Seroepidemiology of Toxoplasma gondii Infection in Women of Reproductive Age: A Cross-Sectional Study in a Northwestern Mexican City

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Abstract

Background: Through a cross-sectional survey, we determined the seroprevalence and correlates of Toxoplasma gondii (T. gondii) infection in women of reproductive age in Hermosillo City, Mexico.

Methods: We studied 445 women of reproductive age in Hermosillo City in the northwestern Mexican state of Sonora. Women were enrolled in the University of Sonora. Sera of women were examined for IgG and IgM antibodies to T. gondii by commercially available enzyme immunoassays. The association of T. gondii seropositivity with the characteristics of the pregnant women was determined by bivariate and multivariate analyses.

Results: Of the 445 women (mean age: 22.18 ± 5.6 years) studied, 16 (3.6%) had IgG antibodies to T. gondii, and two (12.5%) were also positive for IgM antibodies to T. gondii. Of the 16 anti-T. gondii IgG-positive women, six (37.5%) had IgG levels higher than 150 IU/mL, four (25.0%) between 100 and 150 IU/mL, and six (37.5%) between 9 and 99 IU/mL. Multivariate analysis of socio-demographic and behavioral variables showed that T. gondii seropositivity was associated with older age (odds ratio (OR): 5.30; 95% confidence interval (CI): 1.37 - 20.50; P = 0.01) and boar meat consumption (OR: 6.86; 95% CI: 1.27 - 37.07; P = 0.02).

Conclusions: Women of reproductive age in Hermosillo City had a low seroprevalence of T. gondii infection. However, this finding indicates that most of these women were susceptible to a primary infection. Factors associated with T. gondii infection found in this study may be useful for the optimal planning of preventive measures against T. gondii infection and its sequelae.

Keywords: Toxoplasma; Women; Epidemiology; Seroprevalence; Risk factors; Cross-sectional study; Mexico

Introduction

The parasite Toxoplasma gondii (T. gondii) causes infections in humans and animals in all continents [1, 2]. Infection with T. gondii is acquired by several routes, including uptake of oocysts released by felids [2, 3], ingestion of raw or undercooked meat containing tissue cysts [4], congenitally [5], and organ transplant [6]. Infections with T. gondii are usually asymptomatic; however, some infected individuals may develop acute toxoplasmosis [7]. This disease may present as lymphadenopathy or chorioretinitis [6, 7], but a life-threatening meningoencephalitis may occur in immunocompromised patients [7]. On the other hand, primary infections with T. gondii in pregnant women are causes of miscarriages, stillbirths and congenital disease with eye and central nervous system involvement [7, 8]. Clinical manifestations of congenital disease can be present at birth or appear later in life [9, 10]. Infection with T. gondii in most hosts leads to lifelong chronic infection and generates immunological memory responses that protect the host against new infections [11]. Infections with T. gondii in women immunized against this parasite rarely lead to congenital toxoplasmosis [12].

The seroepidemiology of T. gondii infection in women of reproductive age in Mexico has been scantily studied. In a national seroepidemiology survey about the prevalence of toxoplasmosis in Mexico in 1992, Velasco-Castrejon et al reported a high incidence of T. gondii infection in women of re-
productive age [13]. We are not aware of any further study of *T. gondii* infection in women of reproductive age in Mexico. Therefore, we sought to determine the seroprevalence of *T. gondii* infection and factors associated with this infection in women of reproductive age in the northwestern Mexican city of Hermosillo.

Materials and Methods

Study design and women studied

Through a cross-sectional study design, we studied women of reproductive age in Hermosillo City in the northwestern Mexican state of Sonora. Women were enrolled in the University of Sonora from May 2015 to June 2017. As a strategy to enroll participants, university departments were visited, and women of reproductive age were informed about the project and invited to participate. Those women who agreed to participate were referred to the clinical laboratory of the university for blood sampling. Inclusion criteria were as follows: 1) female; 2) aged 13 - 46 years old; and 3) agreed to participate in the study. Occupation, socio-economic status, or educational level were not restrictive criteria for enrollment. In total, 445 women (mean age: 22.18 ± 5.6; range 13 - 46 years) were included in the study.

