HIGH SEROPREVALENCE OF *TOXOPLASMA GONDII* INFECTION IN INMATES: A CASE CONTROL STUDY IN DURANGO CITY, MEXICO

C. Alvarado-Esquivel1,*, J. Hernández-Tinoco2, L. F. Sánchez-Anguiano2, A. Ramos-Nevárez3, S. M. Cerrillo-Soto3, L. Sáenz-Soto3 and O. Liesenfeld4,#

1 Biomedical Research Laboratory, Faculty of Medicine and Nutrition, Juárez University of Durango State, Avenida Universidad, S/N. 34000 Durango, Mexico
2 Institute for Scientific Research “Dr. Roberto Rivera-Damm”, Juárez University of Durango State, Avenida Universidad, S/N. 34000 Durango, Mexico
3 Clínica de Medicina Familiar, Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado, Predio Canoas, S/N. 34079 Durango, Mexico
4 Institute for Microbiology and Hygiene, Campus Benjamin Franklin, Charité Medical School, Hindenburgdamm 27, D-12203 Berlin, Germany

Received: January 24, 2014; Accepted: January 27, 2014

**Purpose:** The seroprevalence of infection with the parasite *Toxoplasma gondii* and the association with risk factors has not been determined in inmates. Through a case-control study, 166 inmates from a state correctional facility in Durango City, Mexico and 166 age- and gender-matched non-incarcerated subjects were examined for the presence of anti-*T. gondii* IgG and IgM antibodies using enzyme-linked immunoassays.

**Results:** Seroprevalence of anti-*T. gondii* IgG antibodies was higher in inmates (35, 21.1%) than in controls (14, 8.4%) (OR = 2.90; 95% CI: 1.43–5.94; *P* = 0.001). Anti-*T. gondii* IgM antibodies were detected in two (1.2%) inmates and in seven (4.2%) controls (*P* = 0.17). Multivariate analysis of socio-demographic, incarceration, and behavioral characteristics of inmates revealed that *T. gondii* seropositivity was associated with being born out of Durango State (OR = 3.91; 95% CI: 1.29–11.79; *P* = 0.01). In addition, *T. gondii* seroprevalence was higher (*P* = 0.03) in inmates that had suffered from injuries (17/56: 30.4%) than those without such history (18/110: 16.4%).

**Conclusions:** The seroprevalence of *T. gondii* infection in inmates in Durango City is higher than the seroprevalences found in the general population in the same city, indicating that inmates may represent a new risk group for *T. gondii* infection. Further research on *T. gondii* infection in inmates is needed.

**Keywords:** *Toxoplasma gondii*, infection, seroprevalence, inmates, epidemiology, Mexico

---

**Introduction**

*Toxoplasma gondii* infection is a common parasitic infection present in about a third of the humanity [1]. Most *T. gondii* infections are clinically unapparent but some infected individuals develop lymph node, eye, and central nervous system diseases [2]. Infections with *T. gondii* in immunocompromised patients may lead to a life-threatening disease [3]. In addition, primary infections with *T. gondii* in pregnant women represent a risk for congenital disease [4]. *T. gondii* is a food-borne protozoan [5]. There are two major routes of *T. gondii* infection: by ingesting food or water contaminated with oocysts shed by cats and by ingestion of raw or undercooked meat containing tissue cysts [2]. Transmission of *T. gondii* may also occur by blood transfusion [6] or organ transplantation [7].

Inmates are of epidemiological importance because they have an increased prevalence of a number of infectious diseases, including infections with human immunodeficiency virus [8, 9], hepatitis B virus [8], hepatitis C virus [10], and tuberculosis [11]. Furthermore, food-borne infections caused by bacteria and viruses have been described in inmates [12–14]. In a recent study, a high sero-
prevalence of *Helicobacter pylori* exposure was found in inmates [15]. In addition, the high seroprevalence of HIV among inmates is of concern because co-infection of HIV and *T. gondii* represents a risk for a life-threatening disease of the central nervous system. However, the prevalence of infection with *T. gondii* in inmates and the association with risk factors for infection has not been investigated yet. Therefore, we sought to determine the seroprevalence of *T. gondii* infection in inmates in Durango City, Mexico. In addition, we determined the association of seropositivity to *T. gondii* with the socio-demographic, clinical, incarceration, and behavioral characteristics of the inmates.

