



Knowledge, attitudes and practices towards toxoplasmosis among pregnant women receiving antenatal care in Sana'a city, Yemen

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ABSTRACT

Background and Aims: There is a lack of studies on pregnant women's knowledge, attitudes, and practices (KAPs) towards toxoplasmosis in Yemen. Therefore, this study assessed these KAPs among pregnant women receiving antenatal care in Sana'a city, Yemen.

Subjects and Methods: A KAP survey was conducted among 410 pregnant women in Sana'a using a structured questionnaire. The association between women's characteristics and their KAPs was then studied.

Results: Of 410 women, 58.5% had heard of toxoplasmosis. Of these, 53.3% had good knowledge and 73.3% had positive attitudes towards it. Women with no previous miscarriage or premature birth had significantly higher levels of poor knowledge (OR = 4.1, 95% CI: 2.39–7.10; $p < 0.001$ and OR = 2.9, 95% CI: 1.61–5.05; $p < 0.001$, respectively) and negative attitudes (OR = 5.6, 95% CI: 23.00–10.57; $p < 0.001$ and OR = 2.7, 95% CI: 1.36–5.48; $p = 0.004$, respectively) than their counterparts. Negative attitudes were significantly higher in primigravida than multigravida women (OR = 2.1, 95% CI: 1.17–3.79; $p = 0.012$), but significantly lower among women in the first (OR = 0.3, 95% CI: 0.20–0.56; $p < 0.001$) or second trimester (OR = 0.2, 95% CI: 0.10–0.48; $p < 0.001$) than their counterparts. Acceptable practices were reported by 95.4% of women, with no association with demographic or obstetric characteristics.

Conclusion: There is a need for educational interventions for pregnant women in Sana'a about toxoplasmosis to prevent its potential adverse events in their fetuses.

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1. Introduction:

Approximately half of the world's population is estimated to have latent infections with *Toxoplasma gondii*, which typically does not

pose a risk to immunocompetent individuals [1]. Nonetheless, toxoplasmosis can have detrimental outcomes, including death, in developing fetuses and patients with compromised immune systems. Most human infections arise from the

consumption of raw or undercooked meat containing tissue cysts and from the ingestion of food or water contaminated with oocysts [1-3]. Furthermore, transmission can occur through the consumption of raw milk, blood transfusions, and organ transplants [4]. The infection can also be transmitted congenitally from mothers who experience a primary infection during or shortly before pregnancy, resulting in serious consequences for fetuses or newborns, including brain or eye damage, miscarriages, and stillbirths [5, 6]. Although most acutely infected pregnant women tend to be asymptomatic or mildly symptomatic, their fetuses remain susceptible to congenital infection and its associated serious consequences [7]. Therefore, it is critical to educate pregnant women about the prevention and transmission of toxoplasmosis to reduce the incidence of congenital toxoplasmosis.

Differences in knowledge, attitudes and practices (KAPs) towards toxoplasmosis may explain the differences in infection rates among pregnant women. The epidemiology of infection among pregnant women varies widely at national, regional and global levels [8]. *T. gondii* seroprevalence in pregnant women and women of childbearing age varies across regions, with rates ranging from 6.1% to 77.5% in the Americas, 8.2% to 63.2% in Europe, 25.3% to 75.2% in Africa, and 0.8% to 60% in Asia and Oceania [9]. On the other hand, the incidence of congenital toxoplasmosis has been found to be highest in South America, Africa, and the Middle East [6].

Toxoplasma seroprevalence among pregnant women and those seeking healthcare in major cities in Yemen ranged from 3.3% to 14% for anti-*Toxoplasma* IgM and from 31% to 46.2% for anti-*Toxoplasma* IgG [10-15]. While such seroprevalence studies also assessed behaviors associated with toxoplasmosis risk, most studies did not assess women's knowledge and attitudes towards the infection. Although the risk factors for the infection are well known, lacking clarity about their knowledge and attitudes makes it difficult to develop effective educational

interventions to raise awareness of infections. Therefore, this study aimed to assess the KAPs of pregnant women towards toxoplasmosis in Sana'a city, Yemen.

2. Subjects and Methods

Study design, population and setting

A cross-sectional survey of KAPs was conducted among pregnant women receiving antenatal care (ANC) in Sana'a city from December 2022 to April 2023. Pregnant women of any age were included in the survey if they were Yemeni nationals, sought ANC, and gave written informed consent for voluntary participation.

