EISSN: 2707-0425

East African Journal of Science, Technology and Innovation, Vol. 5 (3): June 2024

Knowledge, Attitude, and Practices Toward Toxoplasmosis Among Community Members in Iringa Municipal, Tanzania

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Abstract

Toxoplasmosis caused by an intracellular protozoan parasite, *Toxoplasma gondii*, is emerging as one of the causes of morbidities and mortalities in many countries. In Tanzania, Iringa is among the regions reported to have high human cases of the disease. However, information about the risk factors for its transmission is lacking. The work explored community awareness about the disease in Iringa municipal. A cross-section study was conducted in Iringa Municipal, to assess the community knowledge, attitude, and practices associated with toxoplasmosis transmission as a basis for planning control strategies. A semi-structured questionnaire was administered to selected respondents from households with complaints of rodent infestation and or keeping pigs in randomly selected wards of Iringa municipal to gather information on awareness, attitude, and practices regarding toxoplasmosis and respondent's social demographic characteristics such as sex, age, economic activities, and level of education. A total of 143 participants were interviewed, where 63.6% and 36.4% were males and females, respectively. Of the respondents, 21% were government-employed, and 49% had attained post-secondary education. The majority of the respondents (32.2%) were of 36-45 years followed by a group of 18-25 years (23.1%). No association between disease knowledge and sex was observed, however, respondents aged 18-25 years had significantly higher knowledge compared to other age groups (p-value=0.037). The knowledge was found to increase with the level of education whereas those with the tertiary level were more knowledgeable about the disease ($p < 0.0001$). Among the observed risky practices for disease transmission included livestock keeping, keeping cats, and unprotected handling of abortion cases in animals. The study has established inadequate knowledge about toxoplasmosis among community members and the presence of disease transmission practices risking the public health in Iringa municipal. Therefore, public health education is recommended to prevent transmission of the disease.

Keywords: *Awareness; practices; knowledge; protozoa; Iringa; Tanzania*

Received: 09/09/23
Accepted: 31/01/24
Published: 28/06/24

Cite as, *Ntungwa et al., (2024)*. Knowledge, Attitude, and Practices Toward Toxoplasmosis Among Community Members in Iringa Municipal, Tanzania. *East African Journal of Science, Technology and Innovation 5(3).*

Introduction

Toxoplasmosis is a zoonotic disease caused by an apicomplexan intracellular protozoan parasite known as *Toxoplasma gondii.* It infects humans and other warm-blooded animals being distributed in all countries (Furtado *et al.*, 2011; Smith *et al.*, 2021). The disease is among emerging and neglected zoonotic diseases. It has been reported to affect about a third of the world's population (Dubey and Jones, 2008). Toxoplasmosis is considered an important public

health concern in most tropical African countries especially in communities where farming and livestock-keeping practices are major economic activities. In most cases, the groups that face serious consequences due to the disease include pregnant women, and Immunocompromised individuals such as those living with HIV (Rostami *et al*., 2020). *Toxoplasma gondii* is one of the most significant disease-causing pathogens ranked high among foodborne pathogens (Havelaar *et al*., 2012).

The life cycle including the infective stages of the parasite involves humans as intermediate hosts getting infected by eating undercooked meat that contains cysts or by consuming sporulated oocysts that have been found in soil, water, or vegetables and fruits (Leszkowicz *et al*., 2023). The definitive host of the parasites are members of the Felidae family which include domestic cats and the intermediate hosts are other warm-blooded animals including human beings and several species of domesticated and non-domesticated animals. The sexual form of reproduction of *T. gondii* occurs in cats whereas the asexual form takes place in intermediate hosts. The individuals' contact with cats, cat feeding habits, soil contact, ingesting contaminated water, eating raw (unwashed) vegetables, drinking unpasteurized milk, and eating raw or undercooked meat have all been thought to be significant environmental risk factors for *T. gondii* transmission (Gyang *et al*., 2015). The prevalence of *T. gondii* infection is high in people living under poor socioeconomic conditions (Shin *et al*., 2009).

Although many individuals get infected with the parasite, only a tiny fraction of exposed adult and immune-stable animals or humans develop clinical symptoms of illness. In immunocompromised patients, such as AIDS patients and those undergoing chemotherapy, *T. gondii* infection can lead to serious and life-threatening diseases such as chorioretinitis, encephalitis, brain disease, and myocarditis (Almeria and Dubey, 2021). In addition, early infection during early pregnancy can lead to fetal infection and subsequent miscarriage, stillbirth, or serious neonatal disabilities, including epilepsy, encephalitis, blindness, and other neurological disorders (Cook *et al*., 2000). Serological detection of *T. gondii* infection reported values ranging from 6.7% to 47% in different countries (Fromont *et al*., 2009; Shin *et al*., 2009). Despite being a worldwide infection, toxoplasmosis seems to be disproportionately prevalent in the tropics, particularly in Sub-Saharan Africa (SSA), where other endemic diseases like malaria and the human immunodeficiency virus (HIV) are also common (Almeria and Dubey, 2021).

In Tanzania, few studies about human *T. gondii* have been conducted reporting varying extents of the infection. Most of the studies focused on pregnant women and pastoralist communities in different parts of the country. A study conducted in Mwanza reported that 30.9% of women were seropositive for specific antibodies against *T.gondii* (Mwambe *et al*., 2013). In a study carried out in Dar es Salaam 35% was reported as seroprevalence in pregnant women (Doehring *et al*., 1995). The study in the Tanga district of north-eastern Tanzania reported that antibodies to *T. gondii* were detected in 46% of the study population targeted for research (Swai and Schoonman, 2009). A study that involved pastoralists of northern Tanzania reported *T. gondii* seropositivities of 57.7% and 11.3%, respectively (Khan *et al*., 2014). Two studies conducted in a tertiary hospital in northern Tanzania reported that 41.7% (Shao and Ndazana, 2015) and 45% (Paul *et al*., 2018) of pregnant women were seropositive for *Toxoplasma gondii*-specific antibodies. However, the community awareness and risk factors for the infection are not clearly explained.

On the other hand, there is regional variation in the number of mortalities reported due to Toxoplasmosis. Higher mortality rates per population (mortality per 100,000population) recorded were highest in the southern part of the country, of which Iringa had a mortality rate of 1.2 during a 10-year hospital-based retrospective survey (Mboera *et al*., 2019). Despite all the noted public health consequences of the disease especially in the Iringa region, the information on community Knowledge, Attitude, and Practices (KAP) toward Toxoplasmosis in the country is limited. A study conducted in the Mbeya region observed low KAP among communities about the infection (Chalo *et al*., 2023). The study

assessed the community KAP regarding toxoplasmosis among community members of Iringa municipal, Tanzania. The obtained information will guide in designing and establishing disease prevention and control strategies.

