Research Article

Serological Prevalence of Toxoplasmosis in Pregnant Women in Brazilian Federal District and its Possible Association with Sanitation Conditions

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Abstract

Introduction: Toxoplasma infects up to a third of the world's population and the infection can be dangerous to the fetus during pregnancy. In the congenital form, the sequelae in the fetus can be severe and irreversible. Some babies infected with the parasite can be born without complications but present neurological changes during the first year of life, in childhood or even in adulthood. On the other hand, basic sanitation has been considered an important environmental determinant of health. Some studies observed that aspects associated with urban cleaning services and personal hygiene are important factors in the dissemination of toxoplasmosis.

Objective: This study aims to analyze the prevalence of seropositivity for toxoplasmosis in pregnant women screened by the Pregnant Women Protection Program (PWPP) in the Federal District of Brazil between years 2017 to 2020 and its possible association with data related to the infrastructure available for basic sanitation services that households and the urban population of the Federal District have.

Materials and Methods: This is a retrospective study that included a historical series of 127,866 pregnant women screened by the PWPP during prenatal care in the Federal District of Brazil between years 2017 to 2020. The Sanitation Ranking prepared by the Institute Trata Brazil was used, considering the data from the SNIS (National Sanitation Information System - Ministry of Regional Development, Brazil). Sanitation data of Brasília, Federal District, was provided by CODEPLAN (Federal District Planning Company) and "Companhia de Saneamento Ambiental do Distrito Federal - CAESB".

Results: Of the 127,866 patients examined, 48,534 were positive, resulting in an overall prevalence of 38,06% in pregnant women. Analysis of prevalence over time indicate a drop over the years, starting in 2017 with 41,93% to 35,15% in 2020. The prevalence of positive cases grouped by regional health and sewage treatment plants indicated a significant effect for each sewage treatment plant between the years 2017 and the others and between the years 2018 and 2020. That is, a decrease in the prevalence of positive cases from 2017 and 2020. Regarding health region (SRS), there were differences between SRS/Central and SRS/West and SRS/West and SRS/South. The data indicate a lower prevalence of cases in the Central and South SRS, and a higher prevalence in the SRS/West. On the other hand, data on sanitation indicate that the West SRS region present the lowest levels while the Central SRS and South SRS regions present good indices.

Conclusions: Take together, our results showed, over time, a significant drop in the prevalence from 2017 to 2020 that may be due to the implementation of the PWPP in the current molds, based on public

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policies to protect pregnant women and newborns. Data on sanitation and health conditions indicate the highest prevalence of pregnant women infected by toxoplasmosis in the Western SRS region, and a lower prevalence of cases in the central SRS and southern SRS regions of the Federal District. Poor sanitation situation is observed in Western SRS region, while good sanitation conditions are observed in the central SRS and southern SRS regions. Therefore, it seems plausible to suggest, in this case, a relationship between sanitary conditions and the prevalence of seropositivity for toxoplasmosis in pregnant women screened by the Pregnant Women Protection Program (PWPP) in the Federal District of Brazil.

Keywords: Environmental Conditions; Prevalence; Pregnancy; Sanitation; Toxoplasmose; Seropositivity

Introduction

The *protozoan Toxoplasma gondii* is found worldwide. Felines are the only definitive host, while other warm-blooded animals, including humans, are intermediate hosts for the parasite [1–3]. Toxoplasma infects up to a third of the world's population and the infection can be fatal to the fetus during pregnancy and in immunocompromised individuals. The main routes of transmission to humans are ingestion of contaminated raw or undercooked meat, contaminated unpasteurized milk, food, or water with oocysts from cat feces, or vertical transmission via transplacental tachyzoites [2, 5-7]. Beef and lamb are known to be the most common sources of food-related T. gondii infections [2]. Injuries with sharp perforations, blood transfusions and organ transplants are also possible risk factors for infection [4]. The disease is asymptomatic in most patients. However, in the congenital form, the sequelae in the fetus can be severe and irreversible. Some babies infected with the parasite in an intrauterine form can be born without complications but present changes during the first year of life, in childhood or even in adulthood. Among the clinical evidence, the following stand out: brain calcifications, chorioretinitis, blindness, delayed neuropsychomotor development, microcephaly, hydrocephalus, bulging fontanelle, meningoencephalitis, strabismus, hepatosplenomegaly, rash, petechiae, jaundice and pneumonia [8-12]. The WHO (World Health Organization) estimates that more than half of the world's population is infected, however, most individuals are asymptomatic and do not develop the disease [17]. The prevalence of infection can vary for each country, depending on its social and economic determinants [19, 24, 25]. In Brazil, the prevalence indicators for antibodies to toxoplasmosis vary widely, from 54% to 80%, with an equal distribution in both sexes, seroprevalence that increases with age and depends on different factors that influence its epidemiology. [18-20, 24, 25]. During prenatal diagnosis,

serological screening can be performed, enabling the identification of patients susceptible to primary prevention. It also allows the detection of acute *T. gondii* infection and guides treatment to reduce the likelihood of fetal transmission, which is close to 40% in untreated women. The incidence of fetal infection is higher when the disease is acquired in the third trimester of pregnancy compared to the first trimester, but the severity of the involvement is greater when the maternal infection occurs in the first trimester [13-16]. The complications that occur during pregnancy present a serious public health problem in Brazil and worldwide. However, as mitigating factors, there are several support programs developed by the various spheres of health care, which aim to reduce the rate of morbidity and mortality. One of these is the Pregnant Women Protection Program (PWPP), also known as the Mommy Test or Prenatal Screening, which is carried out at the health unit where the pregnant woman is registered, with the main objectives of preventing, diagnosing, and guiding on several types of illnesses during pregnancy, reducing the risk of mortality and sequelae for mothers and their babies. [21, 22]. Recently, we reported [25] a global prevalence of 53.21% for toxoplasmosis in pregnant women screened by the PWPP in the Federal District of Brazil between the years 2014 to 2018. This result is in accordance with global and national data, since the World Health Organization (WHO) estimates that more than half of the world population is infected, this prevalence being conditioned to the social and economic determinants that differentiate countries [19, 24, 26]. On the other hand, basic sanitation has been considered an important environmental determinant of health. Mainly related to the services of drinking water availability, solid waste management, sanitation problems are aggravated by the unplanned growth of urban centres, affecting an important part of the total disease burden in the world. The World Health Organization (WHO, 2017) points out that the lack of sanitation is linked to the transmission of diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid and polio and exacerbates short stature; and is an important factor in several neglected tropical diseases, including intestinal worms, schistosomiasis and trachoma. The lack of sanitation is a problem commonly referred to in Brazil and contributes to the emergence of morbidities and even fatalities in our country, especially diseases associated with poverty such as intestinal parasites [29]. Basic sanitation, in addition to a sanitary and public health issue, is a matter related to the urbanization of social spaces. Brazilian cities have been subject to unbridled growth and without planning, which implies a series of deficiencies and demands public policies that conform to the forms of construction of cities arising from the urban expansion process. Basic sanitation has been considered an important environmental determinant of health. Mainly related to the services of drinking water availability, sanitation and solid waste management, sanitation problems are aggravated by

