Knowledge, Attitude And Preventive Behavior Towards Toxoplasmosis Among Kuwaiti Women With/Without Pregnancy Experience: A Cross Sectional Study

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Abstract

Background: Toxoplasmosis is caused by an obligate intracellular opportunistic protozoan parasite, *Toxoplasma gondii*, with a worldwide distribution. *T. gondii* infection among pregnant women during the first trimester may transmit infection to the fetus with serious congenital consequences. No data is available on knowledge, attitude and preventive behavior towards toxoplasmosis among pregnant women in Kuwait. This cross-sectional study evaluated knowledge, attitude, and preventive behavior towards toxoplasmosis among women in Kuwait, and reviewed the situation in the Middle east.

Methods: Data related to socioeconomic status, knowledge and attitude towards toxoplasmosis were collected from 326 adult female school/university students, and 86 pregnant women through a self-administered online questionnaire during 2019-2021. Participants were divided into two main groups: women with pregnancy experience (PEG) and never-pregnant group (NPG).

Results: PEG (n=212) included 114 currently pregnant and 98 women with history of an earlier pregnancy. NPG included 200 subjects. All participants belonged to a medium-to-high social status and minimum high school education. Nearly 50% of PEG women had inadequate knowledge towards toxoplasma infection, and only 33 (15.6%) knew its mode of transmission compared to 35 (17.5%) in the NPG ($P=0.597$). A significantly higher number of women in PEG (97 of 212, 45.8%) knew it can be prevented compared to 66 of 200 (33%) in NPG ($P= 0.008$). Only 35 (16.5%) of PEG women knew about screening tests for toxoplasma infection, and their main source of information on toxoplasmosis was healthcare professionals and family/friends compared with NPG women who got information through newspapers/books. PEG Women exhibited enhanced preventive behavior towards toxoplasmosis. Nearly 50% of all PEG participants lacked basic knowledge towards toxoplasmosis but >90% of them avoided most high-risk activities during their pregnancy. In addition, this is the first study in the Middle east conducted through an online survey to collect relevant information related to toxoplasmosis from pregnant women.

Conclusions: This study highlights inadequate knowledge and preventive behavior towards toxoplasmosis among Kuwaiti women. Thus, health education on toxoplasmosis should be offered to all adult/pregnant women to reduce congenital toxoplasmosis.

Background

Toxoplasmosis is caused by an obligate intracellular opportunistic protozoan parasite, *Toxoplasma gondii*, which has a worldwide distribution, affecting about one third of the human population [1]. Humans are infected by ingesting cysts from undercooked meat, or by consuming water or food contaminated with infectious oocysts [2]. The consequences of *T. gondii* infection in humans depend on the genetic background and immunity of the host, and strain and inoculum size of the parasite [1, 3, 4]. Infection with *T. gondii* is usually asymptomatic or may cause a self-limiting flu-like illness, but it may

lead to severe infection in individuals with suppressed immune systems [5]. Seroprevalence of *T. gondii* infection in humans varies according to age, population group, geographical location, and dietary habits [6, 7]. In the USA and UK, approximately 16%-40% of the population is infected, and this rate increases further in Central America and Continental Europe where infection rates reach 50%-80% [8]. In addition, *T. gondii* can be vertically transmitted during pregnancy from an immunologically naive mother to her fetus, with the prevalence of congenital toxoplasmosis reaching up to 10 per 10,000 live births in some countries/settings [9].

Epidemiological surveys carried out among pregnant women and women of childbearing age have repeatedly shown a considerable variation in the seroprevalence of *Toxoplasma* infection ranging from 7.5% to 92.5 % in different parts of the world; 9%-11% in the USA, and 72% in Brazil [10]. A total of 242 cases of congenital toxoplasmosis were reported in Europe, of which 196 (81%) of the cases were detected in France [11]. The notification rate was 6.7 cases per 100 000 live births, with the highest rates in France (24.9 cases) followed by Poland (5.2 cases).

Significantly high seroprevalence rates (75%-92.5%) were reported from various tropical African countries [12], in contrast to most South Asian countries where *T. gondii* seroprevalence was relatively moderate to low [13].