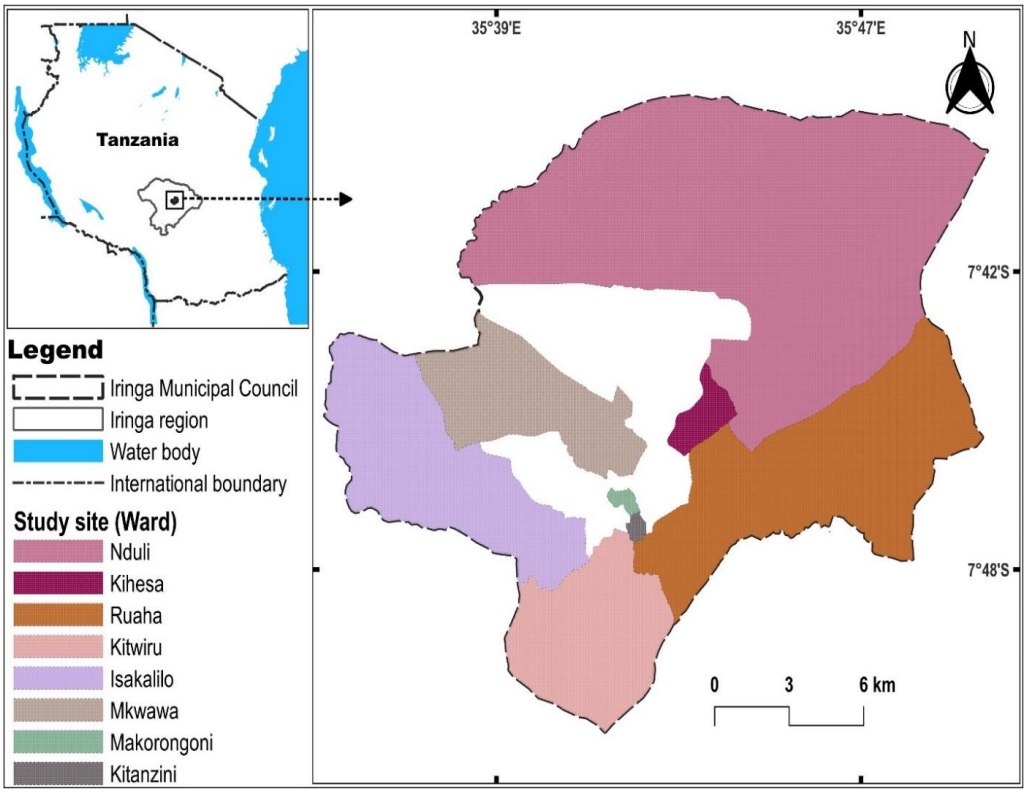
Materials and methods

Study area

The study was conducted in eight randomly selected wards of Iringa municipal from January 2023 to March 2023. The municipality covers an area of 176.987 Square Kilometers and has 18 administrative wards (URT, 2022). The Municipality is bordered by the Iringa Rural District and lies around latitude 7.7° to 7.875° south of the Equator and longitude 35.620° to 35.765° degrees east of the Greenwich Meridian. Characterized by a temperate highland tropical climate with a dry winter climate having an annual average temperature of 20.77°C (69.39°F). Has an average of 166.62 rainy days (45.65% of the time) and 168.4 millimeters of precipitation (6.63 inches) per year (TMA,2021). The area has a total population of 202,490, of which 96,392 are men and 106,098 are women. There are 5,008 households, with an average household size of 3.5. The residents in an area are involved in various economic activities such as agriculture, livestock production, and pet businesses. It also, has a well-established industrial base, including food processing and logistics industries (URT,2022). A total number of 143 participants were involved in the study from the eight wards and the number of participants from each ward given in brackets were; Kihesa (18), Nduli (18), Mkwawa (18), Kitwiru (18), Isakalilo (18), Ruaha (18), Kitanzini (18), and Makorongoni (17) (Figure 1).

Figure 1

Map of Iringa municipal council showing wards involved in the study



Source: QGIS visited on 10 May 2023.

Study design and study population

The cross-sectional study was employed to collect data in Iringa municipal on demographic information and community KAP about toxoplasmosis. The wards were randomly selected and participants within the selected wards were purposively selected. In each ward, a set of inclusion and exclusion criteria were employed to obtain respondents for this survey whereby from each household only one member was selected for the study. The criteria were; for a person to qualify for the survey must be 18 years old and above, must be a member of the selected ward for the study, willingness to participate, and the selected respondent must be from a household with complaints of rodent infestation and or keeping pigs.

Sample size determination

Determination of sample size was done by employing the formula developed by WHO for cross-sectional health studies as; N = (Z2*P*(1-P) *D)/E2 where; N= number of respondents (sample population), P = Expected knowledge level of the disease among individuals in Iringa municipality, D is a design effect which was set as 1, E is a margin of error (precision) taken as 0.05 and Z-is the value corresponding to the 5% level of significance=1.96. Considering the level of knowledge from previously done studies in Tanzania (Onduru *et al.*, 2019; Paul *et al.*,2018). The average level of knowledge was estimated to be 9%. The estimated sample size for the study was 126 participants but was adjusted to 143. The adjustment was done in consideration of different target groups for these different studies of which the previous studies targeted only pregnant women attending prenatal care in Temeke, Dar es Salaam and northern part of Tanzania whereas the current study targeted all groups of community members regardless of sex and physiological status in the Iringa municipal, Tanzania.

Data collection

Assessment of Knowledge, attitude, and practices influencing Toxoplasma gondii infection in Humans in Iringa Municipal

A semi-structured questionnaire was used in the survey to assess the knowledge, attitude, and practices influencing human toxoplasmosis. The questionnaire was developed in English language and then translated into Swahili because the general community in the study area is conversant with the language. Participants were asked for consent before the commencement of the study. The process of data collection then proceeded for those who agreed to take part in the survey, and vice versa. During data collection, the questions were read by an investigator who first briefed the participant on the aim of the study, and then the response from respondents was recorded by the investigator to ensure a good understanding of the addressed subject matter. The questionnaire comprised five parts of which the first part took into account the social demographic information of the participants such as sex, age, education level, and economic activity of the participant. The second section aimed to assess participants' knowledge of the disease. It comprised questions on several aspects such as disease acquisition, transmission, infected animal species, clinical presentations in humans, and inquiries about their awareness of potential treatments for the disease in humans. The third part was about the attitude of the community towards toxoplasmosis where issues like whether the disease is dangerous or not, whether the disease affects livestock only or otherwise, and the ability to cause miscarriage or stillbirth were assessed among study participants. The fourth part was about the community practices that are regarded as influential factors for the transmission of the infection and included practices like keeping cats, availability of rodents in their residential areas, control measures of rodents, proper cooking of meat and boiling of milk before consumption, exposure to cat feces without protective gloves. The last part was about the livestock-keeping systems that were connected to the practices for disease transmission in the public.

