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**HEALTH LITERACY: KNOWLEDGE ABOUT TOXOPLASMOSIS
IN PORTUGAL**

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HEALTH LITERACY: KNOWLEDGE ABOUT TOXOPLASMOSIS IN PORTUGAL

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ABSTRACT

Introduction: Congenital toxoplasmosis is a disease that can have severe repercussions for the fetus. One of the forms of disease prevention is to improve health literacy in the population. The main goal of this study was to analyze the knowledge related to *Toxoplasma gondii* infection among the population living in the Portuguese territory. We also focused on the association between knowledge and sociodemographic and obstetric variables.

Methods: The data were obtained from adults between 18 and 50 years, by an online questionnaire, including questions about sociodemographic characteristics, obstetric information, preventive behavior during pregnancy, and toxoplasmosis-related knowledge (general, symptoms and timing of disease, risk factors, and prevention domains). The Chi-square test or Fisher exact test was used to test the independence between gender, parous, educational background, living environment, and toxoplasmosis-related knowledge. The significance level was set at 0.05.

Results: A total of 171 participants replied to the questionnaire, and 167 were considered for analysis. The median age was 34. The majority were female (73.3%), and 53.7% were parous, lived in an urban environment (80.2%), had at least a bachelor's degree (83.2%), and had studies in other than health sciences (61.1%). Most participants (145; 86.8%) indicated having some information regarding toxoplasmosis, the most common source being medical professionals, the media, and friends.

A higher proportion of correct answers was shown concerning knowledge of risk factors. Regarding symptoms and timing of disease, of the 12 questions, only 2 had a proportion of correct answers above 65%. Female gender and having studies in health sciences were associated with better knowledge in all domains. Higher education was associated with better knowledge in 1/3 of the questions, especially in general knowledge. No clear association was observed between living environment and being parous.

Conclusion: In a sample of adults, most knew about toxoplasmosis. Toxoplasmosis-related knowledge was moderate, except for prevention knowledge which stood out the most. Also, female gender, having at least a bachelor's degree and studies in health sciences were associated with better knowledge of toxoplasmosis.

Key words: Congenital Toxoplasmosis, Pediatrics, Pregnancy, Prevention, *Toxoplasma gondii*

RESUMO

Introdução: A toxoplasmose congénita é uma doença que pode ter repercussões graves para o feto. Uma das formas de prevenção de doença é através da literacia em saúde na população. Este trabalho foi realizado com o intuito de avaliar o conhecimento relacionado com a infecção por *Toxoplasma gondii* e a sua associação com variáveis sociodemográficas e obstétricas em indivíduos residentes em Portugal.

Materiais e métodos: A amostra foi constituída por indivíduos com idade entre os 18 e os 50 anos. Os dados foram recolhidos através de um questionário online, que incluiu perguntas sobre características sociodemográficas, informações obstétricas, comportamento preventivo durante a gravidez e conhecimentos relacionados com a toxoplasmose (geral, sintomas e tempo da doença, fatores de risco e prevenção). O teste do Qui-quadrado ou o teste exato de Fisher foram utilizados para testar a independência entre sexo, gravidez prévia, escolaridade, área de estudos, ambiente de residência (rural/urbano) e conhecimento relacionado à toxoplasmose. O nível de significância adotado foi de 0,05.

Resultados: De um total de 171 participantes, apenas 167 foram considerados para análise. A mediana de idade foi de 34 anos. A maioria era do sexo feminino (73,3%), das quais 53,7% com gravidez prévia, residente em ambiente urbano (80,2%), com pelo menos o grau de licenciado (83,2%) e estudos em áreas não relacionadas com a saúde (61,1%). Cerca de 86,8% dos participantes detinha informação acerca desta patologia, maioritariamente adquirida através de profissionais de saúde, meios de comunicação ou amigos. Relativamente a fatores de risco e formas de prevenção, a maioria da população é conhecedora dos mesmos. Em relação aos sintomas e momento da doença, das 12 questões, apenas 2 tiveram proporção de acertos acima de 65%. Ser do sexo feminino e ter estudos na área de ciências da saúde foram associados a melhor conhecimento em todos os domínios. Ser detentor de grau de licenciado ou superior associou-se a melhores conhecimentos em 1/3 das questões, principalmente em conhecimentos gerais. Nenhuma associação clara foi observada entre o ambiente de residência e gestação prévia.

Conclusão: A maioria dos participantes tinha conhecimento sobre a toxoplasmose, destacando-se os conhecimentos relacionados com a sua prevenção. Ser do sexo feminino, ter grau igual ou superior a licenciatura e estudos na área das ciências da saúde estão associados a melhor conhecimento sobre toxoplasmose.