Socio-demographic, clinical, and behavioral characteristics of the women

Socio-demographic, clinical, and behavioral characteristics of the women were obtained with the aid of a standardized questionnaire. Socio-demographic items were age, birthplace, residence, occupation, educational level, and socio-economic status. Clinical data included obstetric history (number of pregnancies, deliveries, cesarean sections, and miscarriages), and history of blood transfusions or transfusions. Behavioral items included presence of cats at home, cats in the neighborhood, cleaning cat feces, raising farm animals, foreign travel, consumption of raw meat, type of meat consumed (pork, lamb, beef, goat, boar, chicken, turkey, rabbit, deer, squirrel, horse, or other), eating away from home (in restaurants and fast food outlets), consumption of cured meat (chorizo, ham, sausages or salami), consumption of unwashed raw vegetables or fruits, consumption of untreated water or unpasteurized milk, and soil contact (gardening or agriculture).

Detection of anti-*T. gondii* antibodies

A serum sample was obtained from each woman and stored at -20 °C until analyzed. All serum samples were analyzed for IgG antibodies to *T. gondii* by a commercially available enzyme immunoassay “Toxoplasma IgG” kit (Diagnostic Automation/Cortez Diagnostics Inc.). All tests were performed following manufacturer instructions. Positive and negative controls for IgG and IgM were included in each run.

Statistical analysis

We performed the statistical analysis with the aid of Epi Info version 7 and SPSS version 15.0 software. For calculation of the sample size, we used: 1) a reference seroprevalence of 13.5% [14], as the expected frequency for the factor under study, 2) 250,000, as the population size from which the sample was selected, 3) confidence limits of 3.5%, and 4) a 95% confidence level. The result of the sample size calculation was 366 subjects. We used Pearson’s Chi-square test or the Fisher’s exact test (when values were less than 5) for comparison of the frequencies among groups. Multivariate analysis was used to determine the association between *T. gondii* seropositivity and the socio-demographic, and behavioral characteristics of the women. Only variables with a P value ≤ 0.10 obtained in the bivariate analysis were further analyzed by multivariate analysis. To avoid bias, clinical data were not included in the multivariate analysis. We calculated the odds ratios (ORs) and 95% confidence intervals (CIs) by logistic regression analysis using the Enter method. A P value < 0.05 was considered significant.

Ethics aspects

This study was approved by The Institutional Ethics Committee of the University of Sonora, Mexico. The purpose and procedures of the study were explained to all participants. Additionally, written informed consent was obtained from all participants.

Results

Of the 445 women studied, 16 (3.6%) had IgG antibodies to *T. gondii*, and two (12.5%) of these participants were also positive for IgM antibodies to *T. gondii* by enzyme immunoassays. Of the 16 anti-*T. gondii* IgG positive women, six (37.5%) had IgG levels higher than 150 IU/mL, four (25.0%) between 100 and 150 IU/mL, and six (37.5%) between 9 and 99 IU/mL. The socio-demographic characteristics of the women and correlation with *T. gondii* IgG seropositivity are shown in Table 1. The variables “age groups”, “occupation” and “socioeconomic level” showed P values ≤ 0.10 by bivariate analysis. Other socio-demographic variables of women, including birthplace, residence, and educational level showed P values higher than 0.10 by bivariate analysis.

Concerning behavioral characteristics, bivariate analysis showed that the variables “sheep meat consumption” and “boar meat consumption” showed P values ≤ 0.10. Other behavioral variables, including contact with cats, raising farm animals, foreign travel, consumption of raw meat, consumption of pork, beef, venison or meat of goat, chicken, turkey, rabbit, squirrel, horse, or other animals, eating away from home, consumption...
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of cured meat, consumption of unwashed raw vegetables or fruits, consumption of untreated water or unpasteurized milk, and soil contact showed P values higher than 0.10 by bivariate analysis. Table 2 shows a selection of behavioral characteristics of the women and the correlation with *T. gondii* IgG seropositivity. Multivariate analysis of socio-demographic, and behavioral variables with P values ≤ 0.10 obtained in the bivariate analysis showed that *T. gondii* seropositivity was associated with older age (OR: 5.30; 95% CI: 1.37 - 20.50; P = 0.01), and boar meat consumption (OR: 6.86; 95% CI: 1.27 - 37.07; P = 0.02). Table 3 shows the results of the regression analysis.

