



Original Research Article

Environmental and Food Habitat Risk Factors Associated with *Toxoplasma gondii* Infection in Rural Women in Sudan

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ABSTRACT

Keywords

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Risk Factors;
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The overall aim of this study was to determine the prevalence of the disease in certain group of women and to study the environmental and food habitat as risk factors associated with infection. A total of 255 plasma samples were collected from women participated in this study in two villages. Serological results, reflecting *Toxoplasma gondii* prevalence rate were statistically analyzed and linked to epidemiological data collected through a standard questionnaire. The prevalence was 73.1% by using ELISA IgG. The association of the risk factors to the disease discussed in this study. Contact with animals others than cats or dogs and participating in animals birth were significance to infection ($p < 0.01$). Consuming raw meat was highly significance to infection ($p < 0.001$). The present study indicates the need to provide health education to women in order to prevent primary infection during pregnancy.

Introduction

Toxoplasmosis is a parasitic disease caused by the protozoan *Toxoplasma gondii*. It is a coccidian parasite with cats as the definitive host, and warm-blooded animals as intermediate hosts (Frenkel *et al.*, 1970; Dubey, 2008).

Infection in humans is probably most often the result of ingestion of tissue cysts contained in raw or undercooked meat is common in many animals used for food, including sheep, pigs, and rabbits. Infection in cattle is less prevalent than

infection in sheep or pigs. Tissue cysts can survive in food animals for years (Dubey and Beattie, 1988).

Cultural habits may also affect the acquisition of *Toxoplasma gondii* infection; for example, in France the prevalence of antibodies to *Toxoplasma gondii* in humans is very high. Whereas 84% of pregnant women in Paris have antibodies to *Toxoplasma gondii*, comparable figures elsewhere are 32% in New York City and 22% in London (Dubey and Beattie, 1988). The high incidence of *Toxoplasma gondii* infection in humans in France appears to be related in part to the French habit of eating some of their meat raw. In contrast, the high prevalence of the infection in Central and South America is probably due to high levels of contamination of the environment by oocysts (Teutsch *et al.*, 1979). It should be noted, however, that the relative frequency of acquisition of toxoplasmosis from eating raw meat and that due to ingestion of food contaminated by oocysts from cat faeces is very difficult to determine and statements on the subject are at best controversial.

Outbreaks of acute toxoplasmosis in humans in various regions of the world demonstrate that the sources of infection vary greatly in different human populations with differences in culture and eating habits. In Canada, an outbreak of congenital toxoplasmosis in a settlement of Inuits in northern Quebec was associated with frequent consumption of caribou meat, in addition to skinning of fur animals, while seropositivity in pregnant women living in the same settlement was associated with consumption of dried seal meat, seal liver, and raw caribou meat (McDonald *et al.*, 1990; Pেকেles *et al.*, 1990). In Australia, an outbreak of acute and congenital toxoplasmosis was

associated with rare kangaroo meat and undercooked lamb satay which were consumed during a cocktail party in Queensland (Robson *et al.*, 1995). Environmental conditions, differences in the type of food consumed, animal species used in food industry, and the number of cats are examples of factors that may influence the spread of the parasite. Water-borne transmission of *Toxoplasma gondii* has earlier been considered uncommon, but recently human outbreaks connected to water reservoirs have been reported (Aramini *et al.*, 1999; Palanisamy *et al.*, 2006).

In different regions of the world, various types of factors have been implicated in toxoplasmosis transmission; however in the United States and France the ingestion of meat (beef, mutton, or pork) containing parasite cysts is the most common source of human infection (Remington and Desmonts, 1990) while high prevalence in Central America has been related to the frequency of stray cats in a climate favoring survival of oocysts (Lebech *et al.*, 1993).

The Enzyme Link Immunosorbent Assay (ELISA) for *Toxoplasma gondii* antibodies has been adapted for use in human and most domestic animals and modified methods have been developed for the detection of *Toxoplasma* antigen in body fluid. Because of its ease of use, cost-effectiveness and high sensitivity and specificity, it has replaced older tests in many laboratories (Johnson, 1990). These commercial ELISAs are usually based on antigen preparations derived from tachyzoites of *Toxoplasma gondii* (Johnson *et al.*, 1992).