Palavras-chave: Gravidez, Pediatria, Prevenção, Toxoplasmose congénita, *Toxoplasma gondii*

INTRODUCTION

Toxoplasmosis is a parasitic disease caused by *Toxoplasma gondii* (*T. gondii*), an obligate intracellular protozoan parasite (1). Globally, one-third of people are infected with *Toxoplasma*. However, significant heterogeneity in the seroprevalence of *T. gondii* can be seen between different countries and among pregnant women (2). Nevertheless, it is in developing countries where congenital toxoplasmosis is still an important cause of morbidity and mortality (3). In Europe, raw meat consumption was identified as an independent risk factor for acquiring *T. gondii* parasite (4). Other forms of infection include consuming water and poorly washed vegetables and fruits contaminated with feces of infected cats and other felines (2,5), and rarely by transplantation with an infected donated organ and blood transfusion (6). Transmission can also occur from vertical transmission (mother to the fetus), called congenital toxoplasmosis. The most recent surveillance by the European Centre for Disease Prevention and Control (ECDC) reported that in 2019, the overall notification rate was 5.1 cases per 100.000 live births (7). In Portugal, congenital toxoplasmosis is a notifiable disease and, according to *Instituto Nacional de Estatística* (INE), between 2016 and 2018, 9 cases of congenital toxoplasmosis were reported (8–10). According to a previous study, from 1979 to 2013 there was a decrease in *T. gondii* seroprevalence in the Portuguese population, from 47% to 22%, respectively. The latter value is similar to that described in other European countries such as Spain and Italy. Thus, it can be predicted that more than 80% of pregnant women in Portugal are susceptible to primary *T. gondii* infection, which confers an increased risk of developing congenital toxoplasmosis (1).

T. gondii infection usually results in asymptomatic and has a benign course of disease (1). Even asymptomatic, pregnant women can transmit the infection to the fetus (7). Infection during pregnancy can cause miscarriage (11), stillbirth, or trigger severe malformations in the newborn, such as intracranial calcifications, hydrocephalus, psychomotor retardation, seizures, retinochoroiditis, visual impairment, nerve atrophy or cataract (12,13). The first trimester is the period when there is the most significant risk of severe complications in the fetus. Although the risk of transmission increases as gestational age advances, the risk of malformations decreases (13). However, a timely diagnosis allows for appropriate therapy, which reduces the risk of congenital toxoplasmosis and the malformations that the newborn may carry in the future (14,15). In Portugal, there are guidelines for pregnancy surveillance, which include toxoplasmosis evaluation. The evaluation of toxoplasmosis is done by serological techniques, ideally performed in the preconception period. If the pregnant woman is not immune, she should repeat the test every trimester (16).

Currently, there is still no vaccine for toxoplasmosis in humans (17), so population education is still an essential mechanism for disease prevention.

The main goal of this study was to analyze the knowledge related to *T. gondii* infection among the population living in the Portuguese territory. We also focused on the association between knowledge and sociodemographic and obstetric variables.

MATERIALS AND METHODS

A cross-sectional questionnaire-based study was conducted in Portugal.

A literature search was performed in PubMed using the keywords ("Toxoplasmosis" OR "*Toxoplasma gondii*") AND "Knowledge" AND ("Questionnaire" OR "Survey") in August 2022. Six studies were selected to develop a Portuguese-language questionnaire using Google Forms® (5,18–22). The questionnaire included questions regarding a) socio-demographic information, such as age, gender, nationality, civil status, macro geographical area of residence, educational background, and living environment; b) obstetric information, such as previous pregnancies, abortions, and medical follow-up of currently pregnant women; c) preventive behavior in women who are or have been pregnant in the past (5 questions), d) general information and knowledge on toxoplasmosis (11 questions), e) toxoplasmosis risk factors (5 questions), f) knowledge on symptomatology and period of illness (12 questions), and g) toxoplasmosis prevention (7 questions). The questions, aiming to assess the participant's knowledge of toxoplasmosis, were designed as multiple choice (yes, no, don't know/not applicable) (Supplementary Table 1).

In order to ascertain the questionnaire's clarity and average completion time, in November 2022, a pre-testing was conducted on a random sample of 10 individuals. Only minor modifications were made as a result. Pre-test participants were not included in the final study analysis. The average time of completion was 10 minutes.

The online questionnaire was sent through social media platforms (WhatsApp, Instagram, Facebook, and E-mail) and made available from December 2022 to February 2023.