the unplanned growth of urban centres, currently affecting an important part of the total disease burden in the world. The situation of sanitation in the capital of Brazil, Brasília – DF, can be summarized as follow. Although the Federal District was a city designed under modern standards, the fact that it has accelerated growth, going from almost no population to more than 2.5 million (IBGE, 2010) in less than 50 years, has extrapolated population forecasts. This caused, in addition to invasions and uncontrolled urbanization in several areas, enormous social inequalities. Based on data by service providers and on the general results of the PDAD (DF, 2013), carried out by CODEPLAN, which covered the 31 Administrative Regions and 7 Health Regions, regarding data related to the infrastructure available for basic sanitation services that households and the urban population of the Federal District have, the high percentage of households served by the services stands out. The coverage of water supply in DF, by general network, is 97.82%. Virtually all households have an urban garbage collection service. With a lower percentage, but still considered high in terms of care, 85.95% of households have a general sewage network with treatment. Regarding solid waste, there is currently a great concern with some areas, because environmental impacts caused by the inadequate disposal of waste, potentiate alterations in the quality of the soil, air, and surface and groundwater, with effects on the environment fauna and flora, and on public health (disease proliferation). The problem of urban households having the rainwater network infrastructure is that an inefficient rainwater drainage system can cause flooding and the superficial transport of waste, thus contributing to the proliferation of diseases. Another aspect is that there is no rain network, the population erroneously releases rainwater into the sewer pipe, causing serious risks of clogging and return of sewage to the homes. As for rain drainage, in times of rain, it is common flooding that can bring adverse consequences to the population. This fact can be aggravated by the drainage system if there are sizing problems related to it. Runoff waters can often be contaminated since they leach the soil and can come into direct contact with poorly managed solid waste and irregular sewage system networks. That is, these conditions can drag oocysts and contaminate people, as for example in the case of toxoplasmosis. The Federal District occupied the 1st position, in 2020, in relation to the 27 Brazilian federative units according to the Municipal Human Development Index (MHDI). Besides, the Federal District stands out with respect to economic aspects, as it has the highest Human Development Index (HDI) in the country. However, it is important to note that there is a great socioeconomic inequality between the inhabitants. Another negative aspect is the disorderly urban expansion. One of the biggest problems found in the Federal District is the disorderly occupation of land, that is, non-regularized households. Thus, the parameters of land use and occupation are essential factors for adequate management for sustainable development. These problems were intensified by the lack of implementation and planning of basic sanitation services that includes the collection, treatment and destination for the sanitary sewage system, stormwater drainage and management, and solid waste management in an integrated manner, thus preventing degradation of water courses caused mainly by pollution and erosion with silting of the bed of water courses, one of the main socioenvironmental problems today. The diagnosis of the population's health situation addresses the perspective of basic sanitation and the integrated management of solid waste as a promotion and prevention of diseases. Some studies observed that aspects associated with urban cleaning services and personal hygiene are important factors in the dissemination of toxoplasmosis. For instance, Elsheika [31] observed that age group, number of visits to foreign countries, and the habit of ingesting beverages prepared with untreated water can increase the risk of contracting toxoplasmosis. Tropical diseases continue to affect thousands of Brazilians due to poor sanitation conditions, deficient or absent sanitation compliance surveillance, inadequate health policy, poor hygiene habits, and lack of awareness of the population and health professionals. Recently we reported [32] that Brazil presents alarming data on access to basic sanitation services, with challenges to guarantee service to all and on an uninterrupted basis. Coverage by the water supply network is relatively high, although there are still about 35 million Brazilians without access to drinking water. The sewage collection and treatment service still present worrying rates, revealing the harmful potential to the environment, especially due to the contamination of water bodies, which indicate how much the country still needs to move towards universal service. Considering the devastating effects of toxoplasmosis on infected children during pregnancy and the poor sanitation conditions still observed in Brazil, particularly in Brasília, this study aims to analyze the prevalence of seropositivity for toxoplasmosis in pregnant women screened by the Pregnant Women Protection Program (PWPP) in the Federal District of Brazil between years 2017 to 2020 and its possible association with data related to the infrastructure available for basic sanitation services that households and the urban population of the Federal District have. Our hypothesis is that the highest prevalence of toxoplasmosis is found in regions with lower sanitation rates.

Materials and Methods

This is a retrospective study that included a historical series of 127,866 pregnant women screened by the Pregnant Women Protection Program (PWPP) in the Federal District of Brazil between years 2017 to 2020. The PWPP was created following the model of the Humanization Program Before and after Birth implemented by the Ministry of Health of Brazil. Every woman has the right to assistance during pregnancy,

prenatal care, delivery and after delivery. In this sense, the Ministry of Health prepared the pregnant woman's handbook, which aims at a humanized and non-exclusive reception, providing the basis for the pregnant woman protection program. The safety of the patient in this extended path is something crucial, since the booklet is the document of the pregnant woman, where it contains all the information about her pregnancy, guidelines and the care that must be taken along this long-winded path [21]. The Pregnant Women Protection Program (PWPP) in the Federal District of Brazil performs 12 basic exams during prenatal care, diagnosing, among others, Chagas disease / trypanosomiasis, hepatitis B, hepatitis C, HTLV, rubella, syphilis, and toxoplasmosis. Screening tests are performed using dried blood drops stored on filter paper, a technique validated by Gómez and collaborators [22]. Blood samples of pregnant women were obtained via digital puncture with disposable lancets, collected on filter paper (S and S903) and dried at room temperature. In the laboratory, dried blood samples were eluted from the filter paper. During primary infection the body produces IgM antibody against the infectious agent, but there is no production of IgM for long periods, as there is a process of changing the antibody class that changes from IgM to IgG, that is, after a three months we have a reduction in the concentration of antibody of the IgM class, until it is no longer secreted by the plasma cells or is released in a residual form for up to one year. Consequently, the antibody changes classes, with the production of the IgG antibody (which is observable during chronic infection / exposure) and this is characterized as an immunological memory tool, being produced for life (acquired immunity). The purpose of the test is to find out if there is a recent infection or if the pregnant woman has been in contact with the parasite in the past. According to the serological profile presented by the individual, the stage of the infection (acute or chronic) can be determined. The diagnosis is based on direct and indirect methods. Commonly, the indirect method is performed in primary serological screening, being performed for both the IgG and IgM antibodies *T. gondii* using the Elisa method (immunoenzymatic assay). The exam is done at the beginning of the 1st trimester of pregnancy (IgM and IgG) [24, 25, 28, 29]. To estimate the prevalence of toxoplasmosis in pregnant women, the presence of positive IgG and / or IgM was considered.