Few studies were done in Sudan concerning the prevalence of the disease particularly, in childbearing age women as

individual group. The disease was identified at first time in 1966 and the prevalence was 61% (Carter and Fleck, 1966) using Dye test (DT). Another study was done in Khartoum State using ELISA test for IgG and IgM, prevalences obtained were 23.1% and 16.4% respectively (Adnan, 1994). The third study recorded 34.1% prevalence using ELISA IgG in Sudanese pregnant women (Elnahas *et al.*, 2003). In Geizera State where this study was done there was only one study done in 1991 by Abdel-Hameed. He recorded 41.7% sero-prevalence using LAT and also he studied some risk factors of transmission of the disease. This study was done in the capital of State. The current study was designed to determine the past infection and to study the risk factors associated with the infection.

Materials and Methods

Study area & Population

The study was performed in two villages; EL Massoudia and EL Nuba lay in the north of EL Geizera State (middle Sudan) located near Blue Nile, these villages belonging to EL Kamleen province about 50 kilometers south of the capital Khartoum. Most of population in these villages belongs to the same ethnic group. People in these areas presented low socio-economic status, thus people are farmers, animal breeders, or workers particularly after a big industry city was established near this area. Women live in simple life way and although most of them were not working but they lend a hand to improve the economic situation by bringing the water from river, or bringing the wood for cooking or take care of animals including contribution in birth of animals or participate in farms and agricultural process.

Study Design

The study was cross-sectional study for toxoplasmosis in women at the child bearing age. The sample size was calculated as 255 on a prevalence of 20% obtained from first 10 samples collected, $d = 0.05$ at a confidence level of 95%. A total of 5% of the sample population was added to the sample size. Two samples were missed due to the lack of plasma.

Data Collection

Consent form and questionnaire were filled for each individual. Consent form was signed and fingerprinted by each one after agreed participated in the study. Data were collected after convenient interview. The questionnaire was performed. There were questions eliciting socio-demographic data including age, education (illiteracy, primary school, secondary school, university or postgraduate), occupation, residency and related risk factors.

Samples Collection

The blood samples were collected under direct medical supervision by medial venipuncture using 5 ml syringe into heparinized tubes, plasma was obtained by centrifugation of the blood at 5000 rpm for 10 minutes. Plasma was kept in different labeled cryo tubes in -20o C till used. Plasma samples were sent in dry ice to National Reference Laboratory for Toxoplasmosis, Prague, Czech Republic where more investigations were done.

Detection of *Toxoplasma gondii* Antibodies

ELISA IgG (Test-line[®]) is designed for the detection of immunoglobulin G (IgG)

antibodies to *Toxoplasma gondii* in human plasma. The procedures were done according to manufacturing process.

Data Analysis

Statistical evaluation was done by the data obtained into the person computer (PC) using two different programs: (1) Statistical package for social science (SPSS) version 13.0 (SPSS Inc. Chicago, IL. USA) was used to calculate the descriptive statistics to obtain specified statistics on the variables for numerical (mean and median) and categorical (frequency or percentage), also we used this package to calculate the prevalence rate of the disease with different screening tests used. In addition, Chi² test was used for ordinal variables to find the significant different between the infection and risk factors. (2) Statistical analysis was performed by statistical software Stata, version 9.2 (Stata Corp LP, College Station, TX). We used Fisher's exact test (when cells values were less than 5), for comparison of frequencies among groups. Adjusted odd ratio (OR) and relative risk (RR) and 95% confidence interval (CI) were calculated by multivariate analysis using multiple, unconditional logistic regression. A *p*-value less than 0.05 were considered statistically significant.

Results and Discussion

Prevalence Using ELISA IgG

A total of 253 plasma samples from women were tested by using ELISA IgG. The results showed in the Table (1) indicated total prevalence rate of 185(73.1%) of women showed latent infection by *Toxoplasma gondii*. The prevalence rate in EL Nuba village was 82(60.7%) whilst the prevalence was 103(87.3%) in EL Massoudia village.