General information on the study, its main purpose, and the inclusion criteria were provided on the first page. Participants were also informed regarding confidentiality requirements according to the Declaration of Helsinki (2013) and the General Data Protection Regulation of the European Parliament and the Council of the European Union.

The inclusion criteria encompassed men and women between 18 and 50 years old born and living in Portugal.

Statistical analysis

Statistical analyses were conducted using IBM SPSS Statistics Version 29. Normality was assessed with the Shapiro–Wilk test. Categorical data are presented as counts and proportions, and continuous data as median and 25th–75th percentiles (P25, P75). The chi-square test or Fisher exact test was used as appropriate to test the independence between categorical variables, namely gender, parous, educational area (Health/Others), education level (High school (grades ≤12)/ Bachelor, Master/Ph.D.), living environment (Urban/Rural), and toxoplasmosis-related knowledge (questions recoded in correct and incorrect/do not know answers). The significance level was set at 0.05 for two-sided tests.

RESULTS

A total of 171 participants replied to the questionnaire. Four were excluded as they did not meet the inclusion criteria: nationality other than Portuguese ($n = 2$) and age over 50 years old ($n = 2$). The final sample comprised 167 subjects. The majority were female, single or married/non-marital partnership, from Northern Portugal and living in an urban environment. In respect of educational features, most have studies in areas other than health sciences and obtained a degree (Table 1).

Table 1. Participants socio-demographic characteristics

	Median (P25-P75)
Age (years)	34 (28.0-42.5)
	n (%)
Gender	
Female	123 (73.7)
Male	44 (26.3)
Marital status	
Married/Non-marital partnership	75 (44.9)
Divorced	10 (6.0)
Single	81 (48.5)
Widowed	1 (0.6)
Portugal macro geographical area	
North	121 (72.5)
Centre	23 (13.8)
South	20 (12.0)
Autonomous regions	3 (1.8)
Living environment	
Urban	134 (80.2)
Rural	33 (19.8)
Level of completed education	
High school (grades ≤12)	28 (16.8)
Bachelor Degree	72 (43.1)
Master and Doctoral Degree	67 (40.1)

Educational area	
Health Sciences	65 (38.9)
Other	102 (61.1)

P, percentil

Concerning obstetric information, 66 (53.7%) were parous, and 30 (45.5%) had 2 or more childbirths. Two were primiparous, in the second quarter of pregnancy, and reported proper medical follow-up in accordance with pregnancy surveillance norms in Portugal. Most women reported adopting precautions to prevent *T. gondii* infection during pregnancy, except for the consumption of rare meat or sausages (Table 2).

Table 2. Preventive behavior during pregnancy (n = 66)

	Yes	No	Not applicable
n (%)			
Wash hands after gardening	53 (80.3)	2 (3.0)	11 (16.7)
Wash hands after changing cat litter	24 (36.4)	1 (1.5)	41 (62.1)
Wash hands after handling raw meat	64 (97.0)	1 (1.5)	1 (1.5)
Consumption of rare meat or sausages	42 (63.6)	24 (36.4)	0 (0.0)
Consumption of salads or other raw ingredients without appropriate prior washing and disinfection	15 (22.7)	51 (77.3)	0 (0.0)

Of the 167 participants, 145 (86.8%) indicated having some information regarding toxoplasmosis, the most common source being medical professionals, the media and friends. About one-third (54; 32.3%) were tested for toxoplasmosis, and 4 (2.4%) were immune. Few participants (24; 14.4%) knew anyone who had *T. gondii* infection in the past.

More than half of the participants answered correctly all questions concerning general toxoplasmosis knowledge, except the one related to the highest risk of transmission of infection from mother to fetus. In the latter, there was a higher proportion of "do not know" answers. Respecting risk factors, almost all questions achieved higher proportions of correct answers. The question about handling raw venison presented a higher percentage of "do not know" answers. Regarding symptoms and timing of disease, less knowledge was shown. Significantly, of the 12 questions in this domain, only 2 had a proportion of correct answers above 65%. Of the remaining questions, all, except one, had more than 50% "do not know" responses. In the prevention domain, the highest percentage of correct answers was obtained in 6 of the 7 questions. In 4 of them, the

proportion was higher than 65%. Only one question had the highest percentage of answers indicated in the "do not know" option (Table 3).