Sanitation Data

The Sanitation Ranking prepared by the Institute Trata Brazil [32] was used as the basis for the data presented here, considering the data from the SNIS (National Sanitation Information System - Ministry of Regional Development, Brazil) [33], which were consulted for the 100 largest Brazilian municipalities in terms of inhabitants in 2020. The database gathers information from state, regional and municipal service providers for access to water, sewage collection and treatment, and solid waste. The information computed by the SNIS is self-declared, that is, it is presented by the service providers themselves. Sanitation data of Brasília, Federal District, was provided by CODEPLAN (Federal District Planning Company) and "Companhia de Saneamento Ambiental do Distrito Federal - CAESB". The regulation of the management of water resources and sanitation services occurs through a single body, the "Federal District Water and Sanitation Agency - ADASA" [34]. This body is responsible for regulating, controlling, and inspecting the quality and quantity of surface water bodies in the territory of the Federal District, as well as water supply and sewage services.

Ethical Considerations

This study is a continuation of the research "Prevalence of diseases screened in the Pregnant Women Protection Program of the State of Mato Grosso do Sul between 2004 and 2007" approved by the Research Ethics Committee of CEP / UFMS (Protocol No. 1046).

Data Analysis

Initially, frequencies were calculated to identify duplications and typos. Duplicate and / or inconsistent records (0.3%) were discarded. The data were organized using Excel ™ spreadsheets and the descriptive measures were calculated using EpiInfo software version 6.4, EpiInfo 2000 version 3.2.2v, and ArcView GIS version 3.3. The coverage of pregnant women screened by PWPP in the total population was calculated using the expected rate for pregnant women according to Ordinance No. 650 of October 5, 2011, from the Ministry of Health of Brazil, where information was collected on the number of live births in each year plus 10%. Global prevalence (from 2017 to 2020) and per year was estimated; for that, we used data from pregnant women positive for toxoplasmosis divided by the total number of pregnant women screened multiplied by 100, both globally and per year, with a 95% confidence interval.

Statistical Analysis

Data were analyzed using the IBM® SPSS® Statistic 28 program (USA). All data passed the Test of Homogeneity of Variances (Levene's Test), demonstrating non-significant data ($p>0.05$) which indicated that the variances of the data were equal. Thus, the data presented were submitted to analysis of variance (ANOVA). Data were analyzed with one-way ANOVA (One-way ANOVA), since the interest of the study was to compare the variation of dependent variables, such as the number of screenings, the number of positive cases and the prevalence of cases between the years 2017 to 2020 (independent variable, year). After analysis of variance, the data were submitted to a post hoc test, the Tukey test. This test was chosen because the data had the same sample size and homogeneous variance, in addition to avoiding the occurrence of type 1 errors. All data used a significance level of $p< 0.05$.

Results

To investigate a possible spatial distribution of Toxoplasmosis in the Federal District, the data were separated and analyzed by the different health regions according to their geographic location. In this way, the data collected were distributed by the Central, Center South, Southwest, North, East, West, and South health regions. When comparing the number of screenings between different regions, there was no significant difference in the average number of screenings performed between the years 2017 to 2020, $F_{(3.24)} = 0.15$, $p > 0.05$ (Table 1).

The comparison of positive cases grouped by health region did not reveal a significant difference in the average number of positive cases recorded between the years 2017 and 2020, $F_{(3.24)} = 0.10$, $p > 0.05$ (Table 2).

When analyzing the prevalence of positive cases by health region, a significant effect was verified depending on the year analyzed, $F_{(3.24)} = 18.17$, $p < 0.01$. Post hoc comparisons using Tukey's test indicated significant differences between the year 2017 and the others and between the years 2018 and 2020. In summary, there was a decrease in the prevalence of positive cases between the years 2017 (M = 41.55 % EP = 0.72) and 2020 (M = 34.78%, EP = 0.69), $p < 0.01$ (Table 3). revalence (%) Positive Cases Grouped by Health Region.

To investigate the distribution of Toxoplasmosis according to the coverage of basic sanitation in the different regions of the Federal District, we analyzed our data grouped by the location of the Sewage Treatment Station (ETE) in the region. There was no significant difference in the average number of screenings performed between the years 2017 to 2020, $F_{(3.52)} = 0.09$, $p > 0.05$ (Table 4).

Likewise, we analyzed the number of positive cases distributed according to ETE. There was no significant difference in the mean number of positive cases recorded between the years 2017 to 2020, $F_{(3.52)} = 0.06$, $p > 0.05$ (Table 5).

Table 1: Number of Screenings Grouped by Health Region (SRS).

	2017	2018	2019	2020
SRS - CENTRAL	1.899	1.794	2.018	1.682
SRS – CENTER SOUTH	3.399	3.879	4.007	3.63
SRS - SOUTHWEST	7.554	8.021	8.862	7.986
SRS - NORTH	4.375	4.903	4.884	4.857
SRS - EAST	3.187	3.714	4.084	3.925
SRS - WEST	5.812	6.412	7.166	6.372
SRS - SOUTH	3.122	3.565	3.554	3.203
Annual	29.348	32.288	34.575	31.655
Mean (M)	4.192,57	4.612,57	4.939,29	4.522,14
Standard Error (SE)	723,79	776,55	878,35	794,20

Table 2: Positive Cases Grouped by Health Region.

	2017	2018	2019	2020
SRS - CENTRAL	729	667	715	533
SRS - CENTER SOUTH	1.463	1.496	1.445	1.274
SRS - SOUTHWEST	3.136	3.093	3.221	2.771
SRS - NORTH	1.836	1.934	1.761	1.777
SRS – EAST	1.344	1.454	1.522	1.434
SRS - WEST	2.555	2.632	2.714	2.277
SRS - SOUTH	1.242	1.204	1.245	1.06
Annual	12.305	12.48	12.623	11.126
Mean (M)	1.757,86	1.782,86	1.803,29	1.589,43
Standard Error (SE)	313,342	317,393	328,946	285,525

Table 3: Prevalence (%) Positive Cases Grouped by Health Region.

