

Original Article

Seroprevalence, Seroconversion, and Risk Factors for Toxoplasmosis among Pregnant Women in Taipei, Taiwan

Ching-Sheng Hung¹, Hung-Wen Su², Yu-Luen Lee³, Hui-Wen Weng¹, Yin-Chin Wang^{4,5}, Toshio Naito^{7,8}, Akiko Tsubouchi⁹, Giueng-Chueng Wang¹, and Chia-Kwung Fan^{4,5,6*}

¹Department of Laboratory Medicine;

²Department of Obstetrics and Gynecology, Wan Fang Hospital;

³Department of Microbiology and Immunology;

⁴Department of Molecular Parasitology and Tropical Diseases;

⁵Center for International Tropical Medicine, School of Medicine, College of Medicine; and

⁶Master Program of Global Health and Development, College of Public Health and Nutrition, Taipei Medical University, Taipei, Taiwan;

⁷Department of General Medicine;

⁸Department of Infection Control Science; and

⁹Research Support Center, School of Medicine, Juntendo University, Tokyo 113-8431, Japan

SUMMARY: Herein, we determined the seroprevalence, seroconversion, and risk factors associated with *Toxoplasma gondii* (*T. gondii*) infection among pregnant women in Taipei, Taiwan. Pregnant women attending antenatal consultation in a Taipei medical center were invited, and 104 women completed a self-administered structured questionnaire. Venous blood samples were collected during the first and third trimester after consent was obtained. Serum IgG and IgM antibodies (Abs) as well as IgG avidity were analyzed using an enzyme-linked fluorescent assay. Of the samples collected in the first trimester, seven were seropositive for IgG Abs and one was seropositive for IgG + IgM Abs with a borderline avidity index, resulting in an overall seroprevalence of 7.7%. No statistically significant association was found between toxoplasmosis and age, pregnancy history, or any risk factors. Seroconversion was not detected from paired sera between the first and third trimesters. Pregnant women with senior high school education level or those who claimed to know *Toxoplasma* exhibited a significantly higher seroprevalence than those with bachelor degree ($P = 0.05$) or those who claimed not to have this knowledge ($P = 0.05$). Therefore, failure to understand the importance of *T. gondii* infection and the prevention measures resulted in the development of toxoplasmosis among these women.

INTRODUCTION

Toxoplasma gondii (*T. gondii*) is a zoonotic protozoa found worldwide, and cats have been identified as the definitive host. Humans can become infected with toxoplasmosis by drinking water or eating food contaminated with oocysts released in cat feces or by accidental ingestion of raw or undercooked meat, such as pork and lamb containing *T. gondii* tissue cysts (1,2). Most patients with primary infection are asymptomatic, only a few patients develop symptoms such as lymphadenitis and chorioretinitis. Nevertheless, asymptomatic patients carry a lifelong latent infection. In this stage, the *T. gondii* cysts conceal in host organs including the brain, heart, and skeletal muscles (3). The reactivation of *T. gondii* in immunocompromised patients with latent infection leads to toxoplasmic encephalitis with fatal consequences (3). A previous study has indicated

that latent chronic toxoplasmosis also increases the risk of neuropsychiatric disorders, particularly schizophrenia, depression, psychiatric hospitalization, and suicide (4).

After maternal infection with of *T. gondii* for the first time during gestation, the parasite enters the fetal circulation through the placenta, resulting in congenital toxoplasmosis (CT). Early maternal infection (in the first and second trimester) may result in severe CT and cause utero fetal death and spontaneous abortion. By contrast, late maternal infection (third trimester) typically results in normal appearance newborns. The infection is initially unnoticed; however, if left untreated, it can lead to mental and psychomotor retardation, microcephaly, hydrocephalus, seizures, blindness, and death when affected individuals reach the age of 20–30 years (5). The overall risk of maternal-fetal transmission of the parasite is estimated at approximately 30%; the risk of infection increases with increasing gestation time (3,6).

The direct detection of *T. gondii* is difficult, therefore, most clinical laboratories use serological tests to detect antibodies against *T. gondii*, such as the latex agglutination test, enzyme-linked immunosorbent assay (ELISA), and indirect fluorescent antibody test (IFAT) (7,8). Toxoplasmosis among pregnant women is a major concern in both developed and developing countries. In

Received June 17, 2014. Accepted October 27, 2014.
J-STAGE Advance Publication February 13, 2015.