Risk Factors Related to Animals and Environment

156(60.9%) of women in this study were not rearing animals in their houses, the main kind of animals reared by women were goats 87(34.9%), 13(5.2%) of women were keeping poultry or sheep. In EL Nuba village women who were not rearing animals in their houses were 96(69.1%), women keeping goats were 34(24.5%) and other animals were found in 9(6.3%) of houses. In EL Massoudia about half of women had no animals in their houses 60(51.3%) and 53(45.3%) had goats and 4(3.4%) have other animals including sheep and poultry.

Cats Contact

Women who kept in their houses cats were 59(23.0%), some of them in EL Massoudia village 32 (27.4%) while in EL Nuba village was 27(19.4%). Most of cats kept indoor in both villages were 51(19.9%), most of women who kept cats indoor were in EL Massoudia village 30(25.6%), in EL Nuba village women who kept cats indoor were 21(15.1%). Some cats were stray, 14(5.5%) of women had contact with these cats. These stray cats were 8(5.8%) in EL Nuba village while they were 6(5.1%) in EL Massoudia village. Women who were feeding raw meat to cats were 42(16.4%) half of them in EL Nuba village 21(15.1%) as the other half in EL Massoudia village 21(17.9%). Women who were directly or indirectly contact with cats' feces were 36(14.1%), 17(12.2%) in EL Nuba village and 19(16.2%) in EL Massoudia village.

No relationship was found between contact with cats and infected women (*p*>0.4). Also no association between women infected and feeding raw meat to cats (*p*>0.7). There was no relationship

between women infected and cats keeping ($p>0.8$). Stray cats had no observed role in transmission of the infection to women in both villages ($p>0.5$). Furthermore, no relationship between infection in women and contact with cats faces during cleaning houses ($p>0.5$), Table (2).

Dogs Contact

14(5.5%) of this study target group kept dogs indoor; most of them, in EL Massoudia village was 9(7.7%) while in EL Nuba village was 5(3.6%). No association was found between contact with dogs and women infected with *Toxoplasma gondii* ($p>0.05$), Table (2).

Other Animals

The association between other animals and infection in women was significant ($p<0.01$). The risk was 82.3% compared with 67.7% in women not contact with animals. The OR 2.2 at 95% CI 1.2-4.2, Table (2).

Birthing Animals

Women in rural area usually participate in birthing animals, in this study women who participated in birthing goats were 23(9.0%) most of them in EL Massoudia village 17(14.5%) while 6(4.3%) in EL Nuba village.

The relationship between women who participated in birthing animals and infection with *Toxoplasma gondii* was detected ($p<0.01$). The risk was 95.5% compared with 70.9% in women who did not participate. The OR confirmed that 8.6 at 95% CI 1.4-3.6, Table (2).

Risk Factors Associated with Food Habitat

Eating Raw Meat

The food habitat of women in these villages was like this: women in these villages had eating meat of both beef and lamb (37.9%) while women who consumed beef meat only were 33.6%, and lamb meat consumed by 27.7%, and merely 0.8% were vegetarians. In EL Nuba village, about 47.5% depend on beef meat mainly, then 38.1% eat beef and lamb and thirdly 13.7% eat lamb. In EL Massoudia village the target study group 44.4% depend on lamb meat, then beef and lamb (37.6%) but (17.1%) depend on beef only. 177(69.1%) of Women in these villages consumed raw meat. In EL Nuba village 88(63.3%) consumed raw meat, while 89(76.1%) of women consumed raw meat in EL Massoudia village. Women who prefer to prepare meat for cooking by themselves were 215(84.0%), about 110(79.1%) of them in EL Nuba village and 105(89.7) in EL Massoudia village, most of them were washing hands after preparing meat (96.5%).

The association between eating raw meat and infection by *Toxoplasma gondii* was found highly significant ($p<0.001$). The risk was found to be 81.6% compared with 54.4% who were not eating raw meat. This result was confirmed by calculating the OR which was found 3.7 at 95% CI 2.1-6.7. Women who processed meat were more susceptible to get infection than others ($p<0.001$). The risk was found to be 77.8% compared with 48.7% with women not processing meat.