General knowledge assessment

The community's general level of knowledge on Toxoplasmosis was obtained by considering the mean score percentage of all questions that were set to assess knowledge of the disease. The final interpretation was made on whether the community members under the study had low or high knowledge of the disease. The mean score above 50% was considered of high knowledge of

the disease and that below 50% was considered low or inadequate knowledge of Toxoplasmosis.

Data analysis

Using IBM SPSS version 20 of 2011 (SPSS Inc., Chicago, IL, USA), the information from the questionnaire was summarized, checked for errors, and analyzed. Frequencies and percentages under descriptive statistics were used to determine participants' knowledge, and attitude about toxoplasmosis. The association among the categorical variables such as sex, age, level of education, and economic activity with the different characteristics of participants connected to KAP included in the questionnaire was determined by the chi-square (χ^2) test. Statistically, results were considered significant at $p < 0.05$.

Ethical clearance Report

The Sokoine University of Agriculture Institutional Review Board provided the ethical license for the study with reference number SUA/DPRTC/R/186/67. In addition, the administrative authority of the Iringa District Council granted permission to conduct the study in the selected wards under reference number IMC/T.40/39/82 on 13 February 2023.

Before the study, each participant was asked for their approval to participate, therefore only those people whose consent was obtained were included in the survey.

Results

Social demographic characteristics of the respondents.

Table 1 presents the social demographic information of the participants of the study (n=143). A large proportion of participants were males (63.6%), about 49% had attained post-secondary education, 32.2% were of 36-45 Years and 21% were government-employed (Table 1).

Table 1

Respondents' Demographic information (N=143)

Categorical variables		Frequency	Percentage
Sex	Male	91	63.60%
	Female	52	36.40%
Age	18-25 years	33	23.10%
	26-35 years	29	20.30%
	36-45 years	46	32.20%
	46-55 years	20	14.00%
	56 and above Years	15	10.50%
Level of education	Informal education	7	4.90%
	Primary level education	40	28.00%
	Secondary level education	26	18.20%
	Post-secondary education	70	49.00%
Economic activity	Peasant	29	20.30%
	Farmer	26	18.20%
	Government employed	30	21.00%
	Self-employed	26	18.20%
	Business	20	14.00%

College and university Students	12	8.40%

General knowledge mean score assessment for the study participants

The mean score obtained was 30.1% which reflects the inadequate or low knowledge about the disease among study participants in Iringa municipal, Tanzania. As indicated below (Table 2).

Table 2

Showing results on mean score about participants' general knowledge

Criteria used	Question identity	Response considered	Percentage (%)
Knowledge of the existence of Toxoplasmosis disease	B (1)	Yes	35.7
Awareness of the clinical presentation of the disease	B (2)	Yes	18.2
Ability to mention any relevant clinical sign of the disease	B (3)	Any relevant clinical sign	18.2
One of the common ways through which humans can acquire the disease	B (4)	Yes	35
Transmission from livestock to humans	B (5)	Yes	33
Awareness of stillbirth or miscarriage is among the public health consequences of the disease	B (6)	Yes	29.4
Awareness of the possibility of the disease being treated in humans	B (7)	Yes	41.3
Total			210.8
Mean score			30.1

Key: B indicates the section under which the question was put and numbers in brackets are the question number for the respective section. (The questionnaire had sections A to E)

Knowledge level among participants based on sex

Out of 143 participants in the study, about 35.7% reported having heard about Toxoplasmosis. The 39.9% of male participants involved in the study had never heard about the disease, on the other hand, female participants who reported had never heard about such a disease were only 24.5%. However, upon the Chi-square test, there were no significant statistical differences observed (P-value =0.575). A substantial number of participants total of 65% reported that an individual cannot acquire Toxoplasmosis upon contact with raw meat from an infected animal. About 28% and 13.3% of males and females respectively, participants reported were aware of the concept that Toxoplasmosis can be treated in human beings. The detailed information is in Table 3.

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Knowledge level among participants based on Age groups

There was a significant difference among different age groups of the participants who had heard and were aware of the existence of the disease under study (P-value=0.006), the age group of 18-25 Years made a large number of participants who had heard about the disease more than other age groups. The same aforementioned age group was reported to be aware of the clinical manifestation of the disease in humans and the difference with other age groups was statistically significant (p=0.037). A significant proportion of participants who were aged 18-25 years (18.9%) were aware that Toxoplasmosis can cause miscarriage or stillbirth in humans and other livestock animals. Summarized information is indicated in Table 4

Table 3

General knowledge based on the sex of participants

		Sex		
General knowledge about Toxoplasmosis disease based on the sex of participants		**Male (%)**	**Female (%)**	**Chi-square(P-Value)**
Have you ever heard about a disease known as Toxoplasmosis?				
	Yes	34 (23.8)	17 (11.9)	0.575
	No	57 (39.9)	35 (24.5)	
Do you know the clinical presentation of the disease in humans?				
	Yes	18 (12.6)	8 (5.6)	0.512
	No	73 (51)	44 (30.8)	
Can someone acquire Toxoplasmosis due to contact with raw meat from an infected animal?				
	Yes	28 (19.6)	22 (15.4)	0.164
	No	63 (44.1)	30 (21)	
Are you aware that Toxoplasmosis can be transmitted from animals to humans?				
	Yes	32 (22.4)	16 (11.2)	0.592
	No	59 (41.3)	36 (25.2)	
Do you know that Toxoplasmosis causes miscarriage or stillbirth in humans as well as in livestock such as pigs, sheep, and goats?				
	Yes	29 (20.3)	13 (9.1)	0.386
	No	62 (43.4)	39 (27.3)	
Can Toxoplasmosis be treated in human beings?				
	Yes	40 (28.0)	19 (13.3)	0.386
	No	51 (35.7)	33 (23.1)	

Table 4

Showing results on general knowledge of toxoplasmosis concerning age groups

General knowledge about toxoplasmosis	Age groups					Chi-square (P-Value)
	18-25 n (%)	26-35 n (%)	36-45 n (%)	46-55 n (%)	56 and above n (%)	
Have you ever heard about a disease known as Toxoplasmosis?						
Yes	17 (11.9)	15 (10.5)	14 (9.8)	3 (2.1)	2 (1.4)	
No	16 (11.2)	14 (9.8)	32 (22.4)	17 (11.9)	13 (9.1)	0.006
Do you know the clinical presentation of the disease in humans?						
Yes	12 (8.4)	4 (2.8)	7 (4.9)	2 (1.4)	1 (0.7)	
No	21 (14.7)	25 (17.5)	39 (27.3)	18 (12.6)	14 (9.8)	0.037
Can someone acquire Toxoplasmosis due to contact with raw meat from an infected animal?						
Yes	13 (9.1)	12 (8.4)	10 (7)	10 (7)	5 (3.5)	
No	20 (14)	17 (11.9)	36 (25.2)	10 (7)	10 (7)	0.174
Are you aware that Toxoplasmosis can be transmitted from animals to humans?						
Yes	15 (10.5)	11 (7.7)	12 (8.4)	6 (4.2)	4 (2.8)	
No	18 (12.6)	18 (12.6)	34 (23.8)	14 (9.8)	11 (7.7)	0.416
Do you know that Toxoplasmosis causes miscarriage or stillbirth in humans as well as in livestock such as pigs, sheep, and goats?						
Yes	16 (11.2%)	11 (7.7%)	9 (6.3%)	4 (2.8%)	2 (1.4%)	
No	17 (11.9%)	18 (12.6%)	37 (25.9%)	16 (11.2%)	13 (9.1%)	0.02
Can Toxoplasmosis be treated in human beings?						
Yes	16 (11.2)	12 (8.4)	15 (10.5)	9 (6.3)	7 (4.9)	
No	17 (11.9)	17 (11.9)	31 (21.7)	11 (7.7)	8 (5.6)	0.658