However, there has been a decreasing trend of *T. gondii* prevalence in many countries during the last two decades due to lower exposure to the parasite because of better socio-economic conditions, changes in the nutritional habits and improved hygiene practices and knowledge towards the disease [14–16]. Several studies in the Middle East have shown varying seroprevalence of *Toxoplasma* infection among different Arab nationalities/geographic regions; Mediterranean Arabs (56.4%), African Arabs (29.3%) and the Arabian Gulf region (32%). The prevalence rate of toxoplasmosis in Saudi Arabia varied greatly in different parts of the country [17]. A seroprevalence rate of 27.4%, significantly associated with increasing age was documented among Saudi women of reproductive age in southwestern Saudi Arabia [18].

The State of Kuwait is demographically comprised of a large expatriate population originating mainly from the Asian and Arab countries, comprising nearly 70% of the total 4.7 million inhabitants (The Public Authority for Civil Information, Kuwait, 2019) [19]. Previous studies in select populations had reported a prevalence of *T. gondii* infection (52%-95%) among women of childbearing age in Kuwait [20–22]. However, a more recent study reported a significant decline in prevalence of *T. gondii* infection among pregnant women (12.5%) [16].

Despite recent report of steady declining trends of toxoplasma infection over the past few decades in Kuwait, there is no information on the knowledge (symptoms, transmission methods, treatment, prevention and control of the disease) and perception towards this disease among women of childbearing age and pregnant women in Kuwait.

The main objective of this study was to review the seroprevalence of toxoplasmosis in the Middle East and to evaluate knowledge, attitude, and preventive behavior towards toxoplasmosis among Kuwait

women with/without pregnancy experience.

Materials And Methods

Study design and Study Population

This cross-sectional study was conducted to evaluate socioeconomic status, knowledge, attitude, and preventive behavior towards toxoplasmosis from 326 adult female high school/university students, and 86 pregnant women through a self-administered online questionnaire during October 2019 and February 2021. The target groups for the survey were randomly selected. Participants were divided into two main groups; women with pregnancy experience (PEG) and never-pregnant group (NPG), and the PEG group was subdivided into currently pregnant (CP) and h/o of earlier pregnancy (EP).

Questionnaire

A structured questionnaire was constructed and used to collect sociodemographic characteristics of the participants, and knowledge, attitude, and practice towards toxoplasma infection from the participants. The questionnaire was pre-tested on a random sample of 25 students to optimize the instrument and to determine the time needed to complete the questionnaire.

The questionnaire was reviewed and edited to ensure that the participants clearly understood the questions. The questionnaire was self-administered and anonymous. Questionnaire items were designed to get the data on socioeconomic status and demographic characteristics of the participants, and to assess the basic knowledge, attitude, and practice of the target groups towards the importance of the disease. All respondents were informed of their ethical and consensual rights and were assured of confidentiality of their identity and responses. The questionnaire consisted of 36 closed-ended questions and took approximately 15 minutes to be completed to obtain information on participant's demographic & background (6), basic knowledge (6), sources of information (6), preventive measures (6), risk behavior (5), and attitude (8) towards toxoplasmosis.

The survey was conducted online using WhatsApp and telephone.

Sample size

An online Epi Info™ 7, a public domain set of software tools by Centers for Disease Control and Prevention (CDC), was used to calculate the sample size [23]. For this purpose, we used: a) 20% as the expected frequency, though no data was available for such a study in Kuwait, b) 5% of confidence limits, d) and a 95% confidence level. The calculated sample size was 374 subjects.

A total of 412 randomly selected adult females participated in the online survey, the target groups included pregnant women attending the antenatal clinics (n=86) at any gestational stage, adult graduating students at a Mishref Public high school ≥ 18 years of age (n=57), and undergraduate students at the Faculties of Medicine, 1st Year students (n=54), Engineering & Petroleum (n=76), Business

Administration (n=75), and Social sciences (n=64). However, for data analysis and discussion, the participants were divided into two main groups; women with pregnancy experience (PEG, n= 212) and never-pregnant group (NPG, n= 200); PEG group was subdivided into currently pregnant (CP, n= 114) and women with history of an earlier pregnancy (EP, n= 98).