These results were confirmed by OR 3.7 at 95% CI 1.9-7.3. In this we found that, the kind of meat has no role in getting infection by *Toxoplasma gondii* ($p>0.5$) Table (3).

Drinking Unboiled Milk

Women in the two villages drink milk mainly from cows 176(68.8%), few of them depend on other sources of milk such as goats' milk 19(7.4%) or powdered milk 3(1.2%) and 8(3.1%) they don't drinking milk at all. Some of women in these areas used mixed milk from both cows and goats 15(13.7%) or from both cow and sheep 14(5.5%). In EL Nuba village all women drinking milk, most of them from cows 106(76.3%) and some of them used mixed milk from cows and goats 16(11.5%) others of women used goats' milk 7(5.0%) or mixed cows and sheep milk 8(5.8%) and very few depend on powdered milk 2(1.4%). In EL Massoudia village some of women were not drinking milk 8(6.8%) while other consumers were drinking mainly cow's milk 70(59.8%) and few of them were drinking goats milk 12(10.3%) or sheep milk 1(0.9%) or powdered milk 1(0.9%) and some of women consumed mix milk from cows and goats 19(16.2%) or cows and sheep 6(5.1%). Few of women in these areas were drinking unboiled milk 6(2.3%), three of them in EL Nuba village and the others in EL Massoudia village. The role of milk in transmission of *Toxoplasma gondii* was studied, the result shown no significance between drinking unboiled milk and infection ($p>0.05$). The study has also shown that women who were drinking milk of both goats and cattle were more infected by *Toxoplasma gondii* ($p<0.04$), Table (3).

Eating Habits

Taking raw eggs or insufficiently cooked

eggs was not famous in these areas. Women who eat raw or insufficiently cooked eggs were 17(6.6%). In EL Nuba village they were 10(7.2%) but in AL Massoudia village they were 7(6.0%). The frequency of women from two villages eating in restaurant were 30(11.7%), 17(12.2%) from EL Nuba village while 13(11.1%) from EL Massoudia village. No relationship was found between eating raw eggs and infection by *Toxoplasma gondii* ($p>0.4$). The association between eating in restaurants and infection with *Toxoplasma gondii* was observed ($p<0.002$), Table (3). The association between infection and eating fresh vegetables grown in the garden of the house was not observed ($p>0.1$).

Drinking Water

In these villages, people taking water from pipes. Pipes extended in all houses but 114(44.5%) of women had drank water directly from the river or streams, most of them from EL Nuba village 84(60.4%), 30(25.6%) from EL Massoudia village.

All women who participated in this study had tap water in their houses. The source of this water was the groundwater. Some of those women were using sometimes water from streams or river. The relation between using water from streams or river and infection with *Toxoplasma* was not found ($p>0.39$). Table (3).

Soil Contact

Eating soil is a habit used by some pregnant women during their early stage of pregnancy (Morning sickness). The association between contact with soil and infected by *Toxoplasma gondii* was not observed in this study ($p>0.2$). No relationship between infection and

chewing soil as well ($p>0.2$). Furthermore, no association was found between infection and working in garden in the house in this study ($p>0.29$).

Washing Hands

The participating women were questioned if they wash hands in these three cases: firstly: after cleaning their houses, no relationship between that and infection ($p>0.8$), secondly: before eating and also no relationship recorded ($p>0.7$), and thirdly after preparing meat and relationship was found ($p<0.005$).

Risk Factors Associated with Health Situation

Abortion

About 65(25.0%) of women who participated in this study gave a history of abortion. In EL Nuba village 30 (21.6%) of women in this study have history of abortion while 35(29.9%) aborted in EL Massoudia village. Women who did aborted were positive to *Toxoplasma gondii* compared to women not aborted ($p<0.002$). The risk was 87.7% in those who aborted compared with 68% in women who had not aborted. The RR was 1.3 at 95% CI 1.1-1.5. The result was confirmed by OR 3.3 at 95% CI 1.5-7.3, Table (4).

Children Death

Children death was 46(18.0%) in both villages, ages of children death ranged between 1-6 months. In EL Nuba 16(11.5%) of women have child or more died while the high per cent was in EL Massoudia village 30(25.6%).

