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Seroprevalence of toxoplasmosis and associated factors among diabetic patients attending at some selected hospitals in Mogadishu-Somalia

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ABSTRACT

Background: Toxoplasma gondii is one of the most common parasitic infections in humans worldwide. Up to one-third of the human population is estimated to be infected by toxoplasmosis. Diabetes increases the risk of many infections due to a decreased immune system, including T. gondii as an opportunistic infection. This study aimed to determine the Seroprevalence of Toxoplasmosis and its associated factors among diabetic patients attending selected hospitals. **Methods:** This analytical cross-sectional study was conducted in Mogadishu, Somalia, from December 2022 to July 2023. Blood samples were collected from 384 diabetic patients. Toxoplasma IgM and IgG combination rapid test cassettes were used to screen samples from diabetic patients at Adan Adde and Dr. Sumait hospitals. Questionnaire data and serological results were analyzed using SPSS 25. Binary logistic regression analysis was used to measure associations between dependent and independent variables. **Results:** Out of 384 study participants, 216 (56%) were positive and 168 (43%) were negative for seroprevalence toxoplasmosis among diabetic patients. The seropositive rate of anti-IgG Toxoplasma test was 53%, while IgM was 2%. Toxoplasma-positive rates were higher in females (72.7%) than males (27.3%). P values were highly significant (OR=0.27, 95%CL (0.17-0.42 P<0.001) differences between females and males regarding anti-Toxoplasma seropositive rates. **Conclusion:** The prevalence of toxoplasmosis in diabetic patients was 56%. An association was found between toxoplasmosis and type of diabetes. Our research found a significant relationship between sex and toxoplasmosis, with seropositivity rates among females being highly significant.

Introduction

Diabetes mellitus, a global health crisis, affects millions of people worldwide and is characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both (1). This metabolic disorder not only leads to significant morbidity and mortality but also increases susceptibility to various infections due to immune system dysregulation (2,3). Toxoplasmosis, caused by the intracellular parasite *Toxoplasma gondii*, poses a significant threat, especially in immunocompromised individuals (4). *T. gondii* is a

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ubiquitous parasite capable of infecting nearly all warm-blooded animals, including humans. Globally, approximately one-third of the human population is estimated to be exposed to this parasite (5,6). While most infections are asymptomatic in immunocompetent individuals, they can lead to severe complications such as encephalitis, retinochoroiditis, and even death, particularly in immunocompromised patients, pregnant women, and their fetuses (7).

The relationship between *T. gondii* infection and diabetes is complex and remains a subject of ongoing research (8). Some studies suggest that chronic *T. gondii* infection may be a risk factor for developing type 2 diabetes, possibly because of the ability of the parasite to disrupt pancreatic beta cells and induce chronic inflammation (9). Conversely, individuals with diabetes who experience immunosuppression may be more vulnerable to *T. gondii* infection and its complications (10). A meta-analysis suggested a potential link between chronic toxoplasmosis and diabetes, further underscoring the need for more in-depth investigations of this association (11). While studies from China showed a higher seroprevalence of *T. gondii* in individuals with different types of diabetes compared to controls and highlighted risk factors such as keeping