	2017	2018	2019	2020
SRS - CENTRAL	38,39%	37,18%	35,43%	31,69%
SRS – CENTER SOUTH	43,04%	38,57%	36,06%	35,10%
SRS - SOUTHWEST	41,51%	38,56%	36,35%	34,70%
SRS - NORTH	41,97%	39,45%	36,06%	36,59%
SRS - EAST	42,17%	39,15%	37,27%	36,54%
SRS - WEST	43,96%	41,05%	37,87%	35,73%
SRS - SOUTH	39,78%	33,77%	35,03%	33,09%
Annual	41,93%	38,65%	36,51%	35,15%
Mean (M)	41,55%	38,25%	36,30%	34,78%
Standard Error (SE)	0,72	0,87	0,37	0,69

Table 4: Screening Grouped by Sewage Treatment Station (ETE).

	2017	2018	2019	2020
ETE ALAGADO	3.398	3.706	4.036	3.63
ETE BRASILIA NORTE	420	514	546	458
ETE BRASILIA SUL	741	493	526	367
ETE BRAZLÂNDIA	828	911	1.093	1.047
ETE GAMA	1.584	1.767	1.721	1.564
ETE MELCHIOR	7.721	8.043	8.845	7.76
ETE PARANOÁ	1.657	2.077	2.257	2.116
ETE PLANALTINA	2.621	2.88	2.9	2.873
ETE RECANTO DAS EMAS	1.582	1.826	1.92	1.798
ETE RIACHO FUNDO	1.126	1.486	1.53	1.45
ETE SAMAMBAIA	2.723	2.978	3.353	3.001
ETE SANTA MARIA	1.538	1.798	1.833	1.639
ETE SÃO SEBASTIÃO	1.53	1.637	1.827	1.809
ETE SOBRADINHO	1.879	2.172	2.188	2.143
Annual	29.348	32.288	34.575	31.655
Mean (M)	2.096,29	2.306,29	2.469,64	2.261,07
Standard Error (SE)	483,78	503,11	555,32	487,94

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When we analyzed the prevalence of positive cases, a significant effect was found for each sewage treatment plant depending on the year analyzed, $F_{(3.55)} = 15.16$, $p<0.01$. Post hoc comparisons using the Tukey test indicated significant differences between the years 2017 and the others, and between the years 2018 and 2020. In summary, there seems to have been a decrease in the prevalence of positive cases between the years 2017 (M = 41.50% EP = 0.82) and 2020 (M = 34.77%, EP = 0.58), $p<0.01$ (Table 6).

In an attempt to evaluate the Toxoplasmosis data taking into account the health region (SRS) and the TEE covering that region, we separated the data by association between SRS and TEE (Table 7). When analyzing the number of screenings, we observed a significant effect on screenings performed depending on SRS, $F_{(6.44)} = 6.14$, $p<0.01$. Post hoc comparisons using Tukey's test indicated significant differences between SRS - Central (M = 462.06) and SRS - Southwest (M = 2026.44), SRS - Central (M = 462.06) and SRS - North (M = 2,377.38) and SRS – Central (M = 462.06) and SRS – West (M = 3,220.25), all with $p<0.01$. There was no significant effect regarding the number of screenings in relation to the year, $F_{(3.44)} = 0.22$, $p>0.05$.

Regarding the positive cases of Toxoplasmosis grouped by health region and the TEE that serve it, there was a significant effect on the number of positive cases depending on the SRS, $F_{(6.44)} = 6.51$, $p<0.01$. Post hoc comparisons using Tukey's test indicated significant differences between SRS - Central (M = 165.25) and SRS - Southwest (M = 763.81), SRS - Central (M = 165.25) and SRS - North (M = 913.50) and SRS – Central (M = 165.25) and SRS – West (M = 1,272.25),

Table 6: Prevalence (%) Positive Cases Grouped by Sewage Treatment Station (ETE).

	2017	2018	2019	2020
ETE ALAGADO	43,44%	40,18%	37,86%	35,43%
ETE BRASILIA NORTE	43,33%	38,13%	34,80%	33,84%
ETE BRASILIA SUL	33,60%	37,32%	34,98%	31,61%
ETE BRAZLÂNDIA	46,74%	45,77%	41,99%	36,20%
ETE GAMA	37,94%	32,71%	35,21%	32,99%
ETE MELCHIOR	42,79%	39,03%	36,53%	34,85%
ETE PARANOÁ	40,74%	38,76%	35,89%	35,87%
ETE PLANALTINA	41,97%	40,76%	35,21%	39,44%
ETE RECANTO DAS EMAS	42,73%	40,53%	37,92%	36,48%
ETE RIACHO FUNDO	39,70%	33,11%	31,63%	32,62%
ETE SAMAMBAIA	40,98%	39,36%	36,44%	34,49%
ETE SANTA MARIA	41,68%	34,82%	34,86%	33,19%
ETE SÃO SEBASTIÃO	43,73%	39,65%	38,97%	37,31%
ETE SOBRADINHO	41,62%	37,71%	36,97%	32,43%
Annual	41,93%	38,65%	36,51%	35,15%
Mean (M)	41,50%	38,42%	36,38%	34,77%
Standard Error (SE)	0,82	0,89	0,64	0,58

all with $p<0.01$ (Table 8). There was no significant effect in the screenings in relation to the year, $F_{(3.44)} = 0.13$, $p>0.05$.

When we analyzed the prevalence of positive cases grouped by region and ETE, a significant effect was observed for each sewage treatment plant depending on the year, $F_{(3.44)} = 23.40$, $p<0.01$ and the SRS $F_{(6.44)} = 5.25$, $p<0.01$. Post hoc comparisons using the Tukey test indicated significant differences between the years 2017 and the others and between the years 2018 and 2020. In summary, there seems to have been a decrease in the prevalence of positive cases between the years 2017 (M = 41 .93%) and 2020 (M = 35.15%), $p<0.01$. Regarding SRS, there were differences between SRS - Central (M = 38.71%) and SRS - West (M = 45.12%) and SRS - West (M = 45.12%) and SRS - South (M = 39.81%), both with $p<0.01$. These data suggest that there was a lower prevalence of cases in the Central and South SRS, and a higher prevalence in the West SRS (Table 9).

Discussion

The aim of this study was to analyze the prevalence of seropositivity for toxoplasmosis in pregnant women screened by the Pregnant Women Protection Program (PWPP) in the Federal District of Brazil between years 2017 to 2020 and its possible association with data related to the infrastructure available for basic sanitation services that households and the urban population of the Federal District have. Our hypothesis was that the highest prevalence of toxoplasmosis is found in regions with lower sanitation rates. This study analyzed the

Table 5: Positive Cases Grouped by Sewage Treatment Station (ETE).