Table 5

Showing results on general knowledge of toxoplasmosis about the level of education among participants

		Level of education				
General knowledge based on level of education		**Informal education**	**Primary level education**	**Secondary level education**	**Post-secondary education**	**Chi-square(P-Value)**
Have you ever heard about a disease known as Toxoplasmosis?	Yes	2 (1.4)	3 (2.1)	3 (2.1)	43 (30.1)	<0.0001
	No	5 (3.5)	37 (25.9)	23 (16.1)	27 (18.9)	
Do you know the clinical presentation of the disease in humans?	Yes	1 (0.7)	0 (0)	2 (1.4)	23 (16.1)	<0.0001
	No	6 (4.2)	40 (28)	24 (16.8)	47 (32.9)	
Can someone acquire Toxoplasmosis due to contact with raw meat from an infected animal?	Yes	3 (2.1)	15 (10.5)	6 (4.2)	26 (18.2)	0.559
	No	4 (2.8)	25 (17.5)	20 (14)	44 (30.8)	
Are you aware that Toxoplasmosis can be transmitted from animals to humans?	Yes	2 (1.4)	8 (5.6)	6 (4.2)	32 (22.4)	0.026
	No	5 (3.5)	32 (22.4)	20 (14)	38 (26.6)	
Do you know that Toxoplasmosis causes miscarriage or stillbirth in humans as well as in livestock such as pigs, sheep, and goats?	Yes	1 (0.7)	5 (3.5)	3 (2.1)	33 (23.1)	<0.0001
	No	6 (4.2)	35 (24.5)	23 (16.1)	37 (25.9)	
Can Toxoplasmosis be treated in human beings?	Yes	4 (2.8)	18 (12.6)	6 (4.2)	31 (21.7)	

No	3 (2.1)	22 (15.4)	20 (14)	39 (27.3)	0.189	

Table 6

Results on general knowledge based on the economic activity of participants

		Economic activity						
General knowledge of toxoplasmosis		**Peasant**	**Farmer**	**Government employed**	**Self-employed**	**Business**	**Student**	**Chi-square(P-Value)**
Have you ever heard about a disease known as Toxoplasmosis?	Yes	2 (1.4)	4 (2.8)	25 (17.5)	11 (7.7)	5 (3.5)	4 (2.8)	<0.0001
	No	27 (18.9)	22 (15.4)	5 (3.5)	15 (10.5)	15 (10.5)	8 (5.6)	
Do you know the clinical presentation of the disease in humans?	Yes	0 (0)	0 (0)	13 (9.1)	7 (4.9)	3 (2.1)	3 (2.1)	<0.0001
	No	29 (20.3)	26 (18.2)	17 (11.9)	19 (13.3)	17 (11.9)	9 (6.3)	
Can someone acquire Toxoplasmosis due to contact with raw meat from an infected animal?	Yes	13 (9.1)	6 (4.2)	13 (9.1)	9 (6.3)	4 (2.8)	5 (3.5)	0.307
	No	16 (11.2)	20 (14)	17 (11.9)	17 (11.9)	16 (11.2)	7 (4.9)	
Are you aware that Toxoplasmosis can be transmitted from animals to humans?	Yes	6 (4.2)	4 (2.8)	15 (10.5)	12 (8.4)	6 (4.2)	5 (3.5)	0.035
	No	23 (16.1)	22 (15.4)	15 (10.5)	14 (9.8)	14 (9.8)	7 (4.9)	
Do you know that Toxoplasmosis causes miscarriage or stillbirth in humans as well as in livestock such as pigs, sheep, and goats?	Yes	4 (2.8)	2 (1.4)	17 (11.9)	9 (6.3)	7 (4.9)	3 (2.1)	0.001
	No	25 (17.5)	24 (16.8)	13 (9.1)	17 (11.9)	13 (9.1)	9 (6.3)	

Can Toxoplasmosis be treated in human beings?	Yes	12 (8.4)	6 (4.2)	14 (9.8)	12 (8.4)	10 (7.0)	5 (3.5)	
	No	17 (11.9)	20 (14.0)	16 (11.2)	14 (9.8)	10 (7.0)	7 (4.9)	0.441

Knowledge level among participants based on their level of education

A greater proportion of participants who have attained post-secondary education (30.1%) knew the existence of toxoplasma infection in both humans and other animals (P-value <0.0001). None of the participants who had primary level education (0%) knew the clinical presentation of the disease. The clinical manifestations of the disease in humans that were mentioned by participants during the study were: Fever, headache, lymphadenopathy, and Neurological signs which were regarded as encephalitis. About 1.4% had informal education, 5.6% had primary-level education, and 4.2% were secondary-level (P-value=0.026). Among the participants, 23.1% from the post-secondary level group reported that the disease can cause miscarriage or stillbirth in humans and other livestock animals such as pigs, cattle, and shoats (P-value<0.0001)**.** Detailed information is considered in Table 5.

Participant's attitudes toward Toxoplasmosis

Among the participants of the study about 43.36% didn't know whether toxoplasmosis is a dangerous disease or not, 50.34% were unaware if the disease is for pregnant women or otherwise, majority of participants 62.94% they didn't know that the disease can cause miscarriage or stillbirth, a small number of participants 2.8% strongly believed that the disease is for livestock only, and the significant

Knowledge level among participants based on their economic activities

Among the participants, 17.5% government employed, reported having heard about the disease. The group of government-employed participants showed to form a large proportion of those who knew about the disease and the difference compared to other groups was significant (P-value<0.0001). A significant number of peasants (20.3%), did not know the clinical presentation of the disease in humans (P-value <0.0001). Only a limited number of participants who were farmers (2.8%) reported that Toxoplasmosis transmission to humans can be from animals. A significant proportion of peasants (17.5%) reported were not aware of miscarriage or stillbirth that can be associated with Toxoplasma infection (P-value=0.001). For more details, consider Table 6

unaware that the disease can be transmitted by eating improperly washed vegetables and improperly cooked meat, 10.49 % agreed that toxoplasmosis is the disease of pregnant women only where about 45.45% were

number of respondents 57.34% were unaware of whether the disease can be transmitted from pregnant woman to her unborn baby. The detailed summary is shown in Table 7.