The relation between mother infected with *Toxoplasma gondii* and the death of their baby was detected significantly ($p<0.009$). The risk was 88.9% compare with 69.7% in women who were negative to *Toxoplasma gondii* and the RR was 1.3. This finding was confirmed by calculating the OR which was 3.5 at 95% CI 1.3-8.9, Table (4).

Congenital Abnormalities

Although higher percentage of abortion and children death, few congenital disturbances were found (2 cases), one case in each village. There was no relationship in this study between cases of congenital abnormalities and mother infected by *Toxoplasma gondii* ($p>0.05$), Table (4).

The knowledge of factors associated with seroconversion in women is particularly important during their reproductive age in order to design preventive measures and avoid acute infections during pregnancy (Alvarado-Esquivel *et al.*, 2007).

Detection of IgG means latent toxoplasmosis and is used usually to determine people under the risk of infection and people who already got infection. In the present study 73.1% of women have got IgG antibodies against *Toxoplasma gondii* and 26.9% of women under risk and may get infection in the future.

Several studies were done over the world using ELISA IgG, some of them obtained high prevalence rate than we obtained here in the same target group (childbearing age) as in Madagascar where 84% was obtained (Lelong *et al.*, 1995), in Cameroon where 77% was recorded (Ndumbe *et al.*, 1992),

Table.1 Prevalence of *Toxoplasma gondii* by using ELISA IgG test in EL Nuba and EL Massoudia villages

Villages	Positive	Negative	Total
EL Nuba	82 (60.7%)	53 (39.3%)	135
EL Massoudia	103 (87.3%)	15 (12.7%)	118
Total	185 (73.1%)	68 (26.9%)	253

Table.2 Risk Factors Associated with Animals and Environment

Factor	Women Studied No. (%)	Risk Ratio & CI	Risk %	Adjusted Odd Ratio 95% CI	P-value
Cat Contact					
Yes	59(23.0)	0.92	69.0	0.77	0.4
No	195(77.0)	(0.77-1.12)	74.4	(0.40-1.44)	
Cat Feeding					
Yes	41(16.2)	0.96	70.7	0.87	0.7
No	212(83.8)	(0.77-1.20)	73.6	(0.42-1.80)	
Keeping Cat					
Indoor	203(80.2)	1.02	73.4	1.07	0.8
Outdoor	50(19.8)	(0.84-1.23)	72.0	(0.54-2.13)	
Stray Cat					
Yes	14(5.5)	0.90	64.3	0.64	0.5
No	239(94.5)	(0.59-1.30)	73.6	(0.22-1.90)	
Cat faces Contact					
Yes	36(14.2)	1.08	77.8	1.34	0.5
No	217(85.8)	(0.89-1.30)	72.4	(0.60-3.03)	
Dog Contact					
Yes	14(5.5)	0.98	71.4	0.91	1.0
No	239(94.5)	(0.70-1.40)	73.2	(0.29-2.90)	
Other Animals					
Yes	85(35.4)	1.22	82.4	2.22	0.01
No	155(64.6)	(1.04-1.40)	67.7	(1.17-4.23)	
Animal Birthing					
Yes	22(8.7)	1.34	95.5	8.6	0.01
No	231(91.3)	(1.20-1.52)	71.0	(1.43-..)	

Table.3 Food Habitat and Habits Risk factors in *Toxoplasma* infection

Risk Factor	Donors Studied No (%)	Risk Ratio & CI	Risk (%)	Adjusted OR & CI	P-value
Raw Meat					
Yes	174(68.8)	1.50	81.6	3.71	0.001
No	79(31.2)	(1.21-1.86)	54.4	(2.10-6.7)	
Meat Process					
Yes	212(83.8)	1.61	77.8	3.71	0.001
No	41(16.2)	(1.17-2.20)	48.8	(1.90-7.3)	
Unboild Milk					
Yes	6(2.4)	1.14	83.3	1.86	1.0
No	247(97.6)	(0.8-1.6)	72.9	(0.28-..)	
Raw Eggs					
Yes	17(6.7)	0.9	64.7	0.7	0.4
No	236(93.3)	(0.61-1.3)	73.7	(0.24-1.8)	
Restaurant Eating					
Yes	30(11.9)	0.6	47.0	0.27	0.002
No	223(88.1)	(0.4-0.9)	67.7	(0.12-0.60)	
Drinking water from river					
Yes	111(43.9)	0.93	70.3	0.8	0.3
No	142(56.1)	(0.80-1.1)	75.4	(0.44-1.34)	