Data Management and Statistical Analysis

The survey data were coded and entered in Microsoft Excel spread sheets and descriptive and analytic statistics were computed using SPSS Version 20. Chi square test (χ^2) and Fisher's Exact test were employed to see the association of demographic history with knowledge of the respondents. A *P*-value less than 0.05 was considered as statistically significant.

Ethical Approval

The participation in this study/survey was voluntary and answer to the survey was in anonymous mode. The Ethical Committee for the Protection of Human Subjects in Research, Kuwait University, and the Ministry of Health, under reference no. 187/2014, indicated that the study does not require ethics approval, as it does not contain any personal data of the participants. The questionnaire was anonymous. All respondents were informed about the objective of the study and informed consent was obtained from all respondents and confidentiality of their identity and responses was assured.

Results

A total of 412 randomly selected adult females participated in the online survey about toxoplasmosis to evaluate their socioeconomic status, knowledge, attitude, and preventive behavior towards toxoplasmosis between October 2019 and February 2021. The age of the female students at the High school, University students and pregnant women attending the antenatal clinic ranged between 18-19 years, 19-25 years, and 20-41 years respectively. Most participants, 175 (42.5%), were in the 18-20 years of age range followed by 126 (30.6%) in the 21-25-year age range. Only 17 (4.1%) participants were >40-year-old. At the time of survey, most of the students 298 of 326 (91.4%) were unmarried. A total of 114 (27.7%) participants were currently pregnant, including 28 among the students. A total of 17 of the currently pregnant participants (14.9%) also gave a history of abortion in the past. Of the 44 of 86 (51.2%) pregnant women attending the antenatal clinics had a university degree. Almost all participants belonged to medium-to-high social status and lived in urban areas.

In terms of statistical analysis and description about knowledge and preventive behavior towards toxoplasmosis, the participants were divided into two main groups: women with pregnancy experience group (PEG) and never-pregnant group (NPG). The PEG (n=212, 51.5%) included 114 currently pregnant (CP) and 98 females with history of an earlier pregnancy (EP), and NPG had (n=200, 48.5%) participants. Concerning '*what do you know about toxoplasmosis: I know nothing*', there was no significant difference between the two groups, 50.5% of the women in the PEG compared to 41.5% in NPG (Chi-square *p*-value= 0.067), Figure 1a. No significant difference was noted between the NP and EP

women ($p < 0.93$) for I know nothing on toxoplasmosis. Of the NPG, the high school girls were least informed (36.6%) compared to 1st Year medical students (11.9%) (Figure 1b), whose main source of information towards toxoplasmosis was newspaper and books.

Though only 33 (15.6%) of the women in PEG knew its mode of transmission compared to women in NPG 35 (17.5%) (Chi-square p -value= 0.597, > 0.05), a significantly higher number of women in the PEG, 97 (45.8%) knew it can be prevented compared to women in NPG, 66 (33.0%) (Chi-square p -value= 0.008, < 0.05), as presented in Figure 2. Within the PEG group, EP women selected '*I know how it is transmitted and how it can be prevented*' as frequent as those who were currently pregnant (P -value=0.071 and 0.611 respectively) (Figure 3).

Overall, 16.5% ($n=35$) of the women in PEG knew about *knowledge on the screening tests* for toxoplasma infection, compared to 12.0% ($n=24$) of women in NPG, there was no statistical difference between the two groups (Chi-square p -value= 0.192, > 0.05). Within the NPG, 1st year medical students were the most informative about the screening test (31.5%) followed by the students in Social sciences (23.4%) and Engineering faculty (22.4%) (Figure 4).

With respect to the *source of knowledge*, there was significant difference between the two groups, a significantly higher number of women in PEG got this information from health care professionals (26.9% vs. 7%, Chi-square p -value= 0.000, < 0.001), and family members and friends (24.1% vs. 14.5%, Chi-square p -value= 0.014, < 0.05) compared with the women in NPG, Figure 5. Social media was the least source of information for all the groups.

