congenital toxoplasmosis: Evaluation of methods comparing mothers and newborns and standard methods for postnatal detection of immunoglobulin G, M, and A antibodies. J Clin Microbiol 2001;39:2267-71.

36. Bessières MH, Berrebi A, Cassaing S, Fillaux J, Cambus JP, Berry A, et al. Diagnosis of congenital toxoplasmosis: Prenatal and neonatal evaluation of methods used in Toulouse University Hospital and incidence of congenital toxoplasmosis. Mem Inst Oswaldo Cruz 2009;104:389-92.

37. Vasconcelos-Santos DV, Azevedo DO, Campos WR, Oréfice F, Queiroz-Andrade GM, Carellos EV, et al. Congenital toxoplasmosis in southeastern Brazil: Results of early ophthalmologic examination of a large cohort of neonates. Ophthalmology 2009;116:2199-205.e1.

38. Röser D, Nielsen HV, Petersen E, Saugmann-Jensen P, Norgaard-Pedersen PB. Congenital toxoplasmosis – A report on the Danish neonatal screening programme 1999–2007. J Inherit Metab Dis 2010;33:241-7.

39. Gómez-Marin JE, De-La-Torre A, Angel-Muller E, Rubio J, Arenas J, Osorio E, et al. First Colombian multicentric newborn screening for congenital toxoplasmosis. PLoS Negl Trop Dis 2011;5:e1195.

40. Faucher B, Garcia-Meric P, Franck J, Minodier P, Francois P, Gonnet S, et al. Long-term oculat outcome in congenital toxoplasmosis: A prospective cohort of treated children. J Infect Dis 2012;64:104-9.

41. Lopes-Mori FMR, Mitsuka-Bregano R, Bittencourt LH, Dias RC, Gonçalves DD, Capobiango JD, et al. Gestational toxoplasmosis in Paraná State, Brazil: Prevalence of IgG antibodies and associated risk factors. Braz J Infect Dis 2013;17:405-9.

42. Noorbakhsh S, Kalani M, Aliakbari AM, Tabatabaei A, Ehsanpour F, Taghipour R, et al. Prevalence of congenital toxoplasmosis in two university hospitals: A brief report. Tehran Univ Med J 2013;71:410-4.

43. Marangoni A, Capretti MG, De Angelis M, Nardini P, Compri M, Foschi C, et al. Evaluation of a new protocol for retrospective diagnosis of congenital toxoplasmosis by use of Guthrie cards. J Clin Microbiol 2014;52:2963-70.

44. Gontijo da Silva M, Clare Vinaud M, de Castro AM. Prevalence of toxoplasmosis in pregnant women and vertical transmission of Toxoplasma gondii in patients from basic units of health from Gurupi, Tocantins, Brazil, from 2012 to 2014. PLoS One 2015;10:e0141700.

45. Rasti S, Hooshyar H, Arbabi M, Fatahian A, Behrashi M, Talebian A, et al. Frequency of Toxoplasma infection among pregnant women and their newborn in Kashan, Iran. Zahedan J Res Med Sci 2015;3:6-12.

46. Contopoulos-Ioannidis D, Wheeler KM, Ramirez R, Press C, Mui E, Zhou Y, et al. Clustering of Toxoplasma gondii infections within families of congenitally infected infants. Clin Infect Dis 2015;61:1815-24.

47. Paraguassu-Chaves CA, Dantas LR, de Almeida FM, Serruta AJ, Soares JM, Xavier DF. Incidence of congenital toxoplasmosis in newborn infant in the western Amazon, Brazil. Int J Adv Eng Res Sci 2019;6:659-70.

48. Bischoff AR, Friedrich L, Cattan JM, de Freitas Uberti FA. Incidence of symptomatic congenital toxoplasmosis during ten years in a Brazilian hospital. Pediatr Infect Dis J 2016;35:1313-6.

49. Carral L, Kaufer F, Pardini L, Durlach R, More G, Venturini MC, et al. Neural toxoplasmosis. PLoS Negl Trop Dis 2011;5:e1195.

50. Zhou Y, et al. Clustering of Toxoplasma gondii infections within families of congenitally infected infants. Clin Infect Dis 2015;61:1815-24.

51. Paraguassu-Chaves CA, Dantas LR, de Almeida FM, Leite JM, da Luz Neto LS, Calderaro IF, et al. Incidence of congenital toxoplasmosis in newborn infant in the western Amazon, Brazil. Int J Adv Sci Eng Inf Technol 2019;6:659-70.