DOI: 10.7883/yoken.JJID.2014.263

*Corresponding author: Mailing address: Department of Molecular Parasitology and Tropical Diseases, School of Medicine, College of Medicine, Taipei Medical University, Taiwan. Tel/Fax: +886-2-27395092, E-mail: tedfan@tmu.edu.tw

developed countries, the reported seroprevalence was 17.3% in the United Kingdom (9), 31.7% in Upper Austria (10), 43.8% in France (11), 4% in South Korea (12), and 10.3% in Japan (13). In developing countries, 6.1% to 20.0% of pregnant women in Mexico had anti-*Toxoplasma* IgG antibodies (14), 49.5% in Brazil (15), 10.6% in Changchun, northern China (16), 28.3% in southern Thailand (17), and 75.2% in Sao Tome and Principe, West Africa (18).

However, during the past 30 years, lifestyle, socioeconomic status, and the health care system have substantially changed in Taiwan. Overseas traveling for Taiwan residents has become more frequent and toxoplasmosis-endemic areas are reportedly popular visiting points (19). Although toxoplasmosis is rarely considered a major concern for pregnant women in Taiwan, in 2009, a case of CT with severe neurological manifestations was reported in a native Taiwanese neonate; thereafter, the Taiwan Health Authority began alerting the population about toxoplasmosis (20). In this study, we investigated the seroprevalence of toxoplasmosis and associated risk factors for pregnant women who attended our antenatal clinic for routine examinations in the Department of Obstetrics and Gynecology in Taipei Medical University-affiliated Wan Fang Hospital between September 2009 and February 2011.

PARTICIPANTS AND METHODS

Participant selection: This cross-sectional study evaluated, pregnant women who attended our antenatal clinic for routine examinations in the Department of Obstetrics and Gynecology in Taipei Medical University-affiliated Wan Fang Hospital, Taipei between September 2009 and February 2011. It was emphasized to each woman that participation in this study would be voluntary and anonymous. Informed consent was obtained from all participants. Overall, 104 pregnant women aged between 20 and 42 years (mean \pm SD = 30.91 \pm 3.85 years), expressed their willingness to participate in this study, and venous blood samples were obtained during the first and third trimesters for determination of serum-levels of anti-*T. gondii* antibodies.

Self-administered questionnaires: Self-administered questionnaires were administered to participants on the day of blood sample collection. Questionnaire items included the participant's knowledge of toxoplasmosis; nationality; age; educational background; maternal history; habits of consumption of certain foods such as unwashed fruits and vegetables, untreated water, and raw or undercooked meat or viscera; and history of contact with cats, cat feces, and soil.

Serological testing for toxoplasmosis: To define the maternal *Toxoplasma* serostatus, all serum samples from the first and third trimesters were tested for anti-*T. gondii* IgG and IgM antibodies (Abs) by ELISA by using the Vitek ImmunoDiagnostic Assay System (VIDAS Toxo IgG II and IgM, bioMérieux, Etoile, France) run in a VIDAS fully automated immunoanalyzer. The procedures and interpretation of the results were performed according to the manufacturer's instructions. For the IgG and IgM assays, positive results were defined as IgG/IgM values of ≥ 8 international units (IU)/mL and index values (IVs) of ≥ 0.65 .

Equivocal results were defined as IgG/IgM values ranging from 4 to 8 IU/mL and IVs ranging between 0.55 and 0.65. Negative results were defined as IgG/IgM values of < 4 IU/mL and IVs of < 0.55 . An IgM-positive sample was further tested for IgG avidity using a commercial kit (VIDAS Toxo IgG avidity; bioMérieux) performed using a VIDAS immunoanalyzer. The avidity index (AI) was the ratio of the signal in the test sample washed with 6 M urea, which disrupts low avidity complexes, to that in the sample washed without 6 M urea. The interpretation of AI was as follows: < 0.200 , low avidity; 0.200–0.300, borderline avidity; > 0.300 , high avidity. According to manufacturer's guidelines, high AI may exclude a recent infection contracted within the past 4 months of gestation whereas low AI does not exclude a recent infection contracted in less than 4 months of gestation, and can be interpreted as a probable recent infection. A borderline AI was considered as undefined toxoplasmosis.