Sample size and sampling method

Because there were no published estimates of KAPs towards toxoplasmosis among Yemeni pregnant women, an assumed proportion of 50% for women with the desired outcomes was used to calculate the sample size, with a 95% confidence level and a 5% precision. Accordingly, a sample size of 384 was calculated using OpenEpi, version 3.01 [16]. The sample size was then increased to 410 to account for an expected non-response rate of 10%.

Six districts out of ten districts of Sana'a city were randomly selected; namely, As Sab'ain, At Tahrir, Ath'thawrah, Az'zal, Ma'een and Shu'aub. Then, 20 ANC clinics, both hospital-based and independent, were selected from these districts based on their ease of access and the permission of responsible physicians. Given the difficulty in obtaining a sampling frame of clinic attendees, pregnant women were sampled consecutively from all selected clinics until the required sample size was reached.

Data collection

Data on demographic characteristics, obstetric history, and KAPs towards toxoplasmosis were collected using a structured questionnaire through face-to-face interviews. The questionnaire was pilot-tested on 20 pregnant women not included in the final analysis of data,

which was then modified accordingly. It consisted of four sections and was developed after reviewing relevant literature. The first section included questions about demographic characteristics (age, place of residence, literacy status, employment status, and household size) and obstetric history (gestational age, gravidity, parity, previous miscarriages, and premature births). The second section included questions about toxoplasmosis knowledge. The knowledge of women who had heard of toxoplasmosis was assessed using 11 questions related to its nature, sources, transmission, and routine diagnostic method, each with three response options (yes, no, or do not know). The third section focused on capturing the attitudes of women who had heard of toxoplasmosis towards the infection. These attitudes were assessed using five statements concerning women's perceptions of their susceptibility to infection, its seriousness for themselves and their fetuses, as well as its preventability, each with three response options (yes, no, or do not know). The fourth section covered preventive practices undertaken by women, whether they had heard of toxoplasmosis or not. These practices were assessed using 11 questions, each with two response options (yes or no).

Data analysis

Data were analyzed using IBM SPSS Statistics, version 23.0 (IBM Corp., Armonk, NY, USA), with a significance level of <0.05 . KAPs of women were described using frequencies and percentages, while continuous data were summarized using the mean and standard deviation (SD) if normally distributed, or the median and interquartile range (IQR) if non-normally distributed.

Responses to knowledge items were scored "1" if correct and "0" if incorrect or 'do not know,' with an overall knowledge score for each participant ranging from 0 to 11. The average knowledge score was then calculated by summing the individual scores and dividing them by the total number of responses. Women with

knowledge scores equal to or above the average score were classified as having good knowledge, while those with knowledge scores below the average score were classified as having poor knowledge. On the other hand, responses to attitude statements were scored "1" if correct and "0" if incorrect or 'do not know,' with an overall attitude score for each participant ranging from 0 to 5. Women with attitude scores equal to or above the average score were classified as having a positive attitude, while those with attitude scores below the average score were classified as having a negative attitude. Regarding the preventive practices reported by women, responses were scored "1" if correct and "0" if incorrect, with an overall practice score for each participant ranging from 0 to 11. Women with preventive practice scores equal to or above the average score were classified as having an acceptable preventive practice, while those with preventive practice scores below the average score were classified as having an unacceptable risky practice.

Univariate analysis with the chi-square test or Fisher's exact test, as appropriate, was used to assess the association between independent variables (demographic and obstetric characteristics) and poor knowledge, negative attitudes, and unacceptable practices towards toxoplasmosis among women. The odds ratios (ORs) and corresponding 95% confidence intervals (CIs) of the associations were reported.

Ethical considerations

Ethical approval for this study was obtained from the Ethics Committee of the Faculty of Medicine and Health Sciences, University of Science and Technology in Sana'a, Yemen. In addition, informed consent was obtained from all participating women after explaining the aim of the study before data collection.