**Materials and methods**

**Study design and study populations**

We performed a case control seroprevalence study using serum samples from previous *T. gondii* [16] and viral hepatitis [17] surveys. One hundred and sixty-six inmates (cases) and 166 controls were examined for the presence of anti-*T. gondii* IgG and IgM antibodies. Cases and controls were randomly selected. Inclusion criteria for the inmates were incarceration for at least 6 months in the state correctional in Durango City, aged 18 years and older, any gender, and who accepted to participate in the study. Inmates included in the study were 18–73 (mean = 33.34 ± 10.80) years old, 127 were males and 39 were females. Inmates were living under crowding conditions. The correctional facility houses inmates that have committed a range of crimes. However, the types of crimes committed were not asked of the inmates in the present survey. Controls were subjects without incarceration from the general population in the same Durango, City. Controls were matched with cases by age and gender. Controls were 18–74 (mean = 33.33 ± 10.81) years old, 127 were males and 39 were females. Age was comparable between cases and controls (P = 0.99).

**Socio-demographic, clinical, incarceration, and behavioral data**

We used archival questionnaires with socio-demographic, clinical, incarceration, and behavioral characteristics of the inmates. Socio-demographic data included age, gender, birthplace, residence, marital status, occupation, and socioeconomic level. The clinical status of inmates was obtained. History of blood transfusions, surgeries, and injuries in inmates was obtained. In addition, in female inmates, obstetric history was obtained. Incarceration characteristics examined included number of incarcerations, jail section, and duration of current incarceration. Behavioral data obtained were foreign travel, alcoholism, drug abuse, presence of piercing and tattoos, and sexual behavior.

**Serological detection of T. gondii antibodies**

Sera from inmates and controls were analyzed by qualitative and quantitative methods for anti-*T. gondii* IgG antibodies with the commercially available enzyme immunoassay kit “Toxoplasma IgG” (Diagnostic Automation Inc., Calabasas, CA, USA). Specific anti-*T. gondii* IgG antibody levels were expressed as International Units (IU)/ml, and a result equal to or greater than 8 IU/ml was considered positive. Sera positive for anti-*T. gondii* IgG antibodies were further analyzed for anti-*T. gondii* IgM antibodies by the commercially available enzyme immunoassay “Toxoplasma IgM” kit (Diagnostic Automation Inc., Calabasas, CA, USA). All tests were performed following the manufacturer’s instructions. Positive and negative controls were included in each assay.

**Statistical analysis**

We performed the statistical analyses with the aid of the following software: Microsoft Excel 2010, Epi Info version 3.5.4 (Centers for Disease Control and Prevention: http://www.cdc.gov/epiinfo/) and SPSS version 15.0 (SPSS Inc. Chicago, Illinois). Comparison of age between cases and controls was performed by the Student’s t test. We used the Pearson’s chi-square test and the Fisher exact test (when values were less than 5) to determine the association of *T. gondii* seropositivity with the inmate characteristics. For multivariate analysis, only inmates characteristics with a P value ≤ 0.25 obtained in the bivariate analysis were included. Multivariate analysis was performed using logistic regression analysis with the Enter method. Odds ratios (OR) and 95% confidence intervals (CI) were calculated, and statistical significance was set at P value < 0.05.

**Ethics statement**

This study was approved by the Ethical Committee of the Institute for Security and Social Services of the State Workers in Durango City. Archival sera and data from previous surveys were examined in the present study. In the previous studies, the purpose and procedures of the surveys were explained to all participants, and a written informed consent was obtained from each participant.

**Results**

Anti-*T. gondii* IgG antibodies were detected in 35 (21.1%) of 166 inmates and in 14 (8.4%) of 166 controls. Sero-prevalence of anti-*T. gondii* IgG antibodies was significantly higher in inmates than in controls (OR = 2.90; 95% CI: 1.43–5.94; P = 0.001). Of the 35 anti-*T. gondii* IgG positive inmates, 22 (13.3%) had anti-*T. gondii* IgG antibody levels higher than 150 IU/ml, 4 (2.4%) between 100 and 150 IU/ml, and 9 (5.4%) between 8 and 99 IU/ml.
Table 1. Socio-demographic and incarceration characteristics of inmates and seroprevalence of *T. gondii* infection