A trend can be observed considering the associations between better toxoplasmosis knowledge and gender, living environment, educational area, level of complete education and being parous. In general, being female, living in a rural area, have studies in health sciences, and having at least a bachelor's degree were associated with better knowledge of toxoplasmosis. The trend is not as clear regarding being parous. Comparing genders was found that women had a higher percentage of correct answers than men in all but one question. It was also found that being female was associated with better knowledge in all domains (16 out of the 31 questions), mainly in general knowledge and prevention domains. Differences between living in a rural or urban environment were obtained in only 5 questions, most of which were in the prevention domain. Heath science education studies were associated with higher percentages of correct answers in most questions. Higher education, in general, was associated with better knowledge in 1/3 of the questions. Being parous was associated with better knowledge in only 8 questions (Table 4).

Table 3. Participants' knowledge of toxoplasmosis, including general, risk factors, symptoms, and prevention

	No	Yes	Do not know
	n (%)		
General knowledge about toxoplasmosis			
Toxoplasmosis is caused by an infection	33 (19.8)	89 (53.3)	45 (26.9)
Toxoplasmosis is caused by a toxic product	121 (72.5)	11 (6.6)	35 (21.0)
<i>T. gondii</i> is shed in the feces of infected cats	17 (10.2)	106 (63.5)	44 (26.3)
<i>T. gondii</i> sometimes is found in raw or undercooked meat	3 (1.8)	132 (79.0)	32 (19.2)
Higher risk for vertical transmission of toxoplasmosis occurs during the 3T of pregnancy	50 (29.9)	33 (19.8)	84 (50.3)
Higher risk for fetus complications occurs during the 1T of pregnancy	16 (9.6)	90 (53.9)	61 (36.5)
There is a vaccine for toxoplasmosis	92 (55.1)	10 (6.0)	65 (38.9)
Risk Factors			
People get toxoplasmosis by changing cat litter*	9 (5.4)	114 (68.3)	43 (25.7)
People get toxoplasmosis by consuming undercooked pork**	9 (5.5)	119 (72.1)	37 (22.4)
People get toxoplasmosis by handling raw venison	45 (26.9)	46 (27.5)	76 (45.5)
People get toxoplasmosis by gardening without gloves	26 (15.6)	73 (43.7)	68 (40.7)
People get toxoplasmosis by using the glass of an infected person*	76 (45.8)	21 (12.7)	69 (41.6)
Symptoms and timing of disease			
Pregnant women develop serious complications after infection with <i>T. gondii</i>	12 (7.2)	110 (65.9)	45 (26.9)
Unborn and/or newborn develop serious complications after infection with toxoplasmosis*	2 (1.2)	119 (71.7)	45 (27.1)
Toxoplasmosis in a pregnant woman causes fever and feeling like you have the "flu"**	6 (3.6)	64 (38.6)	96 (57.8)
Toxoplasmosis in a pregnant woman causes swollen glands (lymph nodes)*	3 (1.8)	54 (32.5)	109 (65.7)
Toxoplasmosis in a pregnant woman causes no symptoms*	7 (4.2)	59 (35.5)	100 (60.1)
Newborn children become infected with toxoplasmosis while breastfeeding**	41 (24.8)	20 (12.1)	104 (63.0)
<i>T. gondii</i> only passed from mother to fetus if newly infected during that pregnancy***	25 (15.2)	65 (39.6)	74 (45.1)
<i>T. gondii</i> rarely passed from mother to fetus if infected before becoming pregnant**	20 (12.1)	43 (26.1)	102 (61.8)
Baby with toxoplasmosis may have no signs of illness at birth but develop illness later*	9 (5.4)	35 (21.1)	122 (73.5)
Baby with toxoplasmosis may have vision problems*	1 (0.6)	64 (38.6)	101 (60.8)
Baby with toxoplasmosis may have neurological problems*	0 (0)	77 (46.4)	89 (53.6)
Baby with toxoplasmosis may be treated with medicine****	13 (8.0)	37 (22.7)	113 (69.3)
Prevention knowledge			
Feeding your cat dry or commercial cat food and not letting it kill and eat rodents*	14 (8.4)	82 (49.4)	70 (42.2)

Avoiding stray cats*	9 (5.4)	127 (76.5)	30 (18.1)
Letting someone else change the cat's litter box*	24 (14.5)	108 (65.1)	34 (20.5)
Making sure the cat's litter box is changed daily**	34 (20.6)	64 (38.8)	67 (40.6)
Cooking meat well until no pink is seen and the juices run clear	6 (3.6)	135 (81.8)	24 (14.5)
Thoroughly washing and/or peeling all fruits and vegetables before eating them**	2 (1.2)	150 (90.4)	14 (8.4)
Cleaning carefully the cutting boards and utensils after each use*	3 (1.8)	146 (88.0)	17 (10.2)