3. Results

Characteristics of respondent pregnant women

The response rate of pregnant women was 87.2% (410 out of 470 invited women). Table 1 shows that the median (IQR) age of the pregnant women was 26 (8) years (range: 17–45), with more than half being under 26 years old. Most women were urban residents (89.3%), lived in households with fewer than five members (63%), were literate (89.5%), and were unemployed (90.5%). Approximately half of the women were in the third trimester, and most had previously been pregnant (61.9%) and had given birth to one or more children (70.1%). Miscarriages and premature births were reported by 34.1% and 19.5% of women, respectively.

Table 1: Demographic and obstetric characteristics of pregnant women included in the study*

Characteristics	n	(%)
Age (years)		
Median (IQR):	26 (8)	
Range:	17–45	
≤26	215	(52.4)
>26	195	(47.6)
Residence		
Rural	44	(10.7)
Urban	366	(89.3)
Household size (members)^a		
Median (IQR):	5 (4)	
≤5	250	(63.0)
>5	147	(37.0)
Employment status		
Employee	39	(9.5)
Unemployed	371	(90.5)
Literacy status^b		
Illiterate	43	10.5)
Literate	365	89.5)
Gestational trimester^c		
First	136	(33.4)
Second	68	(16.7)
Third	203	(49.9)
Gravidity^d		
Primigravida	156	(38.1)
Multigravida	253	(61.9)
Parity^b		
Nulliparous	122	(29.9)
Parous	286	(70.1)
History of miscarriage		
Yes	140	(34.1)
No	270	(65.9)
History of premature birth		
Yes	80	(19.5)
No	330	(80.5)

* The total number of women was 410; ^a 13 missing cases; ^b 2 missing cases; ^c 3 missing cases; ^d 1 missing case.

Perceived knowledge about toxoplasmosis

Of 410 pregnant women, 240 (58.5%) reported that they had heard of toxoplasmosis. The most commonly reported source of information about toxoplasmosis by women was relatives, neighbors, or friends (64.6%), followed by healthcare providers (HCPs) (23.3%) (Table 2).

Table 2: Perceived knowledge about toxoplasmosis and its sources among pregnant women receiving ANC in Sana'a city, Yemen (2023)

Item	n	(%)
Having heard or read about toxoplasmosis (N = 410)		
Yes	240	(58.5)
No	170	(41.5)
Source of information about toxoplasmosis (N = 240)		
Relatives, neighbors, or friends	155	(64.6)
HCPs	56	(23.3)
Media (Radio or television)	15	(6.3)
Educational campaign	14	(5.8)

ANC, antenatal care; HCPs, healthcare providers.

Actual knowledge about toxoplasmosis

Pregnant women who perceived themselves as knowledgeable about toxoplasmosis had an average knowledge score of 5.5 ± 2.4, with 53.3% (128/240) demonstrating good knowledge. Table 3 shows that 32.5% of women knew that an infectious agent causes toxoplasmosis, and most women (70.8%) recognized cats as a potential source of infection. Less than half of women knew that the infection could be transmitted through contaminated water, contaminated produce, raw or undercooked meat, and raw milk. However, blood transfusion and congenital transmission were identified as modes of transmission by 52.9% and 69.6% of women, respectively. Only 22.1% of women knew that most cases in pregnant women can be asymptomatic, while 61.3% of women knew that toxoplasmosis primarily affects immunocompromised patients,

and 80.8% knew that a blood test is used for diagnosis.

Table 3: Actual knowledge about toxoplasmosis among pregnant women receiving ANC in Sana'a city, Yemen (2023)

Knowledge item	n	(%)
Toxoplasmosis is an infection caused by a pathogen		
Yes	78	(32.5)
No	99	(41.3)
Do not know	63	(26.2)
Presence of cats increases the risk of infection		
Yes	170	(70.8)
No	29	(12.1)
Do not know	41	(17.1)
Toxoplasmosis could be transmitted through drinking contaminated water		
Yes	94	(39.2)
No	55	(22.9)
Do not know	91	(37.9)
Toxoplasmosis could be transmitted through vegetables and fruits contaminated with soil		
Yes	108	(45.0)
No	67	(27.9)
Do not know	65	(27.1)
Toxoplasmosis could be transmitted through consuming raw or undercooked meat		
Yes	112	(46.7)
No	68	(28.3)
Do not know	60	(25.0)
Toxoplasmosis could be transmitted through drinking raw milk		
Yes	91	(37.9)
No	83	(34.6)
Do not know	66	(27.5)
Toxoplasmosis could be transmitted via blood transfusion		
Yes	127	(52.9)
No	61	(25.4)
Do not know	52	(21.7)
Toxoplasmosis could be transmitted from a pregnant woman to her fetus		
Yes	167	(69.6)
No	36	(15.0)
Do not know	37	(15.4)
Toxoplasmosis could be asymptomatic in pregnant women		
Yes	53	(22.1)
No	121	(50.4)
Do not know	66	(27.5)
Toxoplasmosis only affects immunocompromised patients		
Yes	147	(61.3)
No	63	(26.3)
Do not know	30	(12.5)
Toxoplasmosis is diagnosed with a blood test		
Yes	194	(80.8)
No	46	(19.2)
Do not know	0	(0.0)