Table 7. Participant's attitude towards toxoplasmosis

	SA		A		DA		ID	
	n	%	n	%	n	%	N	%
Toxoplasmosis is a dangerous disease	14	9.79	49	34.27	18	12.59	62	43.36
Toxoplasmosis affects pregnant women only	4	2.8	15	10.49	59	41.26	65	45.45
Transmission of toxoplasmosis can be by improperly washed vegetables and or improperly cooked meat	10	6.99	42	29.37	19	13.29	72	50.34
Miscarriage or stillbirth can be caused by toxoplasmosis	12	83.92	32	22.38	9	6.29	90	62.94
Toxoplasmosis could be transmitted from a pregnant woman to her fetus	21	14.69	25	17.48	15	10.49	82	57.34
Toxoplasmosis is a disease of livestock only	4	2.8	15	10.49	64	44.76	60	41.96

Key: SA= Strongly Agree, A=Agree, DA=Disagree, ID=I don't know

Practices associated with Toxoplasmosis transmission in the community

Among the study participants, about 55.2% reported keeping cats at their homes, and the majority of their cats were staying indoors 78.5%, and only a limited number of their cats stayed outdoors 21.5%. A significant number of participants 49.7% did not make feed for their cats and instead left them to scavenge on their own, 40.6% fed homemade feedstuff, 6.3% fed them leftover from slaughter slabs, and only 3.5% fed their cats with milk. About one-third (36.1%) of the participants reported having never touched manure and other excretions like cat feces without protective gear like hand gloves. The majority number about 79.7% reported having seen rodents in their homes and stores containing livestock feeds and about 76.9% reported being involved in one or more of the ways of controlling these rodents in their surroundings. About 23.4% of respondents reported keeping cats as the means of controlling rodents in their homes, 28% used rodenticides, 29.1% used traps and 19.4% did not make any efforts to control rodents in their environment. The majority of respondents (93.7%) reported using tap water for their domestic activities, 2.8% used bore-hole water, and 2.8% used well water. On the other hand, about 48.3% reported that there is a possibility of animals such as cats, pigs, goats, sheep, and cattle access and being a source of contamination to the water used for their daily activities. Among participants, a significant number (91.6%) consume boiled milk. Details are included in Table 8 below.

Table 8:

Community practices influencing disease transmission.

Practices towards Toxoplasmosis transmission in the community	Frequency (n)	Percentage (%)
Do you keep cats at your home?	79	55.2
If the answer above was yes, where does your cat stay?		
Indoor	62	78.5
Outdoor	17	21.5

What do you feed your cat?		
Feedstuff made at home	58	40.6
Milk	5	3.5
Left over from slaughter slab	9	6.3
Do nothing	71	49.7
Have you ever touched manure and other excretions like cat feces without protective gear such as hand gloves?	52	36.4
Have you ever seen rodents in your home or a store containing livestock feeds?	114	79.7
Do you control rodents in your house?	110	76.9
Control rodents with Rodenticides	49	28
Control rodents by Cats	41	23.4
Control rodents by Traps	51	29.1
Doing nothing	34	19.4
What is the source of water you always use for your domestic activities such as cooking, washing utensils, bathing, drinking, etc.?		
Tap water	134	93.7
River/Stream	1	0.7
Wells	4	2.8
Boreholes	4	2.8
Do you think there is any possibility that animals such as cats, pigs, goats, sheep, and cattle can have access to water you use for your domestic activities?	69	48.3
Do you drink milk?	133	93
If the answer above was yes, do you boil milk before consumption?	131	91.6

Livestock management practices as the risk of transmission of Toxoplasmosis.

The majority of participants reported being involved in keeping one or more types of livestock in their environment and only 5.5% of all participants reported not being involved in keeping any type of livestock. Zero grazing system of production was the most adopted method with 55% of all study participants who were keeping cattle. History of abortions in farms was reported by 17.5% of participants of which abortion in cattle dominated with about 48.3% of all reported abortion cases followed by pigs with 27.6%. Out of all these cases, the majority were handled by nearby animal health experts (56%), some cases were managed by a family member who had no background in animal health education (24%), and in about 20% nothing was done and therefore left to resolve without any technical aid. For detailed information refer to Table 9.

Table 9: Livestock Management Practices Associated with Toxoplasmosis Transmission

About livestock management practices		
Multiple response results	**Frequency(n)**	**Percentage (%)**
Do you keep any type of livestock from the following list (cycle all appropriate answers)		
Do you keep goats?	26	8.9
Do you keep sheep?	14	4.8
Do you keep cattle?	59	20.1
Do you keep Pigs?	62	21.2
Do you keep chickens?	90	30.7
Do you keep dogs?	26	8.9
None of the above	16	5.5
	293	**100**
Normal frequency results (N=143)	**Frequency(n)**	**Percentages (%)**
What production system do you use in keeping livestock?		
Zero grazing system	79	55.2
Free range system	14	9.8
Semi-intensive system	33	23.1
None	17	11.9
Do you have any history of abortions on your farm?	25	17.5
If the answer above was yes, how did you handle abortion cases?		
Reported the case to a nearby animal health expert	14	56
Managed by a family member who is not an animal health expert	6	24

Did nothing	5	20

Multiple response results	**Frequency(n)**	**Percentages (%)**
History of abortion in cattle	14	48.3
History of abortion in goats	2	6.9
History of Abortion in Sheep	5	17.2
History of Abortion in Pigs	8	27.6

Discussion

The study found inadequate community knowledge about toxoplasmosis whereby only less than half the participants were aware of the disease. This reflected that the disease is not known in the community and this might subject them to risky practices. This observation is similar to other studies in other parts of Tanzania reporting a low level of knowledge and awareness among health workers in Dar es Salaam (Onduru *et al*., 2019) and community members in urban and peri-urban areas in Mbeya (Chalo *et al*., 2023).

On the other hand, the observed level of awareness (30.1%) about toxoplasmosis is higher than that reported in countries such as; Iran, Saudi Arabia, and Egypt, with 15.7% (Ebrahimi *et al*., 2015), 28% (AlRashada *et al*., 2016), and 3.2 % (Senosy *et al.,* 2020), respectively. However, the findings are low compared to reports from Yemen, Jordan, Morocco, and Pakistani with 50% (Al-Naggar *et a*l., 2010), 51.1% (Al-Sheyab *et a*l., 2015), 40.2% (Ait Hamou *et al.*, 2021), and 60% (Maqsood *et al*., 2021), respectively. The differences in results can be explained by variability in study populations, cultural and economic contexts, and also the differences in social and demographic characteristics of the studied groups in these countries. The observed low level of awareness about the disease also might be due to the reason that the disease is being neglected and hence not included in public health education programs addressing issues on zoonotic diseases (Chalo *et al*., 2023).