| Characteristic                  | Subjects tested* | Prevalence of *T. gondii* infection | \( P \) value |
|---------------------------------|------------------|-------------------------------------|----------------|
|                                 | No.   | No.   | %        |                |
| Gender                          |       |       |          |                |
| Male                            | 127   | 29    | 22.8     | 0.31           |
| Female                          | 39    | 6     | 15.4     |                |
| Age groups (years)              |       |       |          |                |
| 30 or younger                   | 83    | 20    | 24.1     | 0.6            |
| 31–50                           | 69    | 12    | 17.4     |                |
| >50                             | 14    | 3     | 21.4     |                |
| Birth place                     |       |       |          |                |
| Durango State                   | 119   | 16    | 13.4     | 0.0001         |
| Other Mexican state or abroad   | 47    | 19    | 40.4     |                |
| Residence                       |       |       |          |                |
| Durango State                   | 133   | 22    | 16.5     | 0.003          |
| Other Mexican State             | 33    | 13    | 39.4     |                |
| Marital status                  |       |       |          |                |
| Single                          | 45    | 4     | 8.9      | 0.003          |
| Married                         | 70    | 12    | 17.1     |                |
| Divorced                        | 4     | 0     | 0.0      |                |
| Living together                 | 40    | 15    | 37.5     |                |
| Widowed                         | 6     | 3     | 50.0     |                |
| Occupation                      |       |       |          |                |
| Laborer*                        | 151   | 33    | 21.9     | 0.73           |
| Non-laborer*                    | 15    | 2     | 13.3     |                |
| Socio-economic level            |       |       |          |                |
| Low                             | 105   | 20    | 19.0     | 0.69           |
| Medium                          | 51    | 12    | 23.5     |                |
| High                            | 3     | 1     | 33.3     |                |
| Jail section                    |       |       |          |                |
| A                               | 23    | 5     | 21.7     | 0.51           |
| B                               | 3     | 0     | 0.0      |                |
| C                               | 38    | 6     | 15.8     |                |
| D                               | 40    | 7     | 17.5     |                |
| E                               | 62    | 17    | 27.4     |                |
| Number of incarcerations        |       |       |          |                |
| One                             | 128   | 30    | 23.4     | 0.25           |
| Two or more                     | 38    | 5     | 13.2     |                |
| Duration (years) of current incarceration |       |       |          |                |
| 0.5–1                           | 45    | 9     | 20.0     | 0.88           |
| 1.1–2                           | 56    | 12    | 21.4     |                |
| 2.1–3                           | 23    | 6     | 26.1     |                |
| 3.1–5                           | 26    | 6     | 23.1     |                |
| More than 5                     | 16    | 2     | 12.5     |                |

*Subjects with available data

*Laborer: Agriculture, construction worker, business, driver, factory worker, other

*Non-laborer: student or housekeeping
In comparison, of the 14 anti-
*T. gondii* IgG positive con-
tROLS, 12 (7.2%) had anti-
*T. gondii* IgG antibody levels
higher than 150 IU/ml, 1 (0.6%) between 100 and 150
IU/ml, and 1 (0.6%) between 8 and 99 IU/ml. High (>150
IU/ml) levels of anti-
*T. gondii* IgG antibodies were com-
parable among inmates and controls (*P* = 0.07). Seropre-
vallence of anti-
*T. gondii* IgM antibodies did not differ in
inmates (2, 1.2%) and controls (7, 4.2%) (*P* = 0.17). Both
inmates positive for anti-
*T. gondii* IgM antibodies had high
(>150 IU/ml) levels of anti-
*T. gondii* IgG antibodies, and they had been in jail for 10 months.

Anti-
*T. gondii* IgG antibodies were detected in 6
(15.4%) of 39 female inmates and in 1 (2.6%) of 39 female
controls (*P* = 0.10). While anti-
*T. gondii* IgG antibodies were detected in 29 (22.8%) of 127 male inmates and in
13 (10.2%) of 127 male controls. Seroprevalence of anti-
*T. gondii* IgG antibodies was significantly higher in male
inmates than in male controls (OR = 2.59; 95% CI: 1.27–
5.26; *P* = 0.006). The prevalence of high (>150 IU/ml)
anti-
*T. gondii* IgG antibody levels was similar in male
(18/127: 14.2%) and female (4/39: 10.3%) inmates (*P* =
0.78).