With respect to clinical data, bivariate analysis showed that seropositivity to *T. gondii* was associated with the variables “history of pregnancy” (P = 0.02) and “history of miscarriage” (P = 0.03). Whereas other clinical variables, including history of deliveries, cesarean sections, or blood transfusion, did not show an association with *T. gondii* seropositivity. None of the women studied had a history of organ transplant. Results of the correlation between clinical characteristics and seropositivity to *T. gondii* are shown in Table 4.

### Discussion

The seroepidemiology of *T. gondii* infection in women of reproductive age in Mexico is largely unknown. Epidemiological studies on this infection in women in Mexico have focused on pregnant women. Therefore, in this study, we aimed to determine the seroprevalence and determinants of *T. gondii* infection in women of reproductive age in the northwestern Mexican city of Hermosillo. In this study, we found a 3.6% seroprevalence of *T. gondii* infection in the women studied. We are aware of only one previous report on the seroepidemiology of *T. gondii* infection in women of reproductive age in Mexico. In a national serosurvey of *T. gondii* infection in all 32 states of this country, Velasco-Castrejon et al found a

### Table 1. Socio-Demographic Characteristics of Women and Prevalence of *T. gondii* Infection

| Characteristics          | No. | Prevalence of *T. gondii* infection |
|--------------------------|-----|-----------------------------------|
|                          | No. | % | P value |
| Age group (years)        |     |   |         |
| 13 - 30                  | 399 | 10 | 2.5     | 0.003   |
| 31 - 46                  | 46  | 6  | 13.0    |         |
| Birth place              |     |   |         |
| Sonora State             | 440 | 16 | 3.6     | 0.91    |
| Other Mexican State      | 4   | 0  | 0.0     |         |
| Abroad                   | 1   | 0  | 0.0     |         |
| Residence place          |     |   |         |
| Sonora State             | 441 | 16 | 3.6     | 1.00    |
| Other Mexican State      | 4   | 0  | 0.0     |         |
| Residence area           |     |   |         |
| Urban                    | 392 | 12 | 3.1     | 0.18    |
| Suburban                 | 8   | 1  | 12.5    |         |
| Rural                    | 45  | 3  | 6.7     |         |
| Educational level        |     |   |         |
| No education             | 17  | 0  | 0.0     | 0.74    |
| 1 - 6 years              | 106 | 5  | 4.7     |         |
| 7 - 12 years             | 317 | 11 | 3.5     |         |
| > 12 years               | 5   | 0  | 0.0     |         |
| Occupation               |     |   |         |
| Laborer                  | 32  | 4  | 12.5    | 0.02    |
| Non-laborer              | 413 | 12 | 2.9     |         |
| Socio-economic level     |     |   |         |
| Low                      | 6   | 1  | 16.7    | 0.07    |
| Medium                   | 352 | 10 | 2.8     |         |
| High                     | 87  | 5  | 5.7     |         |

*Laborer: business, employee, professional, or agriculture. Non-laborer: housewife, student, or none.*
Table 2. Bivariate Analysis of Selected Putative Risk Factors for Infection With *T. gondii* in Women