	2017	2018	2019	2020
ETE ALAGADO	1.476	1.489	1.528	1.286
ETE BRASILIA NORTE	182	196	190	155
ETE BRASILIA SUL	249	184	184	116
ETE BRAZLÂNDIA	387	417	459	379
ETE GAMA	601	578	606	516
ETE MELCHIOR	3.304	3.139	3.231	2.704
ETE PARANOÁ	675	805	810	759
ETE PLANALTINA	1.1	1.174	1.021	1.133
ETE RECANTO DAS EMAS	676	740	728	656
ETE RIACHO FUNDO	447	492	484	473
ETE SAMAMBAIA	1.116	1.172	1.222	1.035
ETE SANTA MARIA	641	626	639	544
ETE SÃO SEBASTIÃO	669	649	712	675
ETE SOBRADINHO	782	819	809	695
Annual	12.305	12.48	12.623	11.126
Mean (M)	878,93	891,43	901,64	794,71
Standard Error (SE)	208,66	198,89	203,90	172,10

Table 7: Screenings Performed Grouped by Region and ETE.

Region	ETE	2017	2018	2019	2020
SRS - CENTRAL	ETE ALAGADO	613	638	742	698
SRS - CENTRAL	ETE BRASILIA NORTE	420	514	546	458
SRS - CENTRAL	ETE BRASILIA SUL	741	493	526	367
SRS - CENTRAL	ETE SOBRADINHO	125	149	204	159
SRS - CENTER SOUTH	ETE ALAGADO	2.273	2.393	2.477	2.18
SRS - CENTER SOUTH	ETE RIACHO FUNDO	1.126	1.486	1.53	1.45
SRS - SOUTHWEST	ETE ALAGADO	512	675	817	752
SRS - SOUTHWEST	ETE MELCHIOR	2.737	2.542	2.772	2.435
SRS - SOUTHWEST	ETE RECANTO DAS EMAS	1.582	1.826	1.92	1.798
SRS - SOUTHWEST	ETE SAMAMBAIA	2.723	2.978	3.353	3.001
SRS - NORTH	ETE PLANALTINA	2.621	2.88	2.9	2.873
SRS - NORTH	ETE SOBRADINHO	1.754	2.023	1.984	1.984
SRS - EAST	ETE PARANOÁ	1.657	2.077	2.257	2.116
SRS - EAST	ETE SÃO SEBASTIÃO	1.53	1.637	1.827	1.809
SRS - WEST	ETE BRAZLÂNDIA	828	911	1.093	1.047
SRS - WEST	ETE MELCHIOR	4.984	5.501	6.073	5.325
SRS - SOUTH	ETE GAMA	1.584	1.767	1.721	1.564
SRS - SOUTH	ETE SANTA MARIA	1.538	1.798	1.833	1.639
	Annual	29.348	32.288	34.575	31.655

Table 8: Positive Cases Grouped by Region x ETE (within each health region, the ETEs that serve it).

Region	ETE	2017	2018	2019	2020
SRS - CENTRAL	ETE ALAGADO	252	228	272	211
SRS - CENTRAL	ETE BRASILIA NORTE	182	196	190	155
SRS - CENTRAL	ETE BRASILIA SUL	249	184	184	116
SRS - CENTRAL	ETE SOBRADINHO	46	59	69	51
SRS - CENTER SOUTH	ETE ALAGADO	1.016	1.004	961	801
SRS - CENTER SOUTH	ETE RIACHO FUNDO	447	492	484	473
SRS - SOUTHWEST	ETE ALAGADO	208	257	295	274
SRS - SOUTHWEST	ETE MELCHIOR	1.136	924	976	806
SRS - SOUTHWEST	ETE RECANTO DAS EMAS	676	740	728	656
SRS - SOUTHWEST	ETE SAMAMBAIA	1.116	1.172	1.222	1.035
SRS - NORTH	ETE PLANALTINA	1.1	1.174	1.021	1.133
SRS - NORTH	ETE SOBRADINHO	736	760	740	644
SRS - EAST	ETE PARANOÁ	675	805	810	759
SRS - EAST	ETE SÃO SEBASTIÃO	669	649	712	675
SRS - WEST	ETE BRAZLÂNDIA	387	417	459	379
SRS - WEST	ETE MELCHIOR	2.168	2.215	2.255	1.898
SRS - SOUTH	ETE GAMA	601	578	606	516
SRS - SOUTH	ETE SANTA MARIA	641	626	639	544
	Annual	12.305	12.48	12.623	11.126

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Table 9: Prevalence (%) Positive Cases Grouped by Region and TEE.

Region	ETE	2017	2018	2019	2020
SRS - CENTRAL	ETE ALAGADO	41,11%	35,74%	36,66%	30,23%
SRS - CENTRAL	ETE BRASILIA NORTE	43,33%	38,13%	34,80%	33,84%
SRS - CENTRAL	ETE BRASILIA SUL	33,60%	37,32%	34,98%	31,61%
SRS - CENTRAL	ETE SOBRADINHO	36,80%	39,60%	33,82%	32,08%
SRS - CENTRAL	Mean	38,71%	37,70%	35,07%	31,94%
SRS - CENTER SOUTH	ETE ALAGADO	44,70%	41,96%	38,80%	36,74%
SRS - CENTER SOUTH	ETE RIACHO FUNDO	39,70%	33,11%	31,63%	32,62%
SRS - CENTER SOUTH	Mean	42,20%	37,53%	35,22%	34,68%
SRS - SOUTHWEST	ETE ALAGADO	40,63%	38,07%	36,11%	36,44%
SRS - SOUTHWEST	ETE MELCHIOR	41,51%	36,35%	35,21%	33,10%
SRS - SOUTHWEST	ETE RECANTO DAS EMAS	42,73%	40,53%	37,92%	36,48%
SRS - SOUTHWEST	ETE SAMAMBAIA	40,98%	39,36%	36,44%	34,49%
SRS - SOUTHWEST	Mean	41,46%	38,58%	36,42%	35,13%
SRS - NORTH	ETE PLANALTINA	41,97%	40,76%	35,21%	39,44%
SRS - NORTH	ETE SOBRADINHO	41,96%	37,57%	37,30%	32,46%
SRS - NORTH	Mean	41,96%	39,17%	36,25%	35,95%
SRS - EAST	ETE PARANOÁ	40,74%	38,76%	35,89%	35,87%
SRS - EAST	ETE SÃO SEBASTIÃO	43,73%	39,65%	38,97%	37,31%
SRS - EAST	Mean	42,23%	39,20%	37,43%	36,59%
SRS - WEST	ETE BRAZLÂNDIA	46,74%	45,77%	41,99%	36,20%
SRS - WEST	ETE MELCHIOR	43,50%	40,27%	37,13%	35,64%
SRS - WEST	Mean	45,12%	43,02%	39,56%	35,92%
SRS - SOUTH	ETE GAMA	37,94%	32,71%	35,21%	32,99%
SRS - SOUTH	ETE SANTA MARIA	41,68%	34,82%	34,86%	33,19%
SRS - SOUTH	Mean	39,81%	33,76%	35,04%	33,09%
DF		41,93%	38,65%	36,51%	35,15%