With respect to socio-demographic and incarceration
characteristics (Table 1), four characteristics had *P*
values ≤ 0.25: birth place (*P* = 0.0001), residence before incar-
ceration (*P* = 0.003), marital status (*P* = 0.003), and number
of incarcerations (*P* = 0.25). Other socio-demographic
and incarceration characteristics in inmates including age,
gender, occupation, socioeconomic status, jail section, and
duration of incarcerations had *P* values > 0.25.

Of the clinical characteristics, the seroprevalence of
*T. gondii* infection in healthy inmates (22.5%) was com-

| Table 2. Bivariate analysis of selected behavioral characteristics in inmates and *T. gondii* seroprevalence |
|---------------------------------------------------------------|
| Characteristic | Subjects tested | Prevalence of *T. gondii* infection | *P* value |
|----------------|----------------|----------------------------------|-----------|
| National trips |                |                                  |           |
| Yes            | 79             | 14                               | 17.7      | 0.39 |
| No             | 82             | 19                               | 23.2      |       |
| Traveled abroad|                |                                  |           |
| Yes            | 59             | 13                               | 22        | 0.82 |
| No             | 107            | 22                               | 20.6      |       |
| Drug abuse     |                |                                  |           |
| Yes            | 66             | 15                               | 22.7      | 0.69 |
| No             | 99             | 20                               | 20.2      |       |
| Alcoholism     |                |                                  |           |
| Yes            | 104            | 26                               | 25        | 0.12 |
| No             | 62             | 9                                | 14.5      |       |
| Tattoos        |                |                                  |           |
| Yes            | 52             | 10                               | 19.2      | 0.69 |
| No             | 114            | 25                               | 21.9      |       |
| Piercing       |                |                                  |           |
| Yes            | 59             | 13                               | 22        | 0.82 |
| No             | 107            | 22                               | 20.6      |       |
| Sexual promiscuity |            |                                  |           |
| Yes            | 61             | 11                               | 18        | 0.4  |
| No             | 102            | 24                               | 23.5      |       |
| Condom use     |                |                                  |           |
| Yes            | 42             | 5                                | 11.9      | 0.09 |
| No             | 120            | 29                               | 24.2      |       |
| Homosexuality  |                |                                  |           |
| Yes            | 8              | 2                                | 25        | 0.67 |
| No             | 158            | 33                               | 20.9      |       |
| Bisexuality    |                |                                  |           |
| Yes            | 2              | 0                                | 0         | 1     |
| No             | 163            | 35                               | 21.5      |       |

*Subjects with available data*
Seroprevalence of *T. gondii* infection was similar (*P* = 0.33) in inmates with blood transfusions (5/16: 31.3%) than those without blood transfusions (30/150: 20%). The frequency of *T. gondii* infection was similar (*P* = 1.0) in inmates with history of surgeries (17/83: 20.5%) than those without surgeries (18/83: 21.7%). In contrast, seroprevalence of *T. gondii* infection was higher (*P* = 0.03) in inmates that had suffered from injuries (17/56: 30.4%) than those without such history (18/110: 16.4%). In women, none of the obstetric characteristics, including pregnancies, deliveries, cesarean sections, and abortions, was associated with *T. gondii* seroprevalence.

Concerning the behavioral characteristics of the inmates examined (Table 2), only two variables had *P* values ≤ 0.25 in the bivariate analysis: alcoholism (*P* = 0.12), and no use of condom (*P* = 0.09). Multivariate analysis of socio-demographic, incarceration and behavioral characteristics of inmates that had *P* values ≤ 0.25 in the bivariate analysis revealed that only one characteristic was associated with *T. gondii* seropositivity: being born out of Durango State (OR = 3.91; 95% CI: 1.29–11.79; *P* = 0.01).

**Discussion**

The impact of infection on inmates has been studied for a number of viral and bacterial infections but not for the protozoan parasite *T. gondii*. In a study of 279 autopsies of prison inmates and non-incarcerated patients with AIDS in Texas, USA, researchers found *T. gondii* encephalitis in nine cases [18]. However, the report did not mention whether such nine cases were observed in inmates or non-incarcerated patients. Since there is not any previous report on the seroprevalence of *T. gondii* infection in inmates, the present study was performed to investigate the seroprevalence and correlates of infection with *T. gondii* in inmates in Durango, Mexico.