Ethical considerations: The ethical approval of this study was obtained from the Taipei Medical University Joint Institutional Review Board (Approval No. 201009001). Written informed consent was obtained from all participants.

Statistical analysis: We categorized the participants into two age groups (20–29 years and ≥ 30 years) and two educational groups (junior or senior high school education level and bachelor degree or higher). Serum samples were considered seropositive if they showed any ELISA positivity. Data from self-administered questionnaires and ELISA examination were statistically analyzed using SPSS software (SPSS, Chicago, IL, USA). A logistic regression model was used to estimate crude odds ratios (ORs); 95% confidence intervals (CIs) were calculated to assess the strength of association, and *P* values (*P*) ≤ 0.05 were considered statistically significant.

RESULTS

Participant information: Overall, 104 pregnant women participated in this study. Demographic data, including age and educational levels, are shown in Table 1. The mean age of the participants was 30.91 \pm 3.85 years; the median age was 31 years. More than 50% of the participants had a bachelor degree or higher.

Seroprevalence and toxoplasmosis status: Of the 104 serum samples examined for *Toxoplasma*-specific IgG and IgM Abs, seven samples were seropositive for IgG Abs, and one sample was seropositive for IgG and IgM Abs; no sample was positive for IgM Abs alone. Therefore, the overall seroprevalence was 7.7% (8/104). Among the 104 pregnant women, 96 (92.3%) tested negative for *Toxoplasma*-specific IgG and IgM (IgG[–]/IgM[–]), indicating that they were not infected with *T. gondii*. Conversely, seven women (6.7%) tested positive for IgG and negative for IgM (IgG[+]/IgM[–]), indicating chronic toxoplasmosis infection. One participant was seropositive for both *Toxoplasma*-specific IgG and IgM (IgG[+]/IgM[+]). Therefore, the prevalence of possible maternal infection contracted during pregnancy was 1.0% (1/104). However, this same patient showed a borderline AI (0.287), which was considered as undefined toxoplas-

Table 1. Logistic regression analysis of demographic characteristics and seroprevalence with crude odds ratios (ORs) and 95% confidence intervals (CIs) for toxoplasmosis among pregnant women in Taipei, Taiwan

Variable	Group	No. of women	No. of seropositive for <i>T. gondii</i>	Percentage of seropositive for <i>T. gondii</i> (%)	OR	95% CI	<i>P</i> value
Antibody responses	IgG(+)/IgM(+)	104	1	1.0	ND ¹⁾	ND	ND
	IgG(+)/IgM(-)	104	7	6.7	ND	ND	ND
	IgG(-)/IgM(+)	104	0	0.0	ND	ND	ND
Age (yr)	20-29	32	4	12.5	2.4	0.6-10.4	0.22
	≥30	72	4	5.7	Ref. ²⁾		
Educational level	Senior high school or lower	23	4	17.4	3.8	1.1-16.8	0.05
	Bachelor degree or higher	77	4	5.2	Ref.		
	Not described	4	0	0.0	ND	ND	ND
Pregnancy history	First gestation						
	Yes	59	4	6.8	Ref.		
	No	38	3	7.9	1.2	0.25-5.6	0.84
	Abortion history						
	Yes	26	2	7.7	Ref.		
	No	70	5	7.1	0.9	0.17-5.1	0.93
	Had a hydrocephalus baby						
Yes	2	0	0.0	ND	ND	ND	
No	91	7	7.7	ND	ND	ND	
Knowledge of <i>Toxoplasma</i>	Knows <i>Toxoplasma</i>						
	Yes	38	5	13.2	4.1	0.6-12.4	0.05
	No	62	2	3.2	Ref.		
	Knows infection routes						
	Yes	83	6	7.2	1.9	0.4-9.0	0.76
	No	19	1	5.3	Ref.		
Knows effects on fetus	Yes	29	3	10.3	1.9	0.4-9.0	0.42
	No	69	4	5.8	Ref.		

¹⁾: Not determined.

²⁾: Reference for each statistics.

mosis.