The investigation on the relationship between gender and level of knowledge among participants revealed that males (23.8%) were more aware of the disease than females (11.9%) and the results are in line with the previous study that reported about 17.3% of males were aware of the disease while the females knew about the disease were only 13% (Ebrahimi *et al*., 2015). A different study reported a similar scenario where males had higher knowledge about the disease than females (Nematollahi *et al*., 2011). In contrast, a different pattern where more females (47.2%) than males (36.9%) were aware of the disease has been reported (Ait Hamou *et al*., 2021). Results variability can be explained by differences in cultural context among these different study populations involved in the survey. Due to the variability of cultural perspectives in different countries, the cultural norms in these places differ from those found in Tanzania. Also, the correlation between awareness of the disease and various age groups was determined. A notable statistical distinction was observed, with the age group of 18-24 years exhibiting a higher level of awareness compared to other age groups. In contrast, participants aged 56 and above showed limited knowledge, with only 1.4% being aware of the disease.

These findings are in agreement with the study in Nigeria that reported a similar scenario(Ode *et al*., 2021). Inadequate knowledge in older people above 55 years was considered a major risk factor for the higher seroprevalence values against specific antibodies for *Toxoplasma gondii* in several studies (Mpiga *et al*.,2010; Mabeku *et al*., 2018; Ndiaye and Bonfoh, 2020). This may be due to several factors, such as the fact that most people of this age are in college and some have recently finished tertiary education, that they are more connected to various news media, making them more likely to be aware of different public health diseases of concern, such as toxoplasmosis. In addition, they have easy access to information due to advanced technology to the extent that they have a wealth of information at their fingertips through the use of the internet.

Poor knowledge of toxoplasmosis has been associated with *T. gondii* exposure to individuals (Lema, 2020). The findings of the study indicate that there was an increase in the level of awareness as the level of education increased. A larger portion of respondents who have attained post-secondary education were aware of the disease under the current study in the sense that they knew about the clinical presentation of the disease, transmission routes, preventive measures, and treatment. These findings are equivalent to findings from previous studies, for instance, pregnant women with a low level of education were found to be at higher risk for contracting *Toxoplasma* infection (Ahmad *et al*., 2020). Individuals with higher education levels may be more likely to be aware of the risks, transmission routes, and preventive measures associated with the disease (Yan *et al.,* 2018).

Regarding the attitude of participants towards Toxoplasmosis, about a quarter of the participants believed that *T. gondii* parasites cannot be transmitted through improperly cooked or raw meat. Equally, this puts them at great risk of acquiring the disease as reported by previous findings where the ingestion of improperly washed vegetables and undercooked meat played a significant role in disease transmission with an estimated to about 22% of all reported cases in humans having been associated to meat borne infections (Wehbe *et al*.,2022). Also, about 2.8% of study participants strongly believed that the disease is for livestock only and, therefore, has no health implications for humans. This stands a chance of being an exposure risk factor due to unprotected handling and contact with animal secretions and excretions which have been reported to be a source of infection in humans as tachyzoites infective form of *T. gondii* have been isolated from body fluid such as saliva, urine and unpasteurized milk collected from animals like goats, sheep, cattle, camels, and pigs (Tenter *et al*., 2000).

Cat ownership and exposure to cat feces have been associated with the likelihood of Toxoplasma infection. Slightly above half of the participants reported the presence of cats in and around their homes of which about 36.1% reported having contact with cat feces without protective gear subjecting them to a risk of being exposed to *T. gondii* parasites. This goes in line with previously done studies in Tanzania (Mwambe *et al*., 2013), Palestine (Nijem and Al-Amleh, 2009), and eastern Panama (Etheredge *et al.*, 2004). Nearly half (48.3%) of the study participants reported animals like cats, goats, cattle, sheep, and dogs can access water that is used in their daily activities. This could be a possible source of contamination with Toxoplasma parasites from animal secretions and excretions. Therefore, animal contamination should be considered one of the major risk factors for *T. gondii* exposure to humans in most communities (Hill and Dubey 2002).

Cats serve as the exclusive definitive hosts, whereas other animals, including humans, become infected by ingesting parasitic oocysts from cat feces, contaminated soil, or water. This ingestion eventually results in the development of tissue cysts, which become infectious through the subsequent consumption of infected tissues. These findings are consistent with those reported from other parts of the world (Dubey, 2009; 2010; Yoshida *et al*., 2011).

The majority of the participants (79.7%) reported having seen rodents in their homes and sometimes in stores containing livestock feeds denoting that they may get in contact with these small mammals which are considered an intermediate host of *T. gondii*. Rodents are

reservoirs of various emerging and re-emerging infectious diseases including *T. gondii* parasites as reported by previous investigations (Jones *et al*., 2001; Mgode *et al*., 2014).

The occupation of the majority of the participants (88.8%) which is keeping livestock is considered to be a potential risk for toxoplasmosis transmission among residents in the study area. In connection with that keeping cats have been observed to be a common practice among livestock keepers. A study done in Kenya reported nearly half of the livestock keepers were also keeping cats (Ogendi *et al.,* 2013). The risk of having cats around farms is related t o how often they defecate (Sheppa, 2016). As reported in this study, some (21.5%) of the participants keep their cats outdoors and thus defecate in unknown sites and therefore stand a great chance of disseminating oocysts and contaminating the household surroundings, and pasture land. This suggests that the participants in the study area are at an increased risk of being exposed to Toxoplasma infection.

Furthermore, the malpractice of handling abortion cases in livestock was also considered a great risk factor for toxoplasmosis transmission in the community under study. By referring to our study about 17.5% of study participants reported cases of abortion on their farms and worse enough about 24% of these cases were handled by family members who had no background in animal health education without even any protective gear like hand gloves. Similar findings have been reported among farmers in Thika District, Kenya (Ogendi *et al*., 2013).

Conclusion and Recommendations

The low level of awareness about toxoplasmosis among the study participants may subject the community to risky practices. The age and education levels were associated with the level of knowledge. In addition to inadequate knowledge of the disease, potential risk factors for toxoplasmosis transmission were identified such as poor handling of cat feces, improper handling of abortion cases, and the presence of cats in their homes that are fed on raw offals including leftovers from slaughter slabs and letting cats scavenge for food on their own. Therefore, more studies on community awareness are needed for planning disease control interventions. But also, there should be establishment of health education programs for better awareness among community members about toxoplasmosis disease which is considered of great public health importance.

Acknowledgment

The authors present much appreciation to the African Center of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development Project (ACE II-IRPM&BTD) Project No 5799/TZ for providing financial support to accomplish this study and also the Iringa municipal council for the provision of permission to conduct research in their selected administrative wards. The authors also gratefully acknowledge all study participants for devoting their time to participate in this study.

Financial support

This research was funded by The African Center of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development Project (ACE II-IRPM&BTD) Project No 5799/TZ**.**

Data availability and supporting materials

Supporting materials and data for this study are available upon reasonably emailing hermanosca01@gmail.com

Competing interest

The authors declare that they have no competing interests.