Crime has been associated with mental disorders, i.e., violent behavior of patients suffering from schizophrenic and bipolar disorder is an important public health problem [19]. Of interest, schizophrenia has been linked to homicidal behavior [20], and infection with *T. gondii* appears to be associated with schizophrenics [21–23] and other psychiatric disorders [24, 25]. Thus, one can hypothesize that on one hand infection with *T. gondii* may trigger mental disorders that subsequently lead to behavior changes, crime, and incarceration; on the other hand, incarceration may increase the likelihood of infection with the parasite due to exposure to particular risk factors.

Interestingly, we found that the prevalence of *T. gondii* exposure was significantly higher in inmates than in controls. In addition, the high seroprevalence of *T. gondii* exposure found in inmates (21.1%) is one of the highest seroprevalences reported in population groups in Durango City until now. Seroprevalences found in inmates are as high as the 20% seroprevalence of *T. gondii* exposure reported in patients suffering from schizophrenia [22] and the 21.1% seroprevalence found in waste pickers in Durango City [26]. The seroprevalence found in inmates is also higher than the 6.1–13.3% seroprevalences found in healthy and ill populations in Durango City, including blood donors [27], general population [16], patients with visual impairment [28], liver diseases [29], and people occupationally exposed to raw meat [30] and unwashed fruits and vegetables [31]. The seroprevalence found in inmates is comparable with the weighted mean national seroprevalence of *T. gondii* infection (19.27%) reported in Mexico [32]. It is not clear why inmates had a higher seroprevalence of *T. gondii* exposure than controls. Inmates were confined to the correctional facility, and cats were not observed in the correctional facility. It is not clear whether infection with *T. gondii* was obtained before or during incarceration. Only two inmates had anti-*T. gondii* IgM antibodies and their duration in jail had been 10 months. We were unable to obtain information about eating habits known to be associated with *T. gondii* infection in inmates. Remarkably, seroprevalence of *T. gondii* infection in inmates was high even in the youngest individuals, and there was no increase with age as reported in general population [16]. Regression analysis showed that being born outside of Durango State was associated with *T. gondii* seropositivity. Therefore, such characteristic may have contributed for the high seroprevalence of *T. gondii* exposure in inmates. Previous studies in Durango have shown that seroprevalence of *T. gondii* exposure was higher in persons born in Mexican States other than Durango State than those born in Durango, including general population [16], elderly people [33], and patients suffering from hearing and visual impairments, cancer, human immunodeficiency virus infection, or undergoing hemodialysis [28]. It is likely that inmates born outside Durango State have different behavioral risk for *T. gondii* infection than inmates born in Durango. Intriguingly, regression analysis showed that *T. gondii* was similar in inmates regardless their residence either in Durango or outside Durango. It is not clear why inmates born outside Durango have a higher seroprevalence than those born in Durango. Unknown risk factors for *T. gondii* infection are present in inmates born outside Durango State. We were unable to examine other putative risk factors for *T. gondii* infection, including contact with cats and meat consumption in inmates, because we studied archival data from a hepatitis viruses survey that contained only data related with parenteral or sexual transmission of hepatitis viruses. We cannot rule out the contributing role of food or water in *T. gondii* exposure in inmates. However, information about the source of food was not provided. It is unclear whether the risk of eating contaminated food or water is higher in correctional facilities than elsewhere.

Further studies to examine behavioral factors associated with *T. gondii* exposure in inmates are needed. Results of the present study raise a number of questions: 1) Are there any mental disorders associated with *T. gondii* infection in inmates that have contributed to commitment of crimes? 2) Is there any type of crime associated with infection with *T. gondii*? 3) Did inmates obtain the infection before incar-
ceration or during their stay in jail? 4) Was any food related with infection with *T. gondii* in inmates? Additional studies should be conducted to address these issues.

We conclude that the seroprevalence of *T. gondii* exposure in inmates is higher than those found in non-incarcerated controls and in the great majority of population groups studied in the same city. Therefore, results indicate that inmates are a new risk group for *T. gondii* exposure. Results warrant for further research on *T. gondii* infection in inmates.