| Characteristics                     | No. of women tested | Prevalence of *T. gondii* infection | P value |
|-------------------------------------|---------------------|-------------------------------------|---------|
|                                     | No. | %     |                                    |         |
| Cats at home                        |     |       |                                    |         |
| Yes                                 | 154 | 6     | 3.9                                | 0.80    |
| No                                  | 291 | 10    | 3.4                                |         |
| Cleaning cat excrement              |     |       |                                    |         |
| Yes                                 | 58  | 1     | 1.7                                | 0.70    |
| No                                  | 387 | 15    | 3.9                                |         |
| Traveled abroad                     |     |       |                                    |         |
| Yes                                 | 291 | 12    | 4.1                                | 0.41    |
| No                                  | 154 | 4     | 2.6                                |         |
| National trips                      |     |       |                                    |         |
| Yes                                 | 274 | 7     | 2.6                                | 0.21    |
| No                                  | 169 | 8     | 4.7                                |         |
| Pork meat consumption               |     |       |                                    |         |
| Yes                                 | 402 | 14    | 3.5                                | 0.69    |
| No                                  | 43  | 2     | 4.7                                |         |
| Beef consumption                    |     |       |                                    |         |
| Yes                                 | 418 | 16    | 3.8                                | 0.61    |
| No                                  | 27  | 0     | 0.0                                |         |
| Goat meat consumption               |     |       |                                    |         |
| Yes                                 | 25  | 2     | 8.0                                | 0.22    |
| No                                  | 420 | 14    | 3.3                                |         |
| Sheep meat consumption              |     |       |                                    |         |
| Yes                                 | 67  | 5     | 7.5                                | 0.07    |
| No                                  | 378 | 11    | 2.9                                |         |
| Boar meat consumption               |     |       |                                    |         |
| Yes                                 | 14  | 2     | 14.3                               | 0.08    |
| No                                  | 431 | 14    | 3.2                                |         |
| Venison consumption                 |     |       |                                    |         |
| Yes                                 | 38  | 3     | 7.9                                | 0.14    |
| No                                  | 407 | 13    | 3.2                                |         |
| Horse meat consumption              |     |       |                                    |         |
| Yes                                 | 15  | 1     | 6.7                                | 0.42    |
| No                                  | 430 | 15    | 3.5                                |         |
| Raw meat consumption                |     |       |                                    |         |
| Yes                                 | 6   | 0     | 0.0                                | 1.00    |
| No                                  | 439 | 16    | 3.6                                |         |
| Cow raw milk consumption            |     |       |                                    |         |
| Yes                                 | 121 | 3     | 2.5                                | 0.57    |
| No                                  | 324 | 13    | 4.0                                |         |
| Goat raw milk consumption           |     |       |                                    |         |
| Yes                                 | 21  | 1     | 4.8                                | 0.54    |
| No                                  | 424 | 15    | 3.5                                |         |
| Unwashed raw vegetables consumption |     |       |                                    |         |
| Yes                                 | 66  | 0     | 0.0                                | 0.14    |
| No                                  | 379 | 16    | 4.2                                |         |
| Untreated water consumption         |     |       |                                    |         |
| Yes                                 | 37  | 0     | 0.0                                | 0.38    |
| No                                  | 408 | 16    | 3.9                                |         |
| Soil contact                        |     |       |                                    |         |
| Yes                                 | 149 | 7     | 4.7                                | 0.37    |
| No                                  | 296 | 9     | 3.0                                |         |
33.4% mean seroprevalence of *T. gondii* infection in women aged 15 - 39 years old using indirect immunofluorescence assay with a cut-off titer of 1:128 [13]. Therefore, the 3.6% seroprevalence found in women of reproductive age in Hermosillo City is much lower than the 33.4% mean seroprevalence of *T. gondii* infection in women aged 15 - 39 years found in the national survey [13]. However, comparison of these seroprevalences should be cautious, since there were differences in age and serological test for detection of *T. gondii* infection among the studies. We studied women aged 13 - 46 years old, whereas researchers of the national survey studied women aged 15 - 39 years old. With respect to the tests for detection of anti-*T. gondii* antibodies, we used a commercially available enzyme immunoassay, while researchers of the national survey used an indirect immunofluorescence assay [13]. The results of the national survey were published approximately 25 years ago, and the low seroprevalence of *T. gondii* infection found in women in Hermosillo City may reflect an improvement of hygiene and sanitation measures against *T. gondii* exposure in recent times. In an international context, the seroprevalence of *T. gondii* infection in women in Hermosillo City, Sonora, is lower than the seroprevalence reported in women of reproductive age in other countries. Differences in environmental characteristics among the studies might explain the differences in seroprevalence. Hermosillo City has a hot desert climate, and hot and dry climate conditions are not favorable for *T. gondii* [21]. In a study about quantification of oocyst viability in soil over time, oocysts survived longer in damp conditions than in dry conditions [22]. Additionally, lower seroprevalence of *T. gondii* infection in dry rather than humid climates has been observed in human populations [21, 23] and in rabbits [24].