Sociodemographic characteristics and associated risk factors for toxoplasmosis: The seroprevalence of toxoplasmosis was significantly higher among pregnant women with a senior high school or lower education level (17.4%, 4/23) compared with those who held a bachelor or higher degree (5.2%, 4/77) (OR = 3.8, 95% CI = 0.9-16.8, *P* = 0.05). However, no significant difference in the seroprevalence was found between the age groups of 20-29 years (12.5%, 4/32) and ≥30 years (5.7%, 4/72) (OR = 2.4, 95% CI = 0.6-10.4, *P* = 0.22). With regard to pregnancy history, no significant difference was found in seroprevalence was found between pregnant women who were in the first gestation and those who were not, and between pregnant women who had both an abortion history and hydrocephalus newborns and those who did not have either (*P* > 0.05) (Table 1). Pregnant women who claimed to know *Toxoplasma* showed a statistically higher seroprevalence compared with those who did not know *Toxoplasma* (OR = 4.1, 95% CI = 0.6-12.4, *P* = 0.05). However, no statistical difference in seroprevalence was observed between the pregnant women who claimed to have knowledge of the infection route or the effects on the fetus and those who did not know (*P* > 0.05) (Table 1). Risk factors including coming into contact with cats or soil, eating raw or undercooked meat, eating frozen meat, drinking un-

boiled water, and traveling abroad did not significantly contribute to infection with toxoplasmosis (Table 2).

DISCUSSION

Toxoplasmosis is an endemic zoonotic parasitic disease found worldwide. Although most infections are asymptomatic, toxoplasmosis can cause spontaneous abortion, fetal death, and severe CT. Except for child-bearing women, it is assumed that women of postmenopausal age infected with *T. gondii* have a significantly higher risk of suicide (21), but this assumption requires further investigation. Therefore, toxoplasmosis among women of childbearing and postmenopausal age should be considered a major public health concern. The overall seroprevalence in the 104 pregnant women evaluated in this study was 7.7% (8/104). Our results indicated that the seroprevalence of toxoplasmosis among pregnant women in Taipei was much lower than that reported among aboriginal pregnant women (40.6%) and immigrant pregnant women (18.2%) in Central Taiwan (22), but was similar to that reported in a previous study on Taiwanese pregnant women in Taipei (9.1%) (19), and in Central Taiwan (11.8%) (23). Compared with neighboring countries, the overall seroprevalence in the present study was similar to that reported in Japan (10.3%) (13), and in Changchun, northern China

Table 2. Logistic regression analysis of risk factors and seroconversion status with crude odds ratios (ORs) with 95% confidence intervals (CIs) for toxoplasmosis among pregnant women in Taipei, Taiwan

Variable	Group	No. of women	No. of seropositive for <i>T. gondii</i>	Percentage of seropositive for <i>T. gondii</i> (%)	OR	95% CI	P value
Risk factors	Contact with cats						
	Yes	10	1	10	1.8	0.2–17.0	0.61
	No	85	5	5.9	Ref. ¹⁾		
	Eat raw or undercooked meat						
	Yes	63	4	5.9	0.7	0.1–3.2	0.68
	No	33	3	7.7	Ref.		
	Eat frozen meat						
	Yes	67	4	6.0	0.6	0.1–3.7	0.61
	No	22	2	9.1	Ref.		
	Drink unboiled water						
	Yes	16	2	12.5	2.1	0.4–12.2	0.38
	No	80	5	6.3	Ref.		
	Contact with soil						
	Yes	25	0	0	ND ²⁾	ND	ND
No	69	6	8.7				
Travel abroad							
Yes	20	3	15.0	3.2	0.7–15.5	0.14	
No	76	4	5.3	Ref.			
Seroconversion status	Third gestation	104	8	7.7	1.0	0.4–2.8	1.0
	First gestation	104	8	7.7	Ref.		
Total		104	8	7.7	ND	ND	ND

¹⁾: References for each statistics.

²⁾: Not determined.