With respect to determine the *attitude of participants towards toxoplasma infection transmission* by not getting involved in high-risk activities, $>90\%$ of women in both the groups avoided most of the high-risk activities, however, women in PEG were more likely to avoid changing the cat litter box (p -value 0.004) or eat under cooked meat (p -value 0.001) (Table 1).

Overall, 56.5% of the women in NPG knew nothing about the characteristics of toxoplasmosis compared to 45.3% of the women in PEG (p -value = 0.023). 12% of the women in NPG selected that toxoplasmosis could be transmitted by blood transfusion compared to 4.7% in the women in the PEG (p -value = 0.007). On the other hand, 46.7% of the women in PEG knew that toxoplasmosis is dangerous compared to 37% of the women in NPG (p -value = 0.046), as shown in Table 1.

The data collection through online survey was quick, cost-effective and most of the participants felt comfortable in their spontaneous responses to the questionnaire.

Discussion

Several epidemiological surveys have repeatedly shown a considerable prevalence of *Toxoplasma* infection among pregnant women and women of childbearing age, though several studies have also reported a decreasing trend of *T. gondii* prevalence, both in general population and in pregnant

women in many countries during the last two decades [14-16,24]. A recent systematic review & meta-analysis of 21 studies during the period 1996-2018 showed an overall IgG toxoplasma seroprevalence of 35.0% in public and 29.0% among pregnant women worldwide [25], and another analysis of 36 studies during the period 1979-2018 showed an overall IgG seroprevalence rate of 39.7% (range 21.0%-38.8%) among pregnant women in the countries of Eastern Mediterranean region (EMRO) [24]. However, very high rates were reported from some countries in Africa, Namibia (74.3%), South Africa (70.1%), and Algeria (67.5%) [24]. This variation in the rate of *T. gondii* infection between countries and regions could be attributed to different sociodemographic characteristics such as dietary habits, education and health standards and lack of knowledge and attitude towards disease transmission and prevention. Table 2 shows an updated list on seroprevalence of *T. gondii* IgG and IgM antibodies and associated risk factor among pregnant women & women of childbearing age in countries of the Eastern Mediterranean & African Region [16,22,24-52]. A number of toxoplasma associated risk factors were reported across the Middle east, contact with cat, eating undercooked meat and raw vegetables and older age group (Table 2), however, studies from Kuwait and Nigeria reported no significant risk factors [16,49].

Recently, we reported a significantly lower toxoplasma seroprevalence rate of 12.5% among pregnant women in Kuwait compared to 53.1% reported more than a decade ago [16,22]. Similar decreasing trends were also reported among pregnant women in Saudi Arabia (from 38.8% in 2014 to 21.2% in 2021) and Iran (from 39.2% to 20.1% in 2021) (Table 2) [27,32,40,42].

To our knowledge, no previous study has investigated the knowledge and attitude of adult women and pregnant women in Kuwait towards toxoplasma infection and its associated risk factors. It is worth noting that in this study, an experience of an earlier pregnancy was also considered while determining the knowledge, attitude and preventive behavior towards toxoplasmosis and its associated risk factors. In our survey, all women in NP, EP & CP group had inadequate knowledge on the mode of transmission of toxoplasma infection. However, significantly higher number of CP & EP women had heard about toxoplasmosis and showed positive attitude towards toxoplasma infection prevention than the NP women (p-value <0.05). Though the number of cases in our data were relatively few, however, our data shows that a pregnancy experience does influence/change women's behavior and attitude towards toxoplasma infection and thus, they avoid major risk factors associated with toxoplasma infection, even without having an appropriate knowledge about mode of transmission of toxoplasmosis (the data and figures are presented as supplementary files). Multiple studies have reported earlier that pregnant state itself does influence the knowledge and attitude of women towards toxoplasmosis [53-56]. Table 3 shows toxoplasmosis-related knowledge and preventive practices from several countries in the Middle east [17,31,37,53-61]. In addition, this is the first study in the Middle east conducted through an online survey to collect information on sociodemographic status and toxoplasmosis related knowledge and preventive practices among pregnant women and women of childbearing age. The data collection through online survey was quick cost-effective and the participants were more comfortable in their spontaneous responses to the questionnaire as compared to the traditional methods. Similar observations were reported in an earlier study conducted through an online survey [62].