*There is 1 missing; **there are 2 missing; ***there are 3 missing; ****there are 4 missing; Correct answers in bold; T, Trimester

Table 4. Associations between percentages of correct answers and gender, living environmental, educational area, educational level, and parous

	Gender (%)			Living Environment (%)			Educational area (%)			Education level (%)			Parous (%)			
	F	M	p	R	U	p	H	O	p	HS	B	M/D	p	No	Yes	p
General knowledge about toxoplasmosis																
Toxoplasmosis is caused by an infection	58.5	38.6	.023	42.4	56.0	.162	80.0	36.3	<.001	39.3	55.6	56.7	.263	59.6	57.6	.816
Toxoplasmosis is caused by a toxic product	77.2	59.1	.021	84.8	69.4	.075	89.2	61.8	<.001	46.4	77.8	77.6	.003	68.4	84.8	.030
<i>T. gondii</i> is shed in the feces of infected cats	66.7	54.5	.152	66.7	62.7	.671	86.2	49.0	<.001	32.1	69.4	70.1	<.001	57.9	74.2	.055
<i>T. gondii</i> sometimes is found in raw or undercooked meat	84.6	63.6	.003	87.9	76.9	.164	95.4	68.6	<.001	57.1	77.8	89.6	.002	78.9	89.4	.110
Higher risk for vertical transmission of toxoplasmosis occurs during the 3T of pregnancy	22.8	11.4	.103	18.2	20.1	.799	26.2	15.7	.098	10.7	16.7	26.9	.134	15.8	28.8	.086
Higher risk for fetus complications occurs during the 1T of pregnancy	62.6	29.5	<.001	69.7	50.0	.042	78.5	38.2	<.001	46.4	59.7	50.7	.391	57.9	66.7	.316
There is a vaccine for toxoplasmosis	59.3	43.2	.064	54.5	55.2	.944	70.8	45.1	.001	21.4	61.1	62.7	<.001	59.6	59.1	.950
Risk Factors																
People get toxoplasmosis by changing cat litter	77.9	43.2	<.001	87.5	64.2	.011	89.2	55.4	<.001	60.7	70.4	70.1	.609	68.4	86.2	.019
People get toxoplasmosis by consuming undercooked pork	6.9	59.1	.024	84.8	68.9	.068	83.1	65.0	.011	57.1	70.4	80.3	.066	67.9	84.6	.029
People get toxoplasmosis by handling raw venison	26.0	31.8	.460	24.2	28.4	.635	43.1	17.6	<.001	10.7	31.9	29.9	.088	31.6	21.2	.191
People get toxoplasmosis by gardening without gloves	45.5	38.6	.429	51.5	41.8	.313	58.5	34.3	.002	21.4	51.4	44.8	.025	35.1	54.5	.031
People get toxoplasmosis by using the glass of an infected person	47.5	40.9	.449	39.4	47.4	.410	52.3	41.6	.176	22.2	45.8	55.2	.015	47.4	47.7	.971
Symptoms and timing of disease																
Pregnant women develop serious complications after infection with <i>T. gondii</i>	69.1	56.8	.140	78.8	62.7	.081	73.8	60.8	.083	57.1	66.7	68.7	.549	61.4	75.8	.086
Unborn and/or newborn develop serious complications after infection with toxoplasmosis	77.9	54.5	.003	87.9	67.7	.021	87.7	61.4	<.001	53.6	75.0	75.8	.065	71.9	83.1	.139
Toxoplasmosis in a pregnant woman causes fever and feeling like you have the “flu”	40.7	32.6	.348	33.3	39.8	.491	58.5	25.7	<.001	17.9	40.8	44.8	.043	45.6	36.4	.298
Toxoplasmosis in a pregnant woman causes swollen glands (lymph nodes)	34.1	27.9	.452	21.2	35.3	.121	58.5	15.8	<.001	17.9	33.8	37.3	.174	36.8	31.8	.558