(10.6%) (16); however, the overall seroprevalence in the present study was higher than that reported in South Korea (4%) (12). The difference in seroprevalence among pregnant women in different districts may be attributable to the habits of aboriginal Taiwanese populations of consuming raw liver or other meat products from pigs and rats, as well as to their low economic status, leading to increased risks of infection with toxoplasmosis (22,24,25); however, immigrant pregnant women may be susceptible to toxoplasmosis because of poor hygiene habits associated with their low socioeconomic status, resulting in a high seroprevalence (22). Nevertheless, immigrant pregnant women may have been infected before they came to Taiwan and should not be ignored. Of note, toxoplasmosis is considered an infection associated with poverty even in the United States (26). A considerable number of studies have indicated that several factors can explain the wide variation in the seroprevalence of toxoplasmosis in humans between countries and often within a specific country or between different communities in the same region, including dietary habits, socioeconomic status, cultural habits, quality of water, and sanitation coverage (7,27).

Among the eight seropositive cases positive for serum anti-*T. gondii* IgG Abs, only one case was positive for both anti-*T. gondii* IgG and IgM Abs, and a subsequent IgG avidity test showed a borderline AI of 0.287. However, the titers of IgG and IgM Abs of 9 IU/mL and 1.1 IV, respectively, were low in the first trimester; thereafter, a second test revealed that the titers of IgG and IgM Abs remained stable at 10 IU/mL and 0.97 IV, respectively, in the third trimester. These results indicate that the change in the titers of IgG and IgM Abs was rel-

atively small; notably, the titer of IgM Abs remained low from the first to third trimester, suggesting that a recent primary infection can be excluded (28). Although this participant had two abortions and this was her third pregnancy, fetal health was assessed in regular ultrasound check-ups to assess the health status of the newborn. Because most ELISA and IgM/immunosorbent agglutination assay (ISAGA) techniques can detect IgM Abs months or years after infection, by monitoring a cohort of 446 women infected with toxoplasmosis during pregnancy, Gras et al. (29) reported that IgM Abs persisting for more than 2 years were detected using ISAGA and IFAT in 27% and 9% of women, respectively. Therefore, the detection of IgM Abs is no longer a marker of recent infection, unless IgM Abs are observed at high titers; alternatively, a method currently used to confirm or discard a recent infection is the determination of IgG avidity (3). A high avidity ratio can exclude an infection contracted in the preceding 4 months, consequently discarding an infection contracted during gestation if the test was performed during the first trimester. However, when AI is low or intermediate, the interpretation is ambivalent, because AI cannot exclude an infection contracted in the preceding 4 months or confirm that the infection is recent, unless the index is extremely low. Nevertheless, the advantage of avidity testing is that it ensures that unnecessary spiramycin treatment in pregnant women and unjustified long-term follow-up of fetuses and infants are avoided (3).

Although the sample size of our study (104 participants) was small, the risk factors associated with toxoplasmosis were hardly identified using the present questionnaire. However, eating undercooked or frozen meat

or drinking unboiled water are likely risk factors among pregnant women for contracting toxoplasmosis because risk factor analysis of data of the eight seropositive pregnant women showed that 62.5% (5/8) and 50.0% (4/8) of them had a history of eating undercooked or frozen meat, respectively, and 37.5% (3/8) of the participants had a history of drinking unboiled water. This hypothesis is largely supported by a large-scale seroepidemiological study on toxoplasmosis conducted in 2010 among healthy blood donors in Tiwan, indicating that the consumption of undercooked meat was an independent risk factor for *Toxoplasma* seropositivity (30).