This study showed that 41.5% of the women in the pregnant at-least once group had not heard about toxoplasmosis compared with 50.5% never-pregnant women and that, only 33 (15.6%) of the women in the pregnant-at least-once group knew its mode of transmission compared to the never-pregnant group 35 (17.5%) thus, they may be at a higher risk of possibly being exposed to contracting infection in pregnancy. It is worth noting that in this study, an experience of an earlier pregnancy was also considered while determining knowledge, attitude and preventive behavior towards toxoplasmosis and its associated risk factors. Multiple studies have reported earlier that pregnant state itself does influence the knowledge and attitude of women towards toxoplasmosis [53,55,56].

A literature review of studies from the Middle east countries have reported even higher number of pregnant women ignorant of this infection, as presented in table 3. Several recent studies from the neighboring country Saudi Arabia showed that only 234 (26.8%) of the pregnant women attending antenatal clinic in Al Hassa knew about modes of transmission of toxoplasma infection, many knew cat as a risk factor, but the majority lacked the necessary preventive behavior [53]. In another study, 75.5% of the 400 pregnant women attending antenatal clinic in Dharan, Saudi Arabia had never heard about toxoplasmosis and associated risk factors [31]. A recent cross-sectional study conducted on a random sample of 440 female students at Jazan University, Saudi Arabia found that more than three-quarters (79.1%) of the students had insufficient knowledge about toxoplasmosis and its mode of transmission [17]. A community-based cross-sectional study carried out in Ahvaz County, Iran in 2017 showed that 31.3% of the public had the basic knowledge on toxoplasma infection transmission and regarded close contact with cats as a high risk for toxoplasma infection transmission [57]. In 2016, 75.2% of the pregnant women surveyed in Tikrit city in north-central Iraq had no or inadequate knowledge on toxoplasma infection transmission and consequences of infection during pregnancy [63]. A multinational study conducted among 2598 pregnant women from Malaysia, Philippines and Thailand reported similar data [64].

In this study, the high school girls were the least informed (35.1%) of the knowledge towards toxoplasmosis compared to other University female students. The 1st year medical female students were the most informed student group (77.5%) than the students from the Faculties of Engineering & Petroleum (48.0%), Social Sciences (47.3%) and Business administration (39.0%), however, the differences were not statistically significant. Two **recent** cross-sectional studies showed that 20.9% of the 440 female students at Jazan University, Saudi Arabia and only 3.2% of the 1079 female Beni-Suef University students in Egypt had adequate knowledge about toxoplasmosis and its mode of transmission [17,54].

Only 33 (15.6%) of the pregnant women knew its mode of transmission, however, a significantly higher number of pregnant women 97 (45.8%) knew it can be prevented, and >90% of the pregnant and non-pregnant women exhibited a positive attitude towards toxoplasma infection prevention by avoiding high risk activities of changing the cat litter box or eating under cooked meat. Despite lack of knowledge about toxoplasmosis, a relative positive attitude towards toxoplasma infection transmission prevention has been reported by other studies. A cross-sectional study showed that only 3.2% of the 1079 female Beni-

Suef university students in Egypt had adequate knowledge about toxoplasmosis, however, >70% of female students reported hand washing after gardening and cleaning cat litter boxes [54]. In another cross-sectional study involving 371 pregnant women in Tanzania's Temeke municipality, though 96% of the women were unaware of Toxoplasmosis, but 90% unknowingly observed preventive practices by not eating raw meat [55]. Several factors may be involved in the positive behavioral and lifestyle change towards toxoplasmosis by women during pregnancy and/or with a history of a previous pregnancy by avoiding high risk behavior, even without having an appropriate knowledge about it. Similar hypothesis was presented in an earlier study, that preventive behavior during pregnancy was not necessarily associated with specific knowledge about toxoplasmosis [65].