Toxoplasmosis in a pregnant woman causes no symptoms	37.4	30.2	.398	39.4	34.6	.606	60.0	19.8	<.001	17.9	38.0	40.3	.097	40.4	34.8	.529
Newborn children become infected with toxoplasmosis while breastfeeding	27.9	16.3	.130	30.3	23.5	.418	40.0	15.0	<.001	10.7	25.4	30.3	.132	26.3	29.2	.720
<i>T. gondii</i> only passed from mother to fetus if newly infected during that pregnancy	44.6	25.6	.028	43.8	38.6	.596	46.2	35.4	.167	25.0	47.8	37.3	.101	29.8	57.8	.002
<i>T. gondii</i> rarely passed from mother to fetus if infected before becoming pregnant	30.3	14.0	.035	27.3	25.8	.859	40.6	16.8	<.001	10.7	32.4	25.8	.086	28.6	31.8	.697
Baby with toxoplasmosis may have no signs of illness at birth but develop illness later	21.1	20.9	.977	9.1	24.1	.059	33.8	12.9	.001	10.7	19.7	26.9	.198	22.8	19.7	.674
Baby with toxoplasmosis may have vision problems	43.1	25.6	.042	39.4	38.3	.912	63.1	22.8	<.001	25.0	40.8	41.8	.269	45.6	40.9	.599
Baby with toxoplasmosis may have neurological problems	50.4	34.9	.079	48.5	45.9	.787	73.8	28.7	<.001	25.0	53.5	47.8	.036	50.9	50.0	.923
Baby with toxoplasmosis may be treated with medicine	25.4	14.6	.154	27.3	21.5	.483	40.0	11.2	<.001	14.3	31.4	16.9	.067	29.8	21.5	.294
Prevention knowledge																
Feeding your cat dry or commercial cat food and not letting it kill and eat rodents	52.5	40.9	.189	57.6	47.4	.294	56.9	44.6	.120	35.7	54.9	49.3	.227	51.8	53.0	.891
Avoiding stray cats	82.0	61.4	.006	81.8	75.2	.421	89.2	68.3	.002	60.7	81.7	77.6	.082	75.0	87.9	.065
Letting someone else change the cat's litter box	73.0	43.2	<.001	72.7	63.2	.302	80.0	55.4	.001	35.7	77.5	64.2	<.001	66.1	78.8	.115
Making sure the cat's litter box is changed daily	44.6	22.7	.011	54.5	34.8	.038	38.5	39.0	.945	50.0	39.4	33.3	.313	50.0	40.0	.270
Cooking meat well until no pink is seen and the juices run clear	89.3	61.4	<.001	93.9	78.8	.044	96.9	72.0	<.001	67.9	87.3	81.8	.077	82.1	95.4	.019
Thoroughly washing and/or peeling all fruits and vegetables before eating them	94.3	79.5	.013*	97.0	88.7	.200*	100	84.2	<.001	82.1	95.8	88.1	.083	89.3	98.5	.047*
Cleaning carefully the cutting boards and utensils after each use	91.8	77.3	.011	97.0	85.7	.130*	95.4	83.2	.018	71.4	93.0	89.6	.011	41.1	100	<.001*

B, Bachelor; F, Female; H, Health science studies; HS, High School; M, Male; M/D, Master and Doctoral degree; O, Others; R, Rural; T, Trimester; U, Urban; *Fisher Exact Test

DISCUSSION

This study aimed to investigate toxoplasmosis-related knowledge in a sample of adults of both genders from the Portuguese general population. Our results showed greater certainty of correct answers in general knowledge and infection prevention domains. In contrast, great uncertainty was evident in knowledge about symptoms and the time of illness. In general, being female, have studies in health sciences and having at least a bachelor's degree were associated with better knowledge of toxoplasmosis.

As far as we were concerned, this was the first study conducted in Portugal to assess toxoplasmosis-related knowledge in the general population.

In the present study, 86.8% of participants reported having some information regarding toxoplasmosis, which is in line with other studies conducted in Europe (5,23,24), with reported values from 75.3% in the Netherlands (24) to 94.4% in Poland (23), both studies conducted in pregnant women. These results contrast with the lowest values reported in studies among pregnant women carried out in developing countries such as Tanzania (4.3%) (25), Sri Lanka (4.4%) (21) and Brazil (27.8%) (26). These low values reported by these studies may be related to the fact that there is no surveillance for toxoplasmosis during pregnancy in these countries, making it a little-addressed topic among this population. Also, differences in culture and socio-demographic characteristics could impact the results. Interestingly, lower proportions (22.4%) were also reported in a study performed in Turkey (27). Turkey is a Euro-Asian country with different cultural and social realities than other European countries.