prevalence of toxoplasmosis using data from the Pregnant Woman Protection Program in the Federal District from 2017 to 2020. In this period, 127,866 pregnant women were screened, with 2019 being the year with the highest coverage (34,575 patients) and the year 2017 with the lowest coverage (29,348 patients) (Table 1). However, when comparing the number of screenings there was no significant difference in the average number of screenings performed between the years. Of the 127,866 patients examined, 48,534 were positive, resulting in an overall prevalence of 38,06% in pregnant women screened by the PWPP in the Federal District of Brazil between the years 2017 to 2020. Regarding the prevalence over time, there was a drop over the years, starting in 2017 with 41, 93% to 35, 15% in 2020 (Table 3). Since there was no significant difference in the number of pregnant women evaluated over the years, this decrease in prevalence between 2017 and 2020 it can be suggested that this decrease is influenced by the measures adopted by the

PWPP, including: prevention, diagnosis, and guidance on the various types of diseases still in pregnancy, thus reducing the risks of morbidity and mortality in pregnant women and their babies [21]. In a previous study [25], we reported a prevalence of toxoplasmosis infection from 81.84% in 2014 to 38.65% in 2018. This result is in accordance with global and national data, since the World Health Organization (WHO) estimates that half of the world population is infected, this prevalence being conditioned to the social and economic determinants that differentiate countries [19, 24, 25]. According to studies in Brazil, the prevalence indicators for antibodies to toxoplasmosis vary from 54% to 80% [18-25]. It is important to highlight this large number of pregnant women susceptible to toxoplasmosis infection, which can lead to acute infection during pregnancy and serious problems for the fetus. As mentioned before, in its congenital form, the sequelae in the fetus can be severe and irreversible. Some babies infected with the parasite in an intrauterine

form can be born without complications but present changes during the first year of life or even in adulthood such as: brain calcifications, chorioretinitis, blindness, delayed neuropsychomotor development, microcephaly, hydrocephalus, bulging fontanelle, meningoencephalitis, strabismus, hepatosplenomegaly, rash, petechiae, jaundice and pneumonia [8-12]. One of the objectives of our work was to investigate the spatial distribution of these occurrences, considering the health regions of the Federal District and the sanitary conditions in different areas. The comparison of positive cases grouped by health region did not reveal a significant difference in the average number of positive cases recorded between the years 2017 and 2020. This indicate that there was not a specific health region with highest proportion of positive cases for toxoplasmosis. To investigate the distribution of toxoplasmosis according to the coverage of basic sanitation in the different regions of the Federal District, we analyzed our data grouped by the location of the Sewage Treatment Station (ETE) in the region. There was no significant difference in the mean number of positive cases recorded between the different ETEs among the years of 2017 to 2020 (Table 5). That means, we did not observe a higher frequency of positive cases for toxoplasmosis depending on the coverage of sewage treatment plants in the Federal District. In fact, we observed was a decrease in the prevalence of these cases over the years, regardless of the sewage treatment plant (see Table 6). However, there is no direct relationship between health regions in the Federal District and sewage treatment plants. In fact, it is observed that some health regions are covered by different sewage treatment plants. In this way, we analyzed the health regions considering the coverage by sewage treatment plants. Thus, analyzing the number of screenings performed depending on health region (SRS) and sewage treatment plants associated we find significant differences between SRS - Central and SRS - Southwest, SRS - Central and SRS - North and

SRS – Central and SRS – West (see Table 7). Moreover, the prevalence of positive cases grouped by SRS and ETE indicated a significant effect for each sewage treatment plant between the years 2017 and the others and between the years 2018 and 2020. That is, a decrease in the prevalence of positive cases between the years 2017 and 2020. Regarding SRS, there were differences between SRS - Central and SRS - West and SRS - West and SRS - South. These data suggest that there was a lower prevalence of cases in the Central and South SRS, and a higher prevalence in the West SRS (see Table 9 and Figure 1).

At this point it is necessary to discuss the situation of sanitation in the Federal District of Brazil. Although the Federal District was a city designed under modern standards, the fact that it has accelerated growth, going from almost no population to almost 2.5 million in less than 50 years, has extrapolated population forecasts. This caused, in addition to invasions and uncontrolled urbanization in several areas, enormous social inequalities. In the Federal District, the legal and institutional framework that governs the provision of water supply and sewage services, as well as their related areas, follows the guidelines of the Federal Government. About data related to the infrastructure available for basic sanitation services that households and the urban population of the Federal District have, the high percentage of households served by the services stands out. The coverage of water supply in DF, by general network, is 97.82%. Virtually all households have an urban garbage collection service. With a lower percentage, but still considered high in terms of care, 85.95% of households have a general sewage network with treatment. Some regions of more recent creation are generally served by septic tanks due to the low density. Regarding solid waste, there is currently a great concern with the West SRS (Braslândia and Ceilândia, satellite cities of Brasília), because environmental impacts caused by the inadequate disposal of

Figure 1: Health Regions – Federal District of Brazil. Source: [31].