Regarding the source of knowledge about toxoplasmosis, the main source of information for the women in pregnant group in this study were the health care professionals and family members and friends, social media was the least source of information for all the groups. Several studies have reported similar data, Jones et al, showed that 53% the pregnant women in the USA received toxoplasma-related information from health care workers and 45% from family/friends [66], while another study from Minnesota, USA reported 63% of the pregnant women received information from a doctor and 35% from family/friends [67]. A recent study from Saudi Arabia also reported similar findings [17].

Socioeconomic status and demographic characteristics have been shown to influence the correct knowledge and attitude of a population or study group towards toxoplasmosis. Earlier, studies have shown that women of childbearing age with higher education level, residence in an urban setting and the number of children had better understanding of the symptoms of toxoplasmosis [62,68,69,70]. Almost all participants in this study had higher education level, belonged to medium to high social status and lived in the urban area, however, only 41.5% of the pregnant women had inadequate knowledge about toxoplasma infection transmission and prevention, and none of them knew about the screening tests to check for the infection. Recently, we have reported a steady declining trend of toxoplasma infection in Kuwait over the past few decades, 12.5% one of the lowest in the Middle east [16]. We believe that this trend was probably due to high education level and free access to high standard health services.

Conclusion

This is the first study regarding knowledge and practices about toxoplasmosis among pregnant women and female students at High school and the University in Kuwait. The results of this study showed inadequate knowledge and limited awareness about toxoplasmosis among the participants.

Though only 15.6% of the pregnant women knew its mode of transmission, a significantly higher number of pregnant women 45.8% knew it can be prevented, and >90% showed a positive attitude towards infection preventive measures and avoided most of the high-risk activities. The results also showed that online data collection was quick cost-effective, and the participants were more comfortable in their spontaneous responses to the questionnaire as compared to the traditional methods.

Declarations

Acknowledgement

We would like to thank all participants who took part in the online survey.

Author contributions

JI, NK and AM were part of the working group for this project, and each contributed to the conceptualization and planning of the study, interpretation of data and findings, contributed to the manuscript, and approved the work for publication. In addition, AM analyzed the data, and NK contributed to collecting the online data from the participants. JI also supervised the study.

Funding

This survey has not received any funding.

Ethics approval and consent to participate

The participation in this study/survey was voluntary and answer to the survey was in anonymous mode. All participants were informed of the objectives of the study and clearly understood the questions. It was ensured that no subject under 16 years of age participated in the survey. The Ethical Committees for the Protection of Human Subjects in Research, Kuwait University, and the Ministry of Health, under reference no. 187/2014, indicated that the study does not require any special ethics approval, as it does not contain any personal data of the participants. In addition, all methods were carried out in accordance with relevant guidelines and regulations, as dictated by the Kuwait University and Ministry of Health Ethical Committees for the Protection of Human Subjects in Research.

The questionnaire was anonymous. All respondents were informed about the objective of the study and informed consent was obtained from all respondents and confidentiality of their identity and responses was assured.

Availability of data and materials

The datasets used during the current study are available from the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. Knowledge about *Toxoplasma gondii*, and epidemiological, clinical aspects and preventive attitude of women with/without pregnancy experience towards toxoplasmosis.