The present study demonstrated that pregnant women with a senior high school educational level or lower had a higher seroprevalence of toxoplasmosis compared with those with a bachelor degree or higher. Therefore, pregnant women with a higher educational level should have more knowledge of *T. gondii* biology to prevent toxoplasmosis. However, pregnant women who claimed to know *Toxoplasma* had a higher seroprevalence compared with those who did not have this knowledge. Further analysis showed that 2 of 5 pregnant women with a senior high school education level or lower who claimed to know *Toxoplasma* had a higher seropositive rate (40%) than those with a bachelor degree or higher who claimed to know *Toxoplasma* (9.1%, 3/33). This result may be attributable to a misunderstanding or misinterpretation of the phrase “knowing *Toxoplasma*” by the participants with a low education level. Nevertheless, pregnant women who claimed to know *Toxoplasma* might have overlooked the importance of prevention measures to avoid being accidentally infected with toxoplasmosis or their knowledge of toxoplasmosis might have been incorrect, leading to a condition of frequent exposure to *T. gondii*. Similar findings have been reported in the United States, wherein a national survey showed that pregnant women’s level of knowledge of toxoplasmosis symptoms and measures was relatively low to prevent infection among those with a senior high school education level, whereas, except for the risk of transmission from cats, knowledge on toxoplasmosis among all pregnant women surveyed was low. Therefore, correct information about practices aimed to prevent foodborne toxoplasmosis as well as general information about toxoplasmosis should be continuously provided (31). Evidence from previous studies underscores the importance of health education on toxoplasmosis; a study in Belgium demonstrated that health education was associated with a 63% reduction in *T. gondii* seroconversion among pregnant women (32). In addition, a study in Poland demonstrated that toxoplasmosis-related education of pregnant women doubled their level of knowledge about the disease and prevention in 4 years (33). Therefore, it is urgent for the Taiwan Health Authority to offer adequate health education programs on toxoplasmosis to pregnant women not yet infected with toxoplasmosis to avoid the occurrence of CT during pregnancy.

Acknowledgments We are grateful for support from Taipei Medical University-Municipal Wan Fang Hospital (8wf-eva-18) and Medical Foundation in Memory of Dr. Deh-Lin Cheng (MF-DLC 99019Se). In addition, we thank Ms. May Chou, Ms. Jessica Huang,

and Dr. Liao for technical assistance. Also, we are thankful to Mr. Sorrel Tilley for critical revision of this manuscript.

Conflict of interest None to declare.

REFERENCES

- Petersen E. Toxoplasmosis. *Semin Fetal Neonatal Med.* 2007;12:214-23.
- Jones JL, Dubey JP. Foodborne toxoplasmosis. *Clin Infect Dis.* 2012;55:845-51.
- Robert-Gangneux F, Dardé ML. Epidemiology of and diagnostic strategies for toxoplasmosis. *Clin Microbiol Rev.* 2012;25:264-96.
- Khandaker GM, Zimbron J, Lewis G, et al. Prenatal maternal infection, neurodevelopment and adult schizophrenia: a systematic review of population-based studies. *Psychol Med.* 2013;43:239-57.
- Montoya JG, Liesenfeld O. Toxoplasmosis. *Lancet.* 2004;363:1965-76.
- Paquet C, Yudin MH. Toxoplasmosis in pregnancy: prevention, screening, and treatment. *J Obstet Gynaecol Can.* 2013;35:78-9.
- Fan CK, Lee LW, Liao CW, et al. *Toxoplasma gondii* infection: relationship between seroprevalence and risk factors among primary schoolchildren in the capital areas of Democratic Republic of São Tomé and Príncipe, west africa. *Parasit Vectors.* 2012;5:141.
- Murat JB, Dard C, Fricker-Hidalgo H. Comparison of the Vidas system and two recent fully automated assays for diagnosis and follow-up of toxoplasmosis in pregnant women and newborns. *Clin Vaccine Immunol.* 2013;20:1203-12.
- Flatt A, Shetty N. Seroprevalence and risk factors for toxoplasmosis among antenatal women in London: a re-examination of risk in an ethnically diverse population. *Eur J Public Health.* 2012;23:648-52.
- Sagel U, Krämer A, Mikolajczyk RT. Incidence of maternal toxoplasma infections in pregnancy in upper Austria, 2000-2007. *BMC Infect Dis.* 2011;11:348.
- Berger F, Goulet V, Le Strat Y, et al. Toxoplasmosis among pregnant women in France: risk factors and change of prevalence between 1995 and 2003. *Rev Epidemiol Sante Publique.* 2009;57:241-8.
- Han K, Shin DW, Lee TY, et al. Seroprevalence of *Toxoplasma gondii* infection and risk factors associated with seropositivity of pregnant women in Korea. *J Parasitol.* 2008;94:963-5.
- Sakikawa M, Noda S, Hanaoka M, et al. Anti-toxoplasma antibody prevalence, primary infection rate, and risk factors in a study of toxoplasmosis in 4,466 pregnant women in Japan. *Clin Vaccine Immunol.* 2012;19:365-7.
- Alvarado-Esquivel C, Sifuentes-Alvarez A, Narro-Duarte SG. Seroepidemiology of *Toxoplasma gondii* infection in pregnant women in a public hospital in northern Mexico. *BMC Infect Dis.* 2006;6:113.
- Fonseca AL, Silva RA, Fux B, et al. Epidemiologic aspects of toxoplasmosis and evaluation of its seroprevalence in pregnant women. *Rev Soc Bras Med Trop.* 2012;45:357-64.
- Liu Q, Wei F, Gao S, et al. *Toxoplasma gondii* infection in pregnant women in China. *Trans R Soc Trop Med Hyg.* 2009;103:162-6.
- Nissapatorn V, Suwanrath C, Sawangjaroen N, et al. Toxoplasmosis-serological evidence and associated risk factors among pregnant women in southern Thailand. *Am J Trop Med Hyg.* 2011;85:243-7.
- Hung CC, Fan CK, Su KE, et al. Serological screening and toxoplasmosis exposure factors among pregnant women in the Democratic Republic of Sao Tome and Principe. *Trans R Soc Trop Med Hyg.* 2007;101:134-9.
- Hu IJ, Chen PC, Su FC, et al. Perinatal toxoplasmosis, northern Taiwan. *Emerg Infect Dis.* 2006;12:1460-1.
- Chuang YC, Chen JY, Ji DD, et al. Congenital toxoplasmosis in a neonate with significant neurologic manifestations. *J Formos Med Assoc.* 2012;111:232-3.
- Ling VJ, Lester D, Mortensen PB, et al. *Toxoplasma gondii* seropositivity and suicide rates in women. *J Nerv Ment Dis.* 2011;199:440-4.
- Lin YL, Liao YS, Liao LR, et al. Seroprevalence and sources of *Toxoplasma* infection among indigenous and immigrant pregnant women in Taiwan. *Parasitol Res.* 2008;103:67-74.