References

Ahmad, N., Osman, E., Na, A. G., Wu, L., Mz, A., Yy, S., S, D. O. L. B., & Wnn, W. A. N. Y. (2020). Knowledge and Preventive Behaviour among Pregnant Women with Latent Toxoplasmosis in Malaysia. *Medicine &Health* 15(2), 108–123.

Ait Hamou, S., Lamhamdi, B., Hayah, I., Belbacha, I., Sadak, A., & Laboudi, M. (2021). The level of knowledge about toxoplasmosis among university

students in Rabat in Morocco. *Journal of Parasitology Research*, 2021(1), 5553977.

Almeria, S., & Dubey, J. P. (2021). Foodborne transmission of Toxoplasma gondii infection in the last decade. An overview. Research in Veterinary Science, 135(October 2020), 371–385.

Al-Naggar, R. A., Al-jashamy, K., Al-dubi, S. A. R., Isa, Z., & Alghalibi, S. (2010). Perceptions of Toxoplasmosis among Female University Students. Health (San Francisco), 24(2), 87–89.

AlRashada, N., Al-Gharrash, Z., Alshehri, F., Al-Khamees, L., & Alshqaqeeq, A. (2016). Toxoplasmosis among Saudi Female Students in Al-Ahssa, Kingdom of Saudi Arabia: Awareness and Risk Factors. Open Journal of Preventive Medicine, 06(08), 187–195.

Al-Sheyab, N. A., Obaidat, M. M., Salman, A. E. B., & Lafi, S. Q. (2015). Toxoplasmosis-related knowledge and preventive practices among undergraduate female students in Jordan. Journal of Food Protection, 78(6), 1161–1166.

Chalo, S. L., Mafie, E. M., Katakweba, A. S., & Martin, E. (2023). The community knowledge, awareness, and practices influencing transmission of toxoplasmosis in Mbeya District. *East African Journal of Science, Technology and Innovation* ,6–846.

Cook, A. J. C., Gilbert, R. E., Buffolano, W., Zufferey, J., Petersen, E., Jenum, P. A., Foulon, W., Semprini, A. E., & Dunn, D. T. (2000). Sources of toxoplasma infection in pregnant women: European multicentre case-control study. *British Medical Journal*, 321(7254), 142–147.

Doehring E, Reiter-Owona I, Bauer O, Kaisi M, Hlobil H, Quade G, Hamudu NA, Seitz HM. *Toxoplasma gondii* antibodies in pregnant women and their newborns in Dar es Salaam, Tanzania. *American Journal of Tropical Medicine and Hygiene*, 52(6):546-8.

Dubey, J. P. (2009). Toxoplasmosis of animals and humans: CRC Press; 2009 313 pages. ISBN 978-1-4200-9236-3(Hardback).

Dubey, J. P., & Jones, J. L. (2008). Toxoplasma gondii infection in humans and animals in the United States. *International Journal for Parasitology*, 38(11), 1257–1278.

Ebrahimi, M., Ahmadi, A., Yaghfoori, S., Rassouli, M., & Azizzadeh, M. (2015). Evaluating the prior knowledge of toxoplasmosis among students of the Ferdowsi University of Mashhad. *Medical Journal of the Islamic Republic of Iran*, 29,163

Etheredge, G. D., Michael, G., Muehlenbein, M. P., & Frenkel, J. K. (2004). The roles of cats and dogs in the transmission of Toxoplasma infection in Kuna and Embera children in eastern Panama. *Pan American Journal of Public Health*, 16(3), 176–186.

Fromnt, E. G., Riche, B., & Rabilloud, M. (2009). Toxoplasma seroprevalence in a rural population in France: Detection of a household effect. *BMC Infectious Diseases,* 9, 1–7.

Furtado, J. M., Smith, J. R., Belfort, R., Gattey, D., & Winthrop, K. L. (2011). Toxoplasmosis: A global threat. *Journal of Global Infectious Diseases*, 3(3), 281–284.

Gyang, V. P., Akinwale, O. P., Lee, Y. L., Chuang, T. W., Orok, A., Ajibaye, O., Liao, C. W., Cheng, P. C., Chou, C. M., Huang, Y. C., Fan, K. H., & Fan, C. K. (2015). Toxoplasma gondii infection: Seroprevalence and associated risk factors among primary schoolchildren in Lagos City, Southern Nigeria. *Revista Da Sociedade Brasileira de Medicina Tropical*, 48(1), 56–63.

Havelaar, A. H., Haagsma, J. A., Mangen, M. J. J., Kemmeren, J. M., Verhoef, L. P. B., Vijgen, S. M. C., Wilson, M., Friesema, I. H. M., Kortbeek, L. M., van Duynhoven, Y. T. H. P., & van Pelt, W. (2012). Disease burden of foodborne pathogens in the

Netherlands, 2009. *International Journal of Food Microbiology*, 156(3), 231–238.

Hill, D., & Dubey, J. P. (2002). Toxoplasma gondii: transmission, diagnosis and prevention. *Clinical microbiology and infection*, *8*(10), 634-640.

Jones, J. L., Kruszon-Moran, D., Wilson, M., McQuillan, G., Navin, T., & McAuley, J. B. (2001). Toxoplasma gondii infection in the United States: Seroprevalence and risk factors. *American Journal of Epidemiology,* 154(4), 357–365.

Khan, M. B., Sonaimuthu, P., Lau, Y. L., Al-Mekhlafi, H. M., Mahmud, R., Kavana, N., Kassuku, A., & Kasanga, C. (2014). High seroprevalence of echinococcosis, schistosomiasis, and toxoplasmosis among the populations in Babati and Monduli districts, Tanzania. *Parasites and Vectors*, 7(1), 1–9.

Lema, G. B. (2020). *Toxoplasma gondii infection among outpatients attending Dodoma regional referral hospital in central Tanzania: prevalence and associated risk factors in central Tanzania* (Doctoral dissertation, Sokoine University of Agriculture).

Leszkowicz, M., Weiss, A., Beer, O., Tirosh-levy, S., Riklis, I., Dveyrin, Z., Rorman, E., Zaaroor, N., Perry, M., & Baneth, G. (2023). Comparative Immunology, Microbiology, and Infectious Diseases High infection rates of Toxoplasma gondii in cattle, sheep, and pigs from Israel. Comparative Immunology, Microbiology, and Infectious Diseases, 92(November 2022), 101928

Mabeku, L. B. K., Tchakounte, C., Bonsi, S. T., & Etoa, F.-X. (2018). Prevalence of Toxoplasma gondii and Associated Risk Factors among Pregnant Women Attending Hospital Centers in Penka-Michel, Cameroon. *Journal of Scientific Research and Reports*, 21(2), 1–11.