* The total number of respondents was 240. ANC, antenatal care.

Association between pregnant women’s poor knowledge about toxoplasmosis and their characteristics

None of women’s demographic characteristics were significantly associated with poor knowledge about toxoplasmosis. In contrast, women who had never experienced a miscarriage

(OR = 4.1, 95% CI: 2.39–7.10; *p* <0.001) or premature birth (OR = 2.9, 95% CI: 1.61–5.05; *p* <0.001) showed significantly higher levels of poor knowledge than their counterparts. However, no significant association was found between poor knowledge and gestational trimester, gravidity, or parity (Table 4).

Table 4: Association between poor knowledge about toxoplasmosis and demographic and obstetric characteristics of pregnant women receiving ANC in Sana'a city, Yemen (2023)

Characteristics	Poor knowledge about toxoplasmosis					p-value
	N	n	(%)	OR	(95% CI)	
Age (years)						
≤26	114	46	(40.4)	0.6	(0.40–1.03)	0.062
>26	126	66	(52.4)	Reference		
Residence						
Rural	16	8	(50.0)	1.2	(0.42–3.18)	0.782
Urban	224	104	(46.4)	Reference		
Household size (members)						
≤5	156	72	(46.2)	1.0	(0.56–1.70)	0.924
>5	75	35	(46.7)	Reference		
Literacy status						
Illiterate	9	3	(33.3)	0.7	(0.14–2.29)	0.414
Literate	231	109	(47.2)	Reference		
Employment status						
Unemployed	205	93	(45.4)	0.7	(0.34–1.44)	0.328
Employee	35	19	(54.3)	Reference		
Gestational trimester						
First	76	36	(47.4)	0.9	(0.57–1.41)	0.647
Second	44	17	(38.6)	0.6	(0.34–1.16)	0.135
Third	118	59	(50.0)	Reference		
Gravidity						
Primigravida	82	42	(51.2)	1.3	(0.77–2.25)	0.308
Multigravida	158	70	(44.3)	Reference		
Parity						
Nulliparous	61	30	(49.2)	1.1	(0.64–2.05)	0.649
Parous	179	82	(45.8)	Reference		
History of miscarriage						
Yes	139	45	(32.4)	Reference		<0.001
No	101	67	(66.3)	4.1	(2.39–7.10)	
History of premature birth						
Yes	80	24	(30.0)	Reference		<0.001
No	160	88	(55.0)	2.9	(1.61–5.05)	

N, number of respondents; n, number of respondents with poor knowledge; ANC, antenatal care; OR, odds ratio; CI, confidence interval.

Attitudes towards toxoplasmosis

Pregnant women who perceived themselves as knowledgeable about toxoplasmosis had an average attitude score of 3.4 ± 1.3, with 73.3% (176/240) demonstrating positive attitudes towards the infection. Table 5 shows that most women considered themselves susceptible to

infection (63.3%) and believed that infection is serious for themselves (87.5%) and their fetuses (61.1%). The majority of women believed in the

possibility of preventing infection during pregnancy (93.3%) and preventing transmission from mother to fetus (79.6%).