**References**

1. Hill DE, Chirukandoth S, Dubey JP: Biology and epidemiology of *Toxoplasma gondii* in man and animals. Anim Health Res Rev 6, 41–61 (2005)
2. Montoya JG, Liesenfeld O: Toxoplasmosis. Lancet 363, 1965–1976 (2004)
3. Weiss LM, Kim K: The International Congress on Toxoplasmosis. Int J Parasitol 34, 249–252 (2004)
4. Hill D, Dubey JP: *Toxoplasma gondii*: transmission, diagnosis and prevention. Clin Microbiol Infect 8, 634–640 (2002)
5. Yoshida N, Tyler KM, Llewellyn MS: Invasion mechanisms among emerging food-borne protozoan parasites. Trends Parasitol 27, 459–466 (2011)
6. Figueroa Damián R: Risk of transmission of infectious diseases by transfusion. Ginecol Obstet Mex 66, 277–283 (1998)
7. Barsoum RS: Parasitic infections in transplant recipients. Nat Clin Pract Nephrol 2, 490–503 (2006)
8. Bick JA: Infection control in jails and prisons. Clin Infect Dis 45, 1047–1055 (2007)
9. Nunn A, Cornwall A, Fu J, Bazerman L, Loewenthal H, Beckwith C: Linking HIV-positive jail inmates to treatment, care, and social services after release: results from a qualitative assessment of the COMPASS Program. J Urban Health 87, 954–968 (2010)
10. Vescio MF, Longo B, Babudieri S, Starnini G, Carbonara S, Rezza G, Monarca R: Correlates of hepatitis C virus seropositivity in prison inmates: a meta-analysis. J Epidemiol Community Health 62, 305–313 (2008)
11. Baussano I, Williams BG, Nunn P, Beggiato M, Fedeli U, Piedra LJ, Duran-Morales E, Estrada-Martínez S, Martinez-García SA, Liesenfeld O: Seroepidemiology of *Toxoplasma gondii* infection in psychiatric inpatients in a Northern Mexican city. BMC Infect Dis 6, 178 (2006)
12. Centers for Disease Control and Prevention (CDC): Outbreak of Shiga toxin-producing *Escherichia coli* O111 infections associated with a correctional facility dairy – Colorado, 2010. MMWR Morb Mortal Wkly Rep 61, 149–152 (2012)
13. Rambar R, Hosseini MJ, Kaffashan AR, Farshad S: An outbreak of shigellosis due to *Shigella flexneri* serotype 3a in a prison in Iran. Arch Iran Med 13, 413–416 (2010)
14. Greig JD, Lee MB, Harris JE: Review of enteric outbreaks in prisons: effective infection control interventions. Public Health 125, 222–228 (2011)
15. Alvarado-Esquível C, Hernández-Tinoco J, Sánchez-Anguiano LF, Ramos-Navárez A, Cerrillo-Soto SM, Sáenz-Soto L: High seroprevalence of *Helicobacter pylori* infection in inmates: a case control study in a northern Mexican city. Gastroenterol Res 6, 227–232 (2013)
16. Alvarado-Esquível C, Estrada-Martínez S, Pizarro-Villalobos H, Arce-Quíjones M, Liesenfeld O, Dubey JP: Seroepidemiology of *Toxoplasma gondii* infection in general population in a northern Mexican city. J Parasitol 97, 40–43 (2011)
17. Alvarado-Esquível C, Sablon E, Martínez-García S, Estrada-Martínez S: Hepatitis virus and HIV infections in inmates of a state correctional facility in Mexico. Epidemiol Infect 133, 679–685 (2005)
18. Lyon R, Haque AK, Asmuth DM, Woods GL: Changing patterns of infections inpatients with AIDS: a study of 279 autopsies of prison inmates and nonincarcerated patients at a university hospital in eastern Texas, 1984–1993. Clin Infect Dis 23, 241–247 (1996)
19. Volavka J: Violence in schizophrenia and bipolar disorder. Psychiatr Danub 25, 24–33 (2013)
20. Belli H, Ural C: The association between schizophrenia and violent orhomicidal behaviour: the prevention and treatment of violent behaviour in these patients. West Indian Med J 61, 538–543 (2012)