Question	Never Pregnant NPG, n=200 n (%)	Pregnant-at least-once PEG, n=212 n (%)	p-value
Which of the following would prevent you from getting toxoplasmosis			
Not changing the cat's litter box	68 (34.0%)	102 (48.1%)	0.004*
Cooking meat well	60 (30.0%)	97 (45.8%)	0.001*
Thoroughly washing fruits/vegetables	30 (15.0%)	45 (21.1%)	0.102
Gardening with gloves	31 (15.5%)	24 (11.3%)	0.213
None	132 (66.0%)	98 (46.2%)	0.000*
What is your attitude toward Toxoplasmosis?			
Nothing	113 (56.5%)	96 (45.3%)	0.023*
It is dangerous	74 (37.0%)	99 (46.7%)	0.046*
Causes symptoms	46 (23.0%)	48 (22.6%)	0.931
Affects pregnant women only	18 (9.0%)	10 (4.7%)	0.084
Can be transmitted by unwashed vegetables and under- cooked meat	35 (17.5%)	41 (19.3%)	0.630
Can be transmitted by blood transfusion	24 (12.0%)	10 (4.7%)	0.007*
Can cause miscarriage or stillbirth	67 (33.5%)	87 (41.0%)	0.114
Can be transmitted from pregnant woman to her fetus	34 (17.0%)	37 (17.5%)	0.903

Table 2. Seroprevalence of *Toxoplasma gondii* IgG and IgM antibodies and associated risk factor among pregnant women & women of childbearing age in the Eastern Mediterranean & African Region.

Country	Cases	Seroprevalence		Associated Risk factor	References
		IgG %	IgM%		
Worldwide	Overall	35.0	4.0	ND [#]	
Systematic review & meta-analysis (SRMA)* 1996-2018 [21 studies]	General Public	42.0			Rahmanian et al [25]
	Blood donors	18.0	2.0		
	Women	34.0	5.0		
	Pregnant women	29.0	4.0		
	Newborn/children	4.0			
SRMA*		43.0	3.0		Nayeri et al [26]
published up to April 2019	12,666 history of abortion	33.0	1.0		
40 cross-sectional studies					
35 cross-sectional studies	4436 spontaneous abortion				
EMRO					
SRMAS* 1979-2018	IgG: 26,494 pregnant women	39.7	-		Bigna et al [24]
IgG; 46 studies		-	4.1		
IgM, 36 studies	IgM: 14080 pregnant women				
Saudi Arabia					
Eastern Province	500 pregnant women	21.0	0.8	gestational stage & parity	Al-Yami et al [27]
Al Kharj		32.4	1.0		
SRMA* 2000-2017	306 pregnant women		27.8 21.2	cat, undercooked meat	Qamer et al [28]
Makkah	13,597 women				Alzaheb [29]
Dharan	326 pregnant women	28.5	3.0	cat, age, urban area	
South West		38.8			Alsammani [30]
	400 pregnant women			undercooked meat	
					Elsafi et al [31]
	487 pregnant women			undercooked meat,	
				meat, older age	Almushait et al [32]
Qatar	823 pregnant women	35.1	5.2	age	Abu-Madi et al [33]

Bahrain 2000-2003	4,739 pregnant women	21.8	10.3	cat	Tabbara & Saleh [34]
UAE	1503 pregnant women	22.9	3.1	ND	Dar et al [35]
Iraq					
Basra	177 university students	12.4		cat, raw vegetable/meat	Al-Sadoon et al [36]
Mayson	48 women	27.1		ND	Al-Saadyi et al [37]
Kuwait	224 pregnant women	53.1	13.8	ND	Iqbal & Khalid [22]
Kuwait	280 pregnant women	12.5	2.1	no risk factor detected	Al-Shammari & Iqbal [16]
Beirut, Lebanon Retrospective cohort 1994-2015	2456 pregnant women	82.6	1.8	ND [#]	Nahouli et al [38]
Jordan	220 pregnant women	66.5	0.5	older age, undercooked meat	Obaidat et al [39]
Iran					
Alborz Province	400 women	20.1	8.7	older age, cat, undercooked meat, cat	Shahighi et al [40]
Western region	189 pregnant women	39.7	-		Raissi et al [41]
SRMA*, 43 studies	22 644 pregnant women	39.2	4.0	ND	Malary et al [42]
1990-2015					
Hebron, Palestine	204 pregnant women	27.9	17.6	cat, raw vegetable/meat	Nijem & Al-Amleh [43]
Syria Refugees in Turkey	754 pregnant women	47.0	0.4	ND	Halici-Ozturk et al [44]
Turkey 2012-2017	3474 women	44.2	7.7	ND	Durukan et al [45]
Africa					
SRMA* 2001-2019	10,701 pregnant women	65.1		cat, raw meat	Kajeguka et al [46]