Table 5: Attitudes towards toxoplasmosis among pregnant women receiving ANC in Sana'a city, Yemen (2023)

Attitude statement	n	(%)
Pregnant women are susceptible to toxoplasmosis		
Yes	152	(63.3)
No	73	(30.4)
Do not know	15	(6.3)
Toxoplasmosis is serious for pregnant women		
Yes	210	(87.5)
No	21	(8.8)
Do not know	9	(3.7)
Toxoplasmosis is serious and can cause congenital problems to the fetus (N = 167)		
Yes	102	(61.1)
No	51	(30.5)
Do not know	14	(8.4)
Toxoplasmosis is preventable during pregnancy		
Yes	224	(93.3)
No	4	(1.7)
Do not know	12	(5.0)
Transmission of toxoplasmosis from mother to fetus could be prevented (N = 167)		
Yes	133	(79.6)
No	6	(3.6)
Do not know	28	(16.8)

* The total number of respondents was 240. ANC, antenatal care.

Association between pregnant women’s negative attitudes towards toxoplasmosis and their characteristics

None of the women’s demographic characteristics were significantly associated with their negative attitudes towards toxoplasmosis. In contrast, women in the first trimester (OR = 0.3, 95% CI: 0.20–0.56; *p* <0.001) or second trimester (OR = 0.2, 95% CI: 0.10–0.48; *p*

<0.001) showed significantly lower levels of negative attitudes than those in the third trimester. Significantly higher levels of negative attitudes were found among primigravida women (OR = 2.1, 95% CI: 1.17–3.79; *p* = 0.012), as well as women who had never experienced a miscarriage (OR = 5.6, 95% CI: 23.00–10.57; *p* <0.001) or premature birth (OR = 2.7, 95% CI: 1.36–5.48; *p* = 0.004) compared to their counterparts. However, negative attitudes were not significantly associated with the gravidity or parity of pregnant women (Table 6).

Table 6: Association between negative attitudes towards toxoplasmosis and demographic and obstetric characteristics of pregnant women receiving ANC in Sana'a city, Yemen (2023)

Characteristics	Negative attitudes towards toxoplasmosis					p-value
	N	n	(%)	OR	(95% CI)	
Age (years)						
≤26	114	31	(27.2)	1.1	(0.59–1.87)	0.861
>26	126	33	(26.2)	Reference		
Residence						
Rural	16	5	(31.3)	1.3	(0.42–3.81)	0.770
Urban	224	59	(26.3)	Reference		

Household size (members)						
≤5	156	44	(28.2)	1.2	(0.66–2.35)	0.499
>5	75	18	(24.0)	Reference		
Literacy status						
Illiterate	9	1	(11.1)	0.3	(0.04–2.72)	0.451
Literate	231	63	(27.3)	Reference		
Employment status						
Unemployed	205	56	(27.3)	1.3	(0.54–2.96)	0.581
Employee	35	8	(22.9)	Reference		
Gestational trimester						
First	76	19	(25.0)	0.3	(0.20–0.56)	<0.001
Second	44	8	(18.2)	0.2	(0.10–0.48)	<0.001
Third	118	37	(31.4)	Reference		
Gravidity						
Primigravida	82	30	(36.6)	2.1	(1.17–3.79)	0.012
Multigravida	158	34	(21.5)	Reference		
Parity						
Nulliparous	61	19	(31.1)	1.3	(0.71–2.55)	0.359
Parous	179	45	(25.1)	Reference		
History of miscarriage						
Yes	139	18	(12.9)	Reference		<0.001
No	101	46	(45.5)	5.6	(3.00–10.57)	
History of premature birth						
Yes	80	12	(15.0)	Reference		0.004
No	160	52	(32.5)	2.7	(1.36–5.48)	

N, number of respondents; n, number of respondents negative attitudes; ANC, antenatal care; OR, odds ratio; CI, confidence interval.

Self-reported preventive practices against toxoplasmosis

Pregnant women receiving ANC in Sana’a had an average score of 6.7 ± 0.7 for preventive practices against toxoplasmosis, with 95.4% (391/410) showing acceptable preventive practices against the infection. Table 7 shows that most women (80.7%) reported that they had no contact with cats. Of those who had contact

with cats, 27.8% did not clean the cat litter, and 43.9% wore gloves when cleaning. Most women (69.5%) also reported avoiding contact with soil. Of those engaged with soil, 45.6% wore gloves, and 92.8% washed their hands thoroughly with soap and water afterwards. The majority of women reported washing their hands thoroughly before meals (98.3%), washing vegetables and fruits thoroughly before eating (98%), and cleaning knives and cutting boards after preparing meat (98.5%). Furthermore, 92.2% of women reported not eating or tasting undercooked meat, while 74.1% confirmed not drinking raw milk.