21. Yolken RH, Dickerson FB, Fuller Torrey E: *Toxoplasma* and schizophrenia. Parasite Immunol 31, 706–715 (2009)
22. Alvarado-Esquível C, Urbina-Álvarez JD, Estrada-Martínez S, Torres-Castorena A, Molotla-de-León G, Liesenfeld O, Dubey JP: *Toxoplasma gondii* infection and schizophrenia: a case control study in a low *Toxoplasma* seroprevalence Mexican population. Parasitol Int 60, 151–155 (2011)
23. Arias I, Sorlozano A, Villegas E, de Dios Luna J, McKinney K, Cervilla J, Gutierrez B, Gutierrez J: Infectious agents associated with schizophrenia: a meta-analysis. Schizophr Res 136, 128–136 (2012)
24. Alvarado-Esquível C, Alanis-Quíones OP, Arreola-Valenzuela MA, Rodríguez-Briones A, Piedra-Nevarez LJ, Duren-Morales E, Estrada-Martínez S, Martinez-García SA, Liesenfeld O: Seroepidemiology of *Toxoplasma gondii* infection in psychiatric inpatients in a Northern Mexican city. BMC Infect Dis 6, 178 (2006)
25. James BO, Agbonile IO, Okolo M, Lawani AO, Omoaregba JO: Prevalence of *Toxoplasma gondii* infection among individuals with severe mental illness in Nigeria: a case control study. Pathog Glob Health 107, 189–193 (2013)
26. Alvarado-Esquível C, Liesenfeld O, Márquez-Conde JA, Cinseros-Camacho A, Estrada-Martínez S, Martinez-García SA, González-Herrera A, García-Corral N: Seroepidemiology of infection with *Toxoplasma gondii* in waste pickers and wasteworkers in Durango, Mexico. Zoonoses Public Health 55, 306–312 (2008)
27. Alvarado-Esquível C, Mercado-Suarez MF, Rodríguez-Briones A, Fallad-Torres L, Ayala-Ayala JO, Nerezz-Piedra LJ, Duren-Morales E, Estrada-Martínez S, Liesenfeld O, Márquez-Conde JA, Martinez-García SA: Seroepidemiology of infection with *Toxoplasma gondii* in healthy blood donors of Durango, Mexico. BMC Infect Dis 7, 75 (2007)
28. Alvarado-Esquível C, Liesenfeld O, Torres-Castorena A, Estrada-Martínez S, Urbina-Alvarez JD, Ramos-de la Rocha M, Márquez-Conde JA, Dubey JP: Seroepidemiology of *Toxoplasma gondii* infection in patients with vision and hearing impairments, cancer, HIV, or undergoing hemodialysis in Durango, Mexico. J Parasitol 96, 505–508 (2010)
29. Alvarado-Esquivel C, Torres-Berumen JL, Estrada-Martínez S, Liesenfeld O, Mercado-Suarez MF: *Toxoplasma gondii* infection and liver disease: a case-control study in a northern Mexican population. Parasit Vectors 4, 75 (2011)

30. Alvarado-Esquivel C, Liesenfeld O, Estrada-Martínez S, Félix-Huerta J: *Toxoplasma gondii* infection in workers occupationally exposed to raw meat. Occup Med (Lond) 61, 265–269 (2011)

31. Alvarado-Esquivel C, Estrada-Martínez S, Liesenfeld O: *Toxoplasma gondii* infection in workers occupationally exposed to unwashed raw fruits and vegetables: a case control seroprevalence study. Parasit Vectors 4, 235 (2011)

32. Galvan-Ramirez Mde L, Troyo R, Roman S, Calvillo-Sanchez C, Bernal-Redondo R: A systematic review and meta-analysis of *Toxoplasma gondii* infection among the Mexican population. Parasit Vectors 5, 271 (2012)

33. Alvarado-Esquivel C, Liesenfeld O, Burciaga-López BD, Ramos-Nevárez A, Estrada-Martínez S, Cerrillo-Soto SM, Carrete-Ramírez FA, López-Centeno Mde L, Ruiz-Martínez MM: Seroepidemiology of *Toxoplasma gondii* infection in elderly people in a northern Mexican city. Vector Borne Zoonotic Dis 12, 568–574 (2012)