Central		50.2			
Eastern		47.8			
Northern		38.3			
Western					
Al-Minya, Egypt	96 pregnant women	22.9	-	cat, older age, undercooked meat	Abdelbaset et al [47]
Menoufia, Egypt	364 pregnant women	33.8		same as above	Ibrahim et al [48]
Nigeria	317 women	28.8	3.8	no risk factor detected	Zakari et al [49]
Rabat, Morocco	576 pregnant women	43.0	3.9	older age	Laboudi et al [50]
Dhamar, Yemen	420 women	20.0	1.2	cat, raw vegetables, spontaneous abortion	Al-Adhroey et al [51]
Tripoli, Libya	500 women	50.8	-	age, cat, raw vegetable, rural area	Mahmoud et al [52]

* SRMA, Systematic review & meta-analysis; # ND, not done; **NA, not available

Table 3. Knowledge, attitude and practices towards toxoplasmosis among pregnant women & women of childbearing age in the Eastern Mediterranean & African Region.

Country	Sample size & Target group	KAP	Predictors for KAP	References
Saudi Arabia				
Al Hassa	234 pregnant women	73.2% no knowledge	Old age, education, h/o abortion	Amin et al [53]
Dharan	400 pregnant women	75.5 never heard	ND	Elsafi et al [31]
Jazan	400 Female students	79.1 no knowledge	ND	Mahfouz et al [17]
Ahvaz, Iran	31.3 General public	1735 women	NA	Baghlaninezhad et al [57]
Lebanon	7,290 School students		ND	Caharafeddine et al [58]
Egypt	1079 University female students	96.8% low knowledge	ND	Senosy [54]
Beni-Suef Uni		63% negative attitude		
Mayson, Iraq	Pregnant women	79.5% no knowledge	ND	Al Saadyi et al [37]
Tanzania	371 Pregnant women	96% unaware	70% low preventive practice	Onduru et al [55]
Jordon	280 women and 1390 Female students	51.1% never heard, 24.7-53.7 some info >50% +attitude	ND	Al-Sheyab et al [59]
Palestine	976 Female students	51.1% never heard,	68.8% preventive behavior	Sweileh et al [60]
Al Najah Uni				
Morocco				
Essaouira,	600 pregnant women	97.3% no knowledge	95% preventive behavior	Ouzennou et al [56]
Casablanca	390 pregnant women	58.8% never heard		Hamou & Laboudi [61]

ND, not determined

Supplemental Note

Figures

Figure 1

General knowledge towards *Toxoplasma gondii* infection among women with pregnancy experience group (PEG, n=212) and never-pregnant group (NPG, n=200) to the online survey question ‘what do you know about toxoplasmosis: I know nothing’. The PEG included 114 currently pregnant (CP) and 98 females with history of an earlier pregnancy (EP). Distribution of responses among the 414 target groups participating the online survey to the question ‘what do you know about toxoplasmosis: I know nothing’. The high school girls were the least informed (36.6%) compared to 1st Year medical students (11.9%).

Figure 2

Knowledge towards *Toxoplasma gondii* infection transmission and prevention among women with pregnancy experience group (PEG, n=212) and never-pregnant group (NPG, n=200) to the online survey questions 'I know how it is transmitted' and 'I know it can be prevented'.

Figure 3

Knowledge towards *Toxoplasma gondii* infection, transmission and prevention among women with history of an earlier pregnancy (EP) and currently pregnant women (CP).

Figure 4

Distribution of responses among the 414 target groups participating the online survey to the question 'I know about the screening tests to *T. gondii* infection'. None of the pregnant women attending the antenatal clinic among the 86 pregnant women attending the antenatal clinic knew about the screening tests.

Figure 5

The source of knowledge among women with pregnancy experience group (PEG, n=212) and never-pregnant group (NPG, n=200). A significantly higher number of women in PEG got this information from health care professionals and family members and friends. Social media was the least source of information for all the groups.