Table 7: Self-reported preventive practices against toxoplasmosis among pregnant women receiving ANC in Sana'a city, Yemen (2023)*

Preventive practices	n	(%)
Avoiding contact with cats		
Yes	331	(80.7)
No	79	(19.3)
Avoiding cleaning cat litter (N = 79)		
Yes	22	(27.8)
No	57	(72.2)

Wearing gloves when cleaning cat litter (N = 57)		
Yes	25	(43.9)
No	32	(56.1)
Avoiding contact with soil (e.g., during gardening)		
Yes	285	(69.5)
No	125	(30.5)
Wearing gloves during contact with soil (N = 125)		
Yes	57	(45.6)
No	68	(54.4)
Washing hands with soap and water after contact with soil (N = 125)		
Yes	116	(92.8)
No	9	(7.2)
Washing hands properly before meals		
Yes	403	(98.3)
No	7	(1.7)
Washing vegetables and fruits thoroughly before eating		
Yes	402	(98.0)
No	8	(2.0)
Cleaning knives and cutting boards after use for cutting meat		
Yes	404	(98.5)
No	6	(1.5)
Avoiding eating or tasting undercooked meat		
Yes	381	(92.9)
No	29	(7.1)
Avoiding drinking raw milk		
Yes	304	(74.1)
No	106	(25.9)

* The total number of respondents was 410. ANC, antenatal care.

Association between pregnant women’s unacceptable practices and their characteristics

There was no significant association between women’s unacceptable practices against toxoplasmosis and their demographic or obstetric characteristics (Table 8).

Table (8): Association between unacceptable practices against toxoplasmosis and demographic and obstetric characteristics of pregnant women receiving ANC in Sana'a city, Yemen (2023)

Characteristics	Unacceptable practices against toxoplasmosis					p-value
	N	n	(%)	OR	(95% CI)	
Age (years)						
≤26	215	7	(3.3)	0.5	(0.20–1.33)	0.163
>26	195	12	(6.2)	Reference		
Residence						
Rural	44	3	(6.8)	1.6	(0.45–5.73)	0.444
Urban	366	16	(4.4)	Reference		
Household size (members)						
≤5	250	9	(3.6)	0.5	(0.20–1.29)	0.149
>5	147	10	(6.8)	Reference		
Literacy status						
Illiterate	43	3	(7.0)	1.6	(0.46–5.86)	0.438
Literate	365	16	(4.4)	Reference		
Employment status						

Unemployed	371	17	(4.6)	0.9	(0.20–4.00)	0.700
Employee	39	2	(5.1)	Reference		
Gestational trimester						
First	136	8	(5.9)	1.3	(0.51–3.58)	0.550
Second	68	2	(2.9)	0.7	(0.14–3.10)	0.592
Third	203	9	(4.4)	Reference		
Gravidity						
Primigravida	156	6	(3.8)	0.7	(0.28–1.99)	0.546
Multigravida	253	13	(5.1)	Reference		
Parity						
Nulliparous	122	6	(4.9)	1.1	(0.40–2.93)	0.870
Parous	286	13	(4.5)	Reference		
History of miscarriage						
Yes	140	7	(5.0)	Reference		0.800
No	270	12	(4.4)	0.9	(0.34–2.30)	
History of premature birth						
Yes	80	5	(6.3)	Reference		0.390
No	330	14	(4.2)	0.7	(0.23–1.90)	

N, number of respondents; n, number of respondents with unacceptable practices; ANC, antenatal care; OR, odds ratio; CI, confidence interval.

4. Discussion

As far as we know, this is the first study to analyze the KAPs of pregnant women in Sana’a towards toxoplasmosis, often referred to as “feline germ infection” by most of them. This study revealed a large knowledge gap between pregnant women’s perceived and actual knowledge about toxoplasmosis. More than half of women reported having heard of toxoplasmosis, but a substantial proportion did not have good knowledge. Therefore, even among those who had heard of toxoplasmosis, there were misconceptions and a lack of knowledge about various aspects of the infection. Compared to the present study, awareness of toxoplasmosis was reported for 46.9% of pregnant women seeking healthcare and 67% of mothers of children with Down syndrome in Sana’a city [12, 17]. In the city of Mukalla, east of Yemen, a much higher proportion (94.7%) of pregnant women seeking healthcare reported knowledge of toxoplasmosis [18]. The rate of perceived knowledge about toxoplasmosis in the present study is relatively comparable to the rates observed among pregnant women in Somalia (62%) and Pakistan (54%) [19, 20]. Various

factors, including access to information about the infection, healthcare services, interactions with HCPs, cultural beliefs and regional differences, may influence the level of knowledge about toxoplasmosis in pregnant women.