Maqsood, T., Shahzad, K., Naz, S., Simsek, S., Afzal, M. S., Ali, S., Ahmed, H., & Cao, J. (2021). A Cross-Sectional Study on the Association between Risk Factors of Toxoplasmosis and One Health Knowledge in Pakistan. *Frontiers in Veterinary Science,* 8(November).

Mboera, L. E. G., Kishamawe, C., Kimario, E., & Rumisha, S. F. (2019). Mortality patterns of toxoplasmosis and its comorbidities in Tanzania: A 10-year retrospective hospital-based survey. *Frontiers in Public Health*, 7(FEB), 1–7.

Mgode, G. F., Katakweba, A. S., Mhamphi, G. G., Fwalo, F., Bahari, M., Mdangi, M., Kilonzo, B. S., & Mulungu, L. S. (2014). Prevalence of leptospirosis and toxoplasmosis: a study of rodents and shrews in cultivated and fallow land, Morogoro rural district, Tanzania. *Tanzania Journal of Health Research*, 16(3), 1–7.

Mpiga Mickoto, B., Akue, J. P., Bisvigou, U., Mayi Tsonga, S., & Nkoghe, D. (2010). Serological study on toxoplasmosis among pregnant women from Franceville, Gabon. *Bulletin de la Société de pathologie exotique*, *103*, 41-43.

Mwambe, B., Mshana, S. E., Kidenya, B. R., Massinde, A. N., Mazigo, H. D., Michael, D., Majinge, C., & Groß, U. (2013). Sero-prevalence and factors associated with Toxoplasma gondii infection among pregnant women attending antenatal care in Mwanza, Tanzania. *Parasites and Vectors*, 6(1), 2–6.

Ndiaye, J. L., & Bonfoh, B. (2020). Seroprevalence and risk factors of neosporosis in women attending antenatal care and in domestic carnivores in Dakar city, Senegal. *African Journal of Parasitology Research,* 7(1), 001-007

Nematollahi, A., Mohammad pour, H., Nosratpour, S., & Ebrahimi, M. (2011). Evaluation of Tabriz University students' knowledge about Toxoplasmosis. *Veterinary Clinical Pathology. The Quarterly Scientific Journal*, *5*(2 (18) summer), 1197-1202.

Nijem, K. I., & Al-Amleh, S. (2009). Seroprevalence and associated risk

factors of toxoplasmosis in pregnant women in Hebron district, Palestine. *Eastern Mediterranean Health Journal*, 15(5), 1278–1284.

Ode, S. A., Jubril, A. J., & Emikpe, B. O. (2021). Awareness and habits of Nigerians towards toxoplasmosis and risk factors. *Pan African Medical Journal One Health*, 4(15), 1–11.

Ogendi, E., Maina, N., Kagira, J., Karanja, S., Ngotho, M., & Mbugua, G. (2013). Questionnaire survey on the occurrence of risk factors for *Toxoplasma gondii* infection amongst farmers in Thika District, Kenya. *Journal of the South African Veterinary Association*, *84* (1), 1-6.

Onduru, O. G., Rumisha, S. F., Munyeme, M., & Phiri, A. M. (2019). Evaluation of the level of awareness of congenital toxoplasmosis and associated practices among pregnant women and health workers in Tanzania's Temeke district in Dar es Salaam. *African Health Sciences*, *19*(4), 3027-3037.

Paul, E., Kiwelu, I., Mmbaga, B., Nazareth, R., Sabuni, E., Maro, A., Ndaro, A., Halliday, J. E. B., & Chilongola, J. (2018). *Toxoplasma gondii* seroprevalence among pregnant women attending antenatal clinic in Northern Tanzania. *Tropical Medicine and Health*, 46(1), 1–8.

Rostami, A., Riahi, S. M., Gamble, H. R., Fakhri, Y., Nourollahpour Shiadeh, M., Danesh, M., Behniafar, H., Paktinat, S., Foroutan, M., Mokdad, A. H., Hotez, P. J., & Gasser, R. B. (2020). The global prevalence of latent toxoplasmosis in pregnant women: a systematic review and meta-analysis. *Clinical Microbiology and Infection,* 26(6), 673–683.

Senosy, S. A. (2020). Knowledge and attitudes about toxoplasmosis among female university students in Egypt. *International Journal of Adolescent Medicine and Health*, *34*(3), 20190207.

Shao, E. R., & Ndazana, S. G. (2015). Sero-Prevalence and Factors Associated with *Toxoplasma Gondii* Infection among Pregnant Women Attending Antenatal Care in the Referral Hospital in Tanzania: Cross-Sectional Study. *Annals of Clinical and Laboratory Research*, 3(2), 1–6.

Sheppa SP. Seroprevalence of toxoplasma infection in goats and sheep and associated risk factors in Mvomero district, Tanzania (Doctoral dissertation, Sokoine University of Agriculture).2016.

Shin, D. W., Cha, D. Y., Hua, Q. J., Cha, G. H., & Lee, Y. H. (2009). Seroprevalence of *Toxoplasma gondii* infection and characteristics of seropositive patients in general hospitals in Daejeon, Korea. *Korean Journal of Parasitology*, 47(2), 125–130.

Smith, N. C., Goulart, C., Hayward, J. A., Kupz, A., Miller, C. M., & Dooren, G. G. Van. (2021). Control of human toxoplasmosis. *International Journal for Parasitology,* 51(2–3), 95–121.

Swai, E. S., & Schoonman, L. (2009). Seroprevalence of Toxoplasma gondii infection amongst residents of Tanga district in north-east Tanzania. *Tanzania Journal of Health Research,* 11(4), 205–209.

Tenter, A. M., Heckeroth, A. R., & Weiss, L. M. (2000). Toxoplasma gondii: From animals to humans. *International Journal for Parasitology*, *30*(12–13), 1217–1258.

TMA, Tanzania Meteorological Authority 2021.https://www.meteo.go.tz visited on 30/5/2023.

URT, United Republic of Tanzania (2022), Ministry of Finance and Planning, Tanzania National Bureau of Statistics and President's Office - Finance and Planning, Office of the Chief Government Statistician, Zanzibar. The 2022 Population and Housing Census: Administrative Units Population Distribution Report; Tanzania, December 2022.

Wehbe, K., Pencole, L., Lhuaire, M., Sibiude, J., Mandelbrot, L., Villena, I., & Picone, O.

(2022). Hygiene measures as primary prevention of toxoplasmosis during pregnancy: A systematic review. *Journal of Gynecology Obstetrics and Human Reproduction*, *51*(3), 102300.

Yan, L., Loganathan, S., & Nimir, A. R. (2018). Knowledge, attitude, and practice related to toxoplasma gondii infection among rural and semi-urban communities in Malaysia. *Annals of Clinical Pathology*, *6*(1), 1128.

Yoshida, N., Tyler, K. M., & Llewellyn, M. S. (2011). Invasion mechanisms among emerging food-borne protozoan parasites. *Trends in parasitology*, *27*(10), 459-466.