waste, potentiate alterations in the quality of the soil, air, and surface and groundwater, with effects on the environment fauna and flora, and on public health (disease proliferation). Moreover, households having an inefficient rainwater drainage system can cause flooding and the superficial transport of waste, thus contributing to the proliferation of diseases. Another aspect is that there is no rain network, the population erroneously releases rainwater into the sewer pipe, causing serious risks of clogging and return of sewage to the homes. This poor sanitation situation observed in the Western SRS region of the Federal District may be a risk factor in the proliferation of agents that lead toxoplasmosis infection. Observing the results obtained in our study, the highest prevalence of pregnant women infected by toxoplasmosis was precisely in this region. Therefore, these data suggest a relationship between the poor sanitary conditions of this region with a higher prevalence of toxoplasmosis. On the other hand, our results indicate a lower prevalence of cases in the central and southern regions of the Federal District. This result is in agreement with those reported by Piedade et al [35] who estimated the prevalence of toxoplasmosis in pregnant women screened by Pregnant Women's Protection Program of the Federal District in 2018 and founded the minor's prevalence in central and south health regions. According to CODEPLAN (Federal District Planning Company) and "Companhia de Saneamento Ambiental do Distrito Federal - CAESB", the coverage rate for the collection of household solid waste, water service, sewage service and the infrastructure available for basic sanitation services in relation to the urban population in central and south regions is 100%. Therefore, it seems plausible to suggest, in this case, a relationship between better sanitary conditions and low prevalence of toxoplasmosis. Basic sanitation has been considered an important environmental determinant of health. Mainly related to the services of drinking water availability, sanitation and solid waste management. Even today, populations around the world suffer from diseases caused by the lack of basic sanitation. These are diseases related to poor quality water, diseases related to faeces, diseases related to garbage, or even diseases related to houses built in areas close to a high concentration of vectors. The transmission of toxoplasmosis by direct contagion can occur through inhalation of the transmitting agent, present in the soil, food, feces and contact with cats, pigeons, and rodents. In addition, toxoplasmosis can be transmitted from mother to child, however this only happens when the disease is not diagnosed during pregnancy, or the treatment is not done correctly. Transmission of toxoplasmosis can also happen during pregnancy through the passage of the parasite through the placenta. However, transmission depends on the immunological status of the pregnant woman and the stage of pregnancy: when the woman is in the first trimester of pregnancy and has a compromised immune system, there is a greater chance of transmitting the disease to the baby. Toxoplasmosis in pregnancy causes congenital toxoplasmosis, which is when the baby is infected with this disease while still in the mother's womb. Toxoplasmosis in pregnancy can lead to serious consequences such as malformations of the foetus, low birth weight, premature birth, miscarriage, or death of the baby at birth. The disease is strongly associated with lower socioeconomic levels, present in those social groups that have inadequate hygienic-sanitary living conditions. One of the factors that influence the rates of contamination and mortality by Toxoplasmosis is the urbanization process that acts on this area. This is guided by some factors, such as the contact that rainwater has with contaminated feces, which flow contaminated too few points of urban water flow, concentrating this contamination in large urban centers, with poor sanitation. It was found that regions with higher consumption of unfiltered water were more exposed to contamination by Toxoplasma gondii [36]. Another factor that also influences is on a comparison between the incidence of Toxoplasmosis with the socioeconomic indicators, in the case studied the Gross Domestic Product (GDP), a direct relationship is observed, so that the social situation that the individual is in directly influences in cases of contamination, where in places of greater economic precariousness, these indices showed a positive correlation. It also points out that public policies should prioritize better basic sanitation for the most debilitated regions [36]. The study carried out by Inagaki et al [37] confirmed this assertion, as it indicated a higher seroprevalence in young pregnant women in poor neighborhoods in the city of Aracaju. Neighborhoods with low socioeconomic conditions had a higher proportion of active infection, with reagent IgM. Among the 18 pregnant women with IgM reagent, 4 were from the Santa Maria neighborhood, 2 from the América neighborhood and 2 from the São Conrado neighborhood, characterized as pockets of poverty. These data are consistent with the results of a study carried out with 3,325 newborns in the same municipality, submitted to screening for congenital toxoplasmosis. From the results presented, Inagaki et al [37] observed that there was a higher concentration of pregnant women previously infected by T. gondii residing in poorer areas, which are exposed to known risk factors such as low socioeconomic status and teenage pregnancy. The results of the present study are in agreement with these premises. If we look at the areas with the highest prevalence of pregnant women infected with toxoplasmosis, we will see that they are regions inhabited by people with low economic and educational levels. The human development index of these regions is the lowest in the Federal District. Basic sanitation is part of a country's infrastructure, bringing with it responsibilities in various aspects. In summary, sanitation values a good environment for human beings and rules their relations with this environment. When we talk about basic sanitation in Brazil, we have precarious situations as well as infrastructure in general. Both due to the lack of

works and the historical lack of investments. Basic sanitation incorporates the services of potable water, sanitary sewage, garbage collection and urban drainage, widely associated with public health. In Brazil, basic sanitation is a right guaranteed by the Constitution and defined as a set of infrastructure services. Although solid waste collection and urban drainage are part of sanitation, it is the services of access to potable water and sewage treatment that significantly impact the lives of the population. According to the latest study carried out by the Brazilian Institute of Geography and Statistics (IBGE) in 2019, more than 97% of the population had piped water, while 88.2% of them had access to the general supply network. Brasília is the second capital of the country in the national ranking of basic sanitation published by the Brazilian Association of Sanitary and Environmental Engineering (Abes). After Curitiba, the capital of the country has the best rate in the provision of water services, sewage collection and solid waste management. The capital of Brazil went from 20th to 15th position in the Sanitation Ranking 2022, released by Instituto Trata Brasil [32]. Brasília occupies a prominent position, with the highest score in service indicators, fulfilling the goals of the New Legal Framework for Basic Sanitation. In terms of total water service, Companhia de Saneamento Ambiental do Distrito Federal (Caesb) reached the mark of 99%. The total sewage service indicator shows that 91.77% of the inhabitants of the DF have sewage collection. When the analyzed index is the percentage of sewage treated by water consumed, Brasília reaches 90.03%. Despite these good indicators in recent years, the Federal District still has regions with a lack of adequate sanitation. And when we look at these regions with low levels of sanitation, we find a clear relationship between health and sanitation, where regions with poor sanitation have more public health problems.

Conclusion

Considering the results of our study and those reviewed above, we conclude that several causes are responsible for the high rate of pregnant women infected with toxoplasmosis, but most of these causes are associated with problems of basic sanitation and the socioeconomic conditions of the people who inhabit these areas. In this way, it is necessary, on the part of the public authorities, to establish strategies aimed at improving basic sanitation conditions, access to education, increasing actions aimed at primary prevention, with constant guidelines related to hygienic dietary habits, to minimize exposure to risk factors. Additionally, there is a need to improve the program for early diagnosis of toxoplasmosis, including repetitions of serology for susceptible pregnant women. Educate the population about the risk of littering in the streets; collect sewage correctly and avoid dumping untreated sewage into rivers and thus preserve springs. Environmental Education mainly for people who do not have sustainable habits. Unite public and private companies to accelerate investments in sanitation with sustainable projects. Improve early diagnosis programs in toxoplasmosis focusing on priority regions not only in prenatal care but also in the general population, always reducing the age group, especially in females.

References

1. Boothroyd JC, Grigg ME. Population biology of Toxoplasma gondii and its relevance to human infection. Curr Opin Microbiol 5 (2002): 438-442.

2. Dubey JP. Toxoplasmosis of animals and humans. 2. Maryland: CRC Press (2010).

3. Fekadu A, Shibre T, Cleare AJ. Toxoplasmosis as a cause for behavior disorders - overview of evidence and mechanisms. Folia Parasitol (Praha) 57 (2010): 105-113.

4. Montoya JG, Liesenfeld O. Toxoplasmosis. Lancet 363 (2004): 1965-1976.

5. Torgerson PR, Macpherson CNL. The socioeconomic burden of parasitic zoonoses: global trends. Vet Parasitol 182 (2011): 79-95.