Table.4 Risk Factors Associated with Health Situation

Factor	Women Studied No. (%)	Risk Ratio & CI	Risk (%)	Odd Ratio	95% CI
Abortion					
Yes	65(25.7)	1.30	87.7	3.34	1.52-7.31
No	188(74.3)	(1.13-1.50)	68.1		
Children Death					
Yes	46(18.0)	1.27	88.9	3.50	1.34-8.92
No	208(82.0)	(1.11-1.50)	69.7		
Congenital Abnormal					
Yes	2(0.7)	1.40	100	-	-
No	251(99.3)	(1.30-1.50)	72.9		

in Turkey 77% was recorded (Ozcelik *et al.*, 1996), and in Togo they reported 75% (Deniau *et al.*, 1991). Some of other countries similar prevalence in the same target groups were found as in Brazil 72% (Rey and Ramalho, 1999) and in most of the studies the prevalence rate was lower than our study as in Slovakia the prevalence was 24.2% (Studeníčová *et al.*, 2006). The difference may be due to the difference geographical areas and climate or difference in cultural or food habit or difference in ethnicity or all.

The present study confirmed that 73.1% of women had latent toxoplasmosis; this form of toxoplasmosis is generally considered to be asymptomatic. During the latent toxoplasmosis the parasite survives in the dormant form of bradyzoites mostly in the neural and muscular tissue of the host and probably lasts for the whole life of infected person (Remington and Krahenbuhl, 1982) and it can turn into acute toxoplasmosis only after serious violence of integrity of immune system such as AIDS, treatment with immunosuppressive drugs etc. (Mocsny 1992; Heitman and Irizarry, 1997). Recently, however, significant differences in personality profiles of men and women with latent toxoplasmosis and normal controls were reported to exist (Flegr and Hardy, 1994 ; Flegr *et al.*, 1996), in women with latent toxoplasmosis they found that they had higher intelligence, guilt proneness (are more apprehensive, self-reproaching, insecure), and higher ergic tension and radicalism (Flegr and Havlicek, 1999).

Exposure to cats has been considered a major risk factor for acquisition of infection (Weigel *et al.*, 1999). In the present study, it appears that cats have no direct role in transmission of the disease.

However, while several studies have concluded that exposure to cats increased the risk of *Toxoplasma gondii* seropositivity (McCulloch *et al.*, 1963; Etheridge and Frenkel, 1995), other studies found no association (Buffolano *et al.*, 1966; Fisher and Reid, 1973; Nissapatorn *et al.*, 2002; Ertug *et al.*, 2005; Alvarado-Esquivel *et al.*, 2006). Exposure to cats is not sufficient for transmission of *Toxoplasma gondii* to women; infection in cats and personal hygiene should be evaluated. In Sudan the contact between women and cats are not like in Europe: Each woman has her own cat with litter box and has special relation with her, this kind of relationship is very rare particularly, in rural areas. The association of cats and human toxoplasmosis is difficult to assess by epidemiological surveys because soil, not the cats, is the main culprit (Ertug *et al.*, 2005). Oocysts are not found on cat fur (Dubey, 1995) and are often buried in soil along with cat faeces, and soil contact is universal and difficult to avoid (Dubey, 2000).

Dogs may act as mechanical vectors by rolling in foul-smelling substances and by ingesting faecal materials (Sedlak and Bartova 2006). Experimental infections of dogs support the hypothesis that dogs may play a role in the mechanical transmission of *Toxoplasma gondii* infection to humans (Frenkel, 1973) infection by *Toxoplasma gondii* because people in these areas do not keep dogs indoors due to religion belief.