The present study showed that pregnant women predominantly receive information about toxoplasmosis from relatives, neighbors, or friends, underscoring the important role of social networks and personal contacts in spreading awareness. Notably, less than 25% of informed women cited HCPs as their information source, indicating a need to explore the factors influencing the low involvement of HCPs in toxoplasmosis awareness. Similarly, 39.5% of pregnant women in Mukalla city reported learning about toxoplasmosis from relatives or friends, while 35.9% and 20.4% attributed their knowledge to the media and HCPs, respectively [18]. On the other hand, about one-third of women aware of toxoplasmosis recognized it as an infection caused by a pathogen. In contrast, 16% of pregnant women in three Southeast Asian countries knew that toxoplasmosis is an infection [21], and 15.6% of pregnant women in Somalia recognized it as a parasitic infection [19]. In the present study, 70.8% of women identified cats as a potential source of infection, aligning with a

recent community-level finding in Saudi Arabia, where 69.8% of women identified cats as a source [22]. In contrast, 39% of women in Mukalla city identified cats as a source of infection [18].

Pregnant women's knowledge about the transmission modes of toxoplasmosis in the present study is limited. This finding is consistent with a previous study in Sana'a [12], where 44.7% of pregnant women knew about infection transmission. Likewise, in Mukalla, 40% of pregnant women knew that gardening without gloves could transmit the infection [18]. In comparison, 18% of Moroccan women knew about the transmission routes of infection, and 9.7% knew about transmission through eating raw or undercooked meat [23]. In the eastern region of Saudi Arabia, 20% of pregnant women were aware that contact with soil and eating unwashed vegetables and fruits could lead to transmission [24], while 32% of women considered poor hand hygiene as a facilitator of infection [22]. In Somalia, 17.3% of pregnant women knew the transmission of infection through contaminated water or food [19]. Undercooked meat was recognized to transmit infection by 6%, 42.6% and 46.7% of pregnant women in Somalia, Pakistan and Poland, respectively [19, 20]. Poor knowledge about the transmission modes of toxoplasmosis has also been reported among pregnant women in Southeast Asia [21], where 20.6% were aware of transmission through changing cat litter, 9.4% through eating undercooked meat and gardening without gloves, and 6.9% through drinking untreated water. Notably, congenital transmission of toxoplasmosis was the most recognized mode of transmission by approximately two-thirds of women in the present study. This finding shows that women who had heard of the infection were more aware of the transmission routes that could directly affect their pregnancy. In contrast, lower rates of awareness of congenital transmission were reported from Morocco (17.4%), Somalia

(13.1%), and some Southeast Asian countries [19, 21, 25].

The present study revealed a major knowledge gap among the majority of pregnant women regarding the asymptomatic nature of infection. This finding is consistent with those reported elsewhere [21, 25]. Therefore, it is crucial to educate women about the possibility of asymptomatic infections, as this information can help them understand the importance of preventive measures and regular prenatal screening to reduce transmission from mother to fetus. The awareness of most pregnant women in the present study about the susceptibility of immunocompromised patients to toxoplasmosis is crucial because pregnant women's immune systems alter during pregnancy, making them more susceptible to the infection. On the other hand, approximately 81% of pregnant women in the present study (about 81%) knew that a blood test is used to diagnose infection. However, the present study did not inquire about regular testing for toxoplasmosis. Therefore, it remains unclear how their actual testing history works and whether their knowledge about infection diagnosis translates into practice. In Mukalla city, more than half of pregnant women attending ANC clinics reported having been previously tested for toxoplasmosis [18]. In contrast, only 3.1% of Moroccan pregnant women knew how to diagnose toxoplasmosis [25].