Concerning the different domains of toxoplasmosis knowledge, the general and prevention knowledge presented consistently higher proportions of correct answers than all the other domains. Interestingly, comparing individual questions from both domains, we found some inconsistencies. Despite the vast majority demonstrating good knowledge about preventing infection, only about half of the participants correctly identified toxoplasmosis as an infectious disease. Similarly, contradictory results were found regarding the consumption of raw meat. Despite 81.8% of the participants claiming to know that consumption of well-cooked meat is a preventive behavior, a higher proportion than reported by previous studies (18–20,22,23,26–30), more than half of parous women said having consumed raw meat or sausages during pregnancy. The preventive results may be explained not specifically to toxoplasmosis prevention but to general knowledge of preventive hygiene measures for infections in general, widespread among our population. However, we could not explain the high number of women who reported consuming raw meat during pregnancy. This may reinforce the importance of

toxoplasmosis screening during pregnancy to acquire knowledge about the disease. Ingestion of the parasite in undercooked meat is the primary mechanism of acquiring *T. gondii* parasite in Europe (31). About half of the participants answered correctly to the question of a vaccine for toxoplasmosis. There is no vaccine against *T. gondii*, highlighting the importance of acquiring knowledge about toxoplasmosis prevention, especially during pregnancy, to prevent primary infection in pregnant women and potential consequent sequelae in children. The high number of non-immune women reinforces the importance of monitoring the pregnant woman. Despite medication availability for toxoplasmosis treatment, it's essential not to forget the potential risks inherent in its administration and its associated costs. Thus emphasize the need to implement preventive measures so providing information about them is crucial.

Overall, knowledge was lowest in the domains "symptoms and timing of disease" and "risk factors", where the vast majority of responses were incorrect or "did not know". The same results were previously reported in a study conducted in the United States among pregnant women from the general population (20). The fact that this knowledge is more technical may partly explain these results.

A recent study conducted in Portugal performed on a sample of pet owners showed that the cat was the second most frequent animal. Surprisingly, about a third of participants considered pregnant women not a risk group for contracting zoonotic diseases (32). One of the transmission routes of *T. gondii* occurs through contact with the feces of infected cats, and this knowledge seems to be commonly shared by Portuguese pet owners. A similar result was observed in our sample, although the sample did not exclusively include participants with pets. The fact that publicity on cat hygiene and food products is transmitted regularly through social media in Portugal may explain these results.

Regarding associations between gender and level of knowledge, the present study revealed that women had a better understanding of toxoplasmosis than men, mainly in the prevention knowledge domain. Comparison with previous studies was not made since none included men from the general population. However, studies conducted in specific populations of students from higher education degree courses have shown different trends, finding no differences between male and female participants (19,29,33). In addition to cultural differences, the samples in these studies were composed of younger individuals, which may impact the results.

Nowadays, men are increasingly present in co-parenting and can be a conduit of information about the disease to women during pregnancy. In our statistical analysis, comparison between men who have or never have been fathers was not considered, which could eventually mirror this reality.

Overall, among female participants, it was possible to find that parous women showed a higher proportion of correct answers about toxoplasmosis-related knowledge than non-parous. Although in most of the questions, the difference was not statistically significant. This may be related to the fact that in Portugal, pregnancy surveillance includes assessment for *T. gondii* infection, which allows at least pregnant women to acquire some information about the disease and its prevention. The information vehicle, medical professionals, is similar to that reported in other studies (20,23,24,27,29,30).

Considering the living environment, the present study showed that, on most of the questions, better knowledge was not associated with either the urban or rural environment. However, a trend could be observed once the majority of correct answers were found in the rural group. Another study conducted in Egypt found the same statistically significant trend among female university students (34). In contrast, better results were reported among pregnant women from urban residents in Iraq (35), female students in Saudi Arabia (21) and women from the general population in Italy (5). The fact that there was no difference between the rural and urban environments in our study may be explained by the fact that, in Portugal, mandatory schooling has been 12th grade since 2009, which can demonstrate why all respondents reported having at least this level of schooling. In addition, the vast majority have at least a bachelor's degree; therefore, a higher level of literacy is to be expected. This is in contrast to developing countries, where in rural environment schooling is lower, as reflected in the characteristics of the samples included in these studies (20,29).

Taking into account the educational background, being a graduate and having studies in health sciences were associated with better knowledge in all the domains. However, this difference is less evident in the symptoms and timing of the disease domains. In contrast, poor knowledge was observed in other studies performed on medical doctors (36) and health workers (25), which is an unexpected finding and for which we found no explanation.

Comparisons about different levels of knowledge between studies should be made with caution since there is no validated questionnaire to assess toxoplasmosis-related

knowledge. Although the studies used questionnaires to assess knowledge, the number of questions and the domains considered varied. Also, most studies were conducted on pregnant women (20,23–26,26–29,37).

We verified the existence of gaps in different domains of toxoplasmosis-related knowledge so health literacy is essential to increase understanding of the disease, its risk factors, and prevention with an impact on improving the management of healthcare costs.