23. Chou CS, Lin LY, Chen KM, et al. FlowCytomix analysis for *Toxoplasma gondii* infection in pregnant women in central Taiwan. *J Obstet Gynaecol.* 2011;31:375-9.
24. Fan CK, Su KE, Chung WC, et al. Seroprevalence of *Toxoplasma gondii* antibodies among Atayal aboriginal people and their hunting dogs in northeastern Taiwan. *Jpn J Med Sci Biol.* 1998;51:35-42.
25. Fan CK, Su KE, Wu GH, et al. Seroepidemiology of *Toxoplasma gondii* infection among two mountain aboriginal populations and Southeast Asian laborers in Taiwan. *J Parasitol.* 2002;88:411-4.
26. Hotez PJ. Neglected infections of poverty in the United States of America. *PLoS Negl Trop Dis.* 2008;2:e256.
27. Pappas G, Roussos N, Falagas ME. Toxoplasmosis snapshots: global status of *Toxoplasma gondii* seroprevalence and implications for pregnancy and congenital toxoplasmosis. *Int J Parasitol.* 2009;39:1385-94.
28. Montoya JG, Remington JS. Management of *Toxoplasma gondii* infection during pregnancy. *Clin Infect Dis.* 2008;47:554-66.
29. Gras L, Gilbert RE, Wallon M, et al. Duration of the IgM response in women acquiring *Toxoplasma gondii* during pregnancy: implications for clinical practice and cross-sectional incidence studies. *Epidemiol Infect.* 2004;132:541-8.
30. Chiang TY, Hsieh HH, Kuo MC, et al. Seroepidemiology of *Toxoplasma gondii* infection among healthy blood donors in Taiwan. *PLoS One* 2012;7:e48139.
31. Jones JL, Ogunmodede F, Scheftel J, et al. Toxoplasmosis-related knowledge and practices among pregnant women in the United States. *Infect Dis Obstet Gynecol.* 2003;11:139-45.
32. Foulon W, Naessens A, Derde MP. Evaluation of the possibilities for preventing congenital toxoplasmosis. *Am J Perinatol.* 1994; 11:57-62.
33. Pawlowski ZS, Gromadicka-Sutkiewicz M, Skommer J, et al. Impact of health education on knowledge and prevention behavior for congenital toxoplasmosis: the experience in Poznan, Poland. *Health Educ Res.* 2001;16:493-502.