The present study found no significant association between women's demographics and their level of knowledge about toxoplasmosis. Similarly, age and literacy status were not associated with the knowledge of pregnant women in rural Pakistan [20]. In contrast, age, education level, and profession were found to be significantly associated with pregnant women's awareness of toxoplasmosis in Morocco [25]. Younger age, urban residence, and higher education level were also found to be significantly associated with better knowledge about toxoplasmosis among Polish pregnant women [26]. Regarding obstetric history, the present study found that pregnant women with no

prior miscarriages or premature births had significantly higher levels of poor knowledge about toxoplasmosis than their counterparts. These findings suggest that personal experiences with pregnancy complications may influence women's awareness of toxoplasmosis. Women who have not experienced these negative obstetric outcomes may have had limited access to information and educational resources about toxoplasmosis, resulting in poor knowledge. In contrast, in Morocco and Pakistan, no significant association was found between a history of miscarriage and pregnant women's awareness of toxoplasmosis [20, 25].

Most women in the present study expressed positive attitudes towards toxoplasmosis, recognizing the risk of infection during pregnancy, the potential harm to their fetuses, and the possibility of preventing infection during pregnancy and its congenital transmission. This finding is consistent with that reported elsewhere for pregnant women [19, 25-27]. In the present study, attitudes were not significantly associated with their demographics. However, women in their first and second trimesters were significantly less likely to have negative attitudes than women in the third trimester, suggesting that women's attitudes change as pregnancy progresses and may become more negative in the later stages of pregnancy. The present study also revealed that women who had never experienced a miscarriage or premature birth and those pregnant for the first time were significantly more likely to express negative attitudes towards toxoplasmosis, indicating the role of previous negative events on women's attitudes.

Most women in the present study showed acceptable preventive practices against infection. Consistent with this finding, the majority of pregnant women in Sana'a and Mukalla reported washing freshly consumed produce and not eating undercooked meat [12, 15, 18]. In contrast, approximately 5% of pregnant women in Dhamar reported consuming washed raw vegetables [14]. The lack of a significant association between self-reported unacceptable

practices against toxoplasmosis and the demographic or obstetric characteristics of pregnant women in the present study could be attributed to the fact that adherence to hand and food hygiene practices may be deeply ingrained in their daily routines, regardless of their familiarity with toxoplasmosis or specific demographic and obstetric attributes. Furthermore, it is important to acknowledge the limitations of relying on self-reported information when evaluating hygiene practices, as this may introduce recall bias or social desirability bias. Respondents in this study may have provided answers that they believed were more socially acceptable rather than accurately reflecting their actual practices. In contrast, knowledge about preventive measures against toxoplasmosis was found to be significantly associated with higher educational levels of pregnant women in the Netherlands [28]. Preventive practices were also found to be significantly associated with the younger age and multigravidity of pregnant women in Tanzania [29].

There are several limitations to consider when interpreting the findings of this study. First, conducting the study among pregnant women receiving ANC may limit the generalizability of the findings to the broader pregnant population in the community. Nonetheless, it provides initial insights into the KAPs of pregnant women towards toxoplasmosis in Sana'a city, laying the groundwork for future community-based studies. Second, the use of close-ended questions in the questionnaire could have constrained the ability of participants to elaborate and provide more detailed responses. As a result, valuable insights might have been missed. Therefore, future studies may consider using open-ended questions and/or adopting a qualitative approach to allow the participants to provide more detailed and contextualized responses for an in-depth understanding of their KAPs towards toxoplasmosis. Third, the use of self-reported data could introduce bias despite being helpful and widely used in KAP studies. Self-reported

data are prone to social desirability and recall bias, which could overestimate or underestimate certain attitudes or practices. Respondents may have tailored their responses to questions about attitudes and preventive practices based on what they perceived as socially acceptable, or they may have faced difficulties in accurately recalling information about toxoplasmosis. Nonetheless, self-reported data remain valuable and is commonly employed in KAP studies.

5. Conclusion

Pregnant women receiving ANC in Sana'a lack good knowledge about toxoplasmosis, including various transmission modes and preventive measures, underscoring the need for awareness-raising educational interventions. Knowledge is mostly acquired from informal sources of information, particularly social and personal networks. However, most women have positive attitudes and follow acceptable preventive practices against the infection. Community-based studies are recommended to gain a deeper understanding of pregnant women's KAPs towards toxoplasmosis.

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Conflict of interests

The authors declare no conflict of interest associated with this study.

6. References

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