Having a pet in the family is relatively common in Portugal, so it is crucial to warn about how an infected animal can affect the household's health, especially when including a pregnant woman. Also, due to immigration, the number of children born in Portugal of women from developing countries has increased. This reinforces the need to strengthen prophylactic measures during the medical follow-up of pregnancy to avoid acquiring the parasite in those women.

Strengths and limitations

The strengths of this study include the fact that the questionnaire designed covered different domains of knowledge about toxoplasmosis. Each part was composed of several questions, which allowed for a more comprehensive evaluation of each field.

Another strength is the sample selected for this study. Most existing studies on this topic have set mostly pregnant women and students, with few studying the knowledge of toxoplasmosis in the general population and both genders.

Regarding limitations, we include that the complete questionnaire responses were lower than initially expected. This difficulty may be due to people's lack of interest in the subject studied or primarily to fatigue in answering questionnaires, mainly due to the Covid pandemic, where there was an increase in the number of requests for participation in studies using online questionnaires.

Another limitation of online questionnaires is not known if people use alternative means to get information to answer the questions correctly. Nevertheless, this would lead to an overestimation of results about knowledge. Finally, there was significant heterogeneity in the sample in the variables of gender, living environment and geographical area.

CONCLUSION

In conclusion, our results demonstrated that, in a population of adults, most knew about toxoplasmosis. The related knowledge was moderate, being the prevention domain, which stood out the most. Also, female gender, having at least a bachelor's degree and studies in health sciences were associated with better knowledge of toxoplasmosis.

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Supplementary Table 1. Questionnaire to evaluate knowledge of toxoplasmosis

General information and knowledge about toxoplasmosis

- Have you ever read, heard or seen any information about toxoplasmosis?
- Have you ever been tested for toxoplasmosis (by serology for the causative agent)?
- Have you ever been diagnosed with toxoplasmosis (*T. gondii*)?
- Do you know anyone who has had *T. gondii* infection?
- Is toxoplasmosis caused by an infection?
- Is toxoplasmosis caused by a toxic product?
- Is toxoplasmosis (*T. gondii*) shed in the feces of infected cats?
- Is toxoplasmosis (*T. gondii*) sometimes found in raw or undercooked meat?
- The period of highest risk for transmission of toxoplasmosis, from mother to fetus, occurs during the third trimester of pregnancy.
- The first trimester of pregnancy is the period when toxoplasmosis infection has the highest risk of causing serious changes/problems in the fetus.
- There is a vaccine for toxoplasmosis.
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Risk Factors

- Can people get toxoplasmosis by changing cat litter?
- Can people get toxoplasmosis by eating undercooked pork?
- Can people get toxoplasmosis by handling raw venison?
- Can people get toxoplasmosis by gardening without gloves?
- Can people get toxoplasmosis by using the glass of an infected person?
-

Symptoms and timing of disease

- Can pregnant women develop serious complications after infection with toxoplasmosis (*T. gondii*)?
- Can unborn and/or newborn children develop serious complications after infection with toxoplasmosis (*T. gondii*)?
- Can toxoplasmosis in a pregnant woman cause fever and feeling like you have the “flu”?
- Can toxoplasmosis in a pregnant woman cause swollen glands (lymph nodes)?
- Can toxoplasmosis in a pregnant woman cause no symptoms?
- Can newborn children become infected with toxoplasmosis while breastfeeding?
- Toxoplasmosis (*T. gondii*) can only be passed from a pregnant woman to her fetus if she is newly infected during that pregnancy.
- Toxoplasmosis (*T. gondii*) is rarely passed from a pregnant woman to her fetus if she was infected before becoming pregnant.
- A baby with toxoplasmosis may have no signs of illness at birth but develop illness later.
- A baby with toxoplasmosis may have vision problems.
- A baby with toxoplasmosis may have neurological problems.
- A baby with toxoplasmosis may be treated with medicine.
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Prevention knowledge

- Feeding your cat dry or commercial cat food and not letting it kill and eat rodents.

Avoiding stray cats.

Letting someone else change the cat's litter box.

Making sure the cat's litter box is changed daily.

Cooking meat well until no pink is seen and the juices run clear.

Thoroughly washing and/or peeling all fruits and vegetables before eating them.

Cleaning carefully the cutting boards and utensils after each use.

Preventive behavior in pregnancy

Routinely wash your hands after gardening?

Routinely wash your hands after changing cat litter?

Routinely wash your hands after handling raw meat?

Eat rare meat or sausages?

Eat salads or other raw foods without prior washing and disinfection with appropriate products?