We searched for socio-demographic and behavioral determinants associated with *T. gondii* infection. Bivariate analysis showed that laborers had a higher seroprevalence of *T. gondii* infection than non-laborers. It is possible that laborers had more exposure factors for *T. gondii* infection, i.e. soil contact, older age, etc., than non-laborers. Regression analysis showed that *T. gondii* seropositivity was associated with older age and

### Table 3. Multivariate Analysis of Selected Characteristics of Women and Their Association With *T. gondii* Infection

| Characteristics                  | Odds ratio | 95% confidence interval | P value |
|----------------------------------|------------|-------------------------|---------|
| Older age (31 - 46 years old)    | 5.30       | 1.37 - 20.50            | 0.01    |
| Occupation (laborer)             | 1.85       | 0.40 - 8.52             | 0.42    |
| Socio-economic level (low)       | 1.45       | 0.46 - 4.48             | 0.51    |
| Sheep meat consumption (yes)     | 2.35       | 0.74 - 7.42             | 0.14    |
| Boar meat consumption (yes)      | 6.86       | 1.27 - 37.07            | 0.02    |

### Table 4. Bivariate Analysis of Clinical Data of Women and Seroprevalence of Infection With *T. gondii*

| Characteristics       | No. of women tested | Prevalence of *T. gondii* infection | P value |
|-----------------------|---------------------|------------------------------------|---------|
|                       | No.                 | %                                 |         |
| **Pregnancies**       |                     |                                   |         |
| Yes                   | 66                  | 6                                  | 9.1     | 0.02    |
| No                    | 379                 | 10                                 | 2.6     |         |
| **Deliveries**        |                     |                                   |         |
| Yes                   | 52                  | 4                                  | 7.7     | 0.10    |
| No                    | 393                 | 12                                 | 3.1     |         |
| **Cesarean sections** |                     |                                   |         |
| Yes                   | 30                  | 3                                  | 10.0    | 0.08    |
| No                    | 415                 | 13                                 | 3.1     |         |
| **Miscarriages**      |                     |                                   |         |
| Yes                   | 8                   | 2                                  | 25.0    | 0.03    |
| No                    | 437                 | 14                                 | 3.2     |         |
| **Blood transfusion** |                     |                                   |         |
| Yes                   | 14                  | 0                                  | 0       | 1.00    |
| No                    | 431                 | 16                                 | 3.7     |         |
boar meat consumption. Concerning the link between infection and age, our results agree with other studies. Infection with *T. gondii* has been associated with increasing age in women of reproductive age in central Italy [15], Turkey [18], and Yugoslavia [20]. With respect to the link between infection and boar meat consumption, our results are in line with those reported in previous studies in northern Mexico. We previously found an association between *T. gondii* infection and boar meat consumption in several populations in Durango State, Mexico, including miners [25], elderly people [26], patients with work accidents [27], and the general urban population [28]. The results thus indicate that boar meat consumption is an important factor for *T. gondii* infection in northern Mexico.

Concerning clinical characteristics of women, in the present study, we found that the frequency of *T. gondii* exposure was significantly higher in women with a history of pregnancy and miscarriage. The association between infection and pregnancy might be related with age, since older women are more likely to have had multiple pregnancies in their lives than younger women. However, unknown factors might have influenced the seroprevalence of *T. gondii* infection in women with a history of pregnancy, and further research to elucidate the cause for *T. gondii* exposure in these women should be conducted. The finding of an association between infection and miscarriage agrees with those reported in previous studies in northern Mexico. This association was found in women of the ethnic group of Yoremes in the same state of Sonora [29]. Additionally, an association between high anti-*T. gondii* IgG antibody levels and miscarriages was found in subjects applying for medical certificates in Durango City, Mexico [30]. These serological findings suggest that *T. gondii* infection may be causing miscarriages in northern Mexico.

The present study has some limitations, including a low seroprevalence of *T. gondii* infection in the women studied and sampling of women in only one institution. Further studies with a larger sample size, performed in several institutions, to confirm our results are needed.

**Conclusions**

Women of reproductive age in Hermosillo City had a low seroprevalence of *T. gondii* infection. However, this finding indicates that most of these women were susceptible to a primary infection. Factors associated with *T. gondii* infection found in this study may be useful for optimal planning of preventive measures against *T. gondii* infection and its sequelae.

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**Competing Interests**

The authors declare that no competing interests exist.

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