6. Opsteegh M, Teunis P, Mensink M, et al. Evaluation of ELISA test characteristics and estimation of Toxoplasma gondii sero-prevalence in Dutch sheep using mixture models. Prev Vet Med 96 (2010): 232-240.

7. Weese S. Pets and immune-compromised people. Worms & Germs Blog, Ontario Veterinary College's Centre for Public Health and Zoonoses. (2008).

8. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Ações Programáticas Estratégicas. Atenção à Saúde do Recém-Nascido: Guia para os Profissionais de Saúde. 2a ed. Brasília, DF: Ministério da Saúde; (2014).

9. Lehmann LM, Santos PC, Scaini CJ. Evaluation of pregnant and postpartum women's knowledge about toxoplasmosis in Rio Grande – RS, Brazil. Rev Bras Ginecol Obstet 38 (2016): 538-544.

10. Mozzatto L, Procianoy RS. Incidence of congenital toxoplasmosis in southern Brazil: a prospective study. Rev Inst Med Trop São Paulo 45 (2003): 147-151.

11. Furtado JM, Smith JR, Belfort Jr R, et al. Toxoplasmosis: a global threat. J Glob Infect Dis 3 (2011): 281-284.

12. Fochi MML, Baring S, Spegiorin LCJF, et al. Prematurity and low birth weight did not correlate with anti-toxoplasma gondii maternal serum profiles - a Brazilian report. PLoS One 10 (2015): e0132719.

13. 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 45 (2012): 55-59.

14. Lopes-Mori FMR, Mitsuka-Breganó R, Bittencourt LHFB, et al. Gestational toxoplasmosis in Paraná State, Brazil: prevalence of IgG antibodies and associated risk factors. Braz J Infect Dis 17 (2013): 405-409.

15. Wilking H, Thamm M, Stark K, et al. Prevalence, incidence estimations, and risk factors of Toxoplasma gondii infection in Germany: a representative, cross-sectional, serological study. Sci Rep 6 (2016): 22551.

16. Di Mario S, Basevi V, Gagliotti C, et al. Prenatal education for congenital toxoplasmosis. Cochrane Database Syst Rev (2015): CD006171.

17. Secretaria de Vigilância em Saúde. Boletim eletrônico Epidemiológico: Surto Intra-Familiar de Toxoplasmose, Santa Vitória do Palmar-RS, Julho de 2005. Toxoplasmose, Boletim eletrônico Epidemiológico, ed. 03. (2006): 1-7.

18. Inagaki, Ana Dorcas de Melo, et al. Análise espacial da prevalência de toxoplasmose em gestantes de Aracaju, Sergipe, Brasil. Rev Bras Ginecol Obstet 8 (2014): 1-6.

19. Engroff, Paula, et al. Soroepidemiologia de Toxoplasma gondii em idosos atendidos pela Estratégia Saúde da Família, Porto Alegre, Rio Grande do Sul, Brasil. Revista Ciência & Saúde Coletiva 7 (2014): 1-10.

20. EVANGELISTA, Maria José de Oliveira. Programa de Proteção à Gestante do Estado de Sergipe: impacto sobre a saúde materno infantil (2011): 1-105.

21. SARTORI, Ana Lucia, et al. Triagem pré-natal para toxoplasmose e fatores associados à soropositividade de gestantes em Goiânia, Goiás. Rev Bras Ginecol Obstet 12 (2011): 1-6.

22. Gómez JFB, Apolinário MAO, Castro AJW, et al. Comparação da coleta das amostras de sangue na triagem pré-natal, utilizando o papel de filtro e punção venosa na técnica de elisa para detecção de sífilis. DST - J Bras Doenças Sex Transm 22 (2010): 123-128.

23. IV Simpósio Brasileiro De Toxoplasmose. Resumos dos trabalhos apresentados. Anais Congresso, Rede Brasileira de Pesquisa em Toxoplasmose. (2018): 1-67.

24. Costa, Lima M, et al. Levantamento do Perfil Epidemiológico da Toxoplasmose na Cidade de Jataí-GO. Universidade Federal de Goiás 1-12.

25. Saab F, da Rocha B, Abreu C. Prevalence of seropositivity for toxoplasmosis in pregnant women in the Brazilian Federal District from 2014 to 2018. International Journal for Innovation Education and Research (2020): 346-355.

26. Secretaria De Saúde Do Estado. Caderno De Atenção Ao Pré-Natal Toxoplasmose. Secretaria de Saúde Paraná, [S. l.] 1-24.

27. Paiva RFPS, Souza MP. Associação entre condições socioeconômicas, sanitárias e de atenção básica e a morbidade hospitalar por doenças de veiculação hídrica no Brasil. Cad. Saúde Pública[online] 34 (2018): e00017316.

28. Carvalho, Anna Gabryela Medeiros Afonso et al. Diagnóstico Laboratorial Da Toxoplasmose Congênita. Rev. Ciênc. Saúde Nova Esperança 1 (2014): 1-8.

29. Viellas, Fernandes E, et al. Assistência pré-natal no Brasil. Cad. Saúde Pública 30 (2014): 1-16.

30. Elsheikha HM. Congenital toxoplasmosis: Priorities for further health promotion action. Public Health 122 (2008): 335-353.

31. Saab F, Abreu C. Basic Sanitation and Health - Challenges and Perspectives in Brazil and Brazilian Federal District. International Journal for Innovation Education and Research (2021): 420-436.

32. TRATA BRASIL. Ranking do Saneamento - Instituto Trata Brasil (2022).

33. SNIS. Sistema Nacional de Informação Sobre Saneamento. Ministério das Cidades. Manual dos Indicadores de Abastecimento de Água, Esgotamento Sanitário e Resíduos Sólidos (2008).

34. Adasa, Agência Reguladora de Águas, Energia e Saneamento Básico do Distrito Federal. Distrito Federal. Programa de Saneamento Ambiental e Gestão Territorial do Distrito Federal - Brasília Sustentável. Brasília (2020).

35. Piedade PHM, Ferreira AVSG, Botelho CAO, et al. Perfil epidemiológico das gestantes diagnosticadas com toxoplasmose no exame de pré-natal do distrito federal no ano de 2018. Brazilian Journal of Health Review 4 (2021): 6882-6895.

36. Dias VA, Ortiz MAL. Toxoplasmose na gestação – causas e consequências. Uningá Review Journal, [S.l.] 29 (2017): 1.

37. Inagaki AD, Cardoso NP, Lopes RJ, et al. Análise espacial da prevalência de toxoplasmose em gestantes de Aracaju, Sergipe, Brasil. Rev Bras Ginecol Obstet 36 (2014): 535-540.