Animals could be an important source of transmission of the infection to human, as in the acute stage of the disease they are shedding *Toxoplasma gondii* tachyzoites in all body fluids, including milk (Prelezov *et al.*, 2008). Toxoplasmosis in goats is

more extensively studied because of its importance for human health, as the consumption of goat milk is recommended to children with allergy to cow milk (Prelezov *et al.*, 2008). In this study women who have contact with animals have more than two times risk to get infection than women who have no contact. Moreover, women in rural areas in Sudan have active participation in birthing animals particularly; goats and they are thinking it's a part of their duties. This process is done at home usually without any precautions and it is spread wide. Therefore, it's not surprising to find that women who did this process have more than eight times to get infection with *Toxoplasma gondii* because they were in direct contact with foetus membrane, where the isolation of the parasite can be done successfully.

The role of handling or consumption of raw meat in the acquisition of *Toxoplasma gondii* infection has not always been clear. Several studies have found no association (Peterson *et al.*, 1972; Riemann *et al.*, 1975; DiGiacomo *et al.*, 1990; Seuri and Koskela, 1992; Weigel *et al.*, 1999; Nissapatorn *et al.*, 2002; Alvarado-Esquivel *et al.*, 2006) although some studies have identified an association between eating raw meat and *Toxoplasma gondii* seropositivity (Buffolano *et al.*, 1966; Konishi and Takahashi, 1987; Cook *et al.*, 2000; Alvarado-Esquivel *et al.*, 2006). In this study meat consumption has been found to be the major factor in disease transmission. Women who consumed raw meat probably can get infection three times more than women who do not consume raw meat. In addition, the risk was same in preparing meat. In the current study, no relationship was the observed between seroprevalence and type of meat consumed. In Sudan beef

and lamb are commonly used. In meat producing animals, tissue cysts of *Toxoplasma gondii* are most frequently observed in tissues of infected pigs, sheep, and goats, and less frequently in infected poultry, rabbits, and dogs and tissue cysts are found only rarely in beef and buffalo meat (Tenter *et al.*, 2000). Our result confirmed that consuming raw meat is a major source of infection in the areas in Sudan and consuming raw meat is more important epidemiologically. In the United States, 750 deaths were caused by toxoplasmosis. This makes toxoplasmosis the third leading cause of United States foodborne death (Mead *et al.*, 1999).

A recent study assessing risk factors associated with primary *Toxoplasma gondii* infections in women of childbearing age suggested that in Poland drinking milk maybe a potential risk factor for horizontal transmission to humans (Paul, 1998). This habit was not found in Sudan except in open farms particularly in camels' herder (Khalil *et al.*, 2007). It cannot be excluded that any type of milk is a potential source of infection if consumed raw.

In the current study, no significance different was found between eating raw eggs and infection with *Toxoplasma gondii* because this nutrient habit was not famous in Sudan. Eating in restaurants is being one of the routes of *Toxoplasma gondii* transmission because most of these restaurants do not take care about adequate cooking. Therefore, most of meat and eggs in away take and snacks are presented with insufficient cooking.

The role of contact with soil in affecting the risk of *Toxoplasma gondii* infection has been rarely studied, whereas contact with soil and gardening have been

implicated as risk factors for *Toxoplasma gondii* seropositivity (McCulloch *et al.*, 1963; Etheridge and Frenkel, 1995). In previous study in pregnant women we found relationship between infection and eating black soil (Khalil, 2004). In the present study there was no association between soil contact or soil eating and infection in childbearing women and this is agreement with some studies (Buffolano *et al.*, 1966; Seuri and Koskela, 1992).

Women are washed hands before eating for religion reasons and in rural areas people stick well in their belief, therefore, washing hands before eating is not a risk factor compared with washing hands after preparing meat. Meat may consist of bradyzoites which are resistant to conditions of environments. For this reason washing hands after preparing meat is risk factor.

Congenital toxoplasmosis may cause abortion, neonatal death, or foetal abnormalities with detrimental consequences for the foetus (Remington and Desmonts, 1990; Remington *et al.*, 1995; Hayde and Pollak, 2000). The association between abortion and infection with *Toxoplasma gondii* was observed in this study. This association was confirmed by odd ratio. OR showed that, the probability of abortion in woman infected with *Toxoplasma gondii* is three times higher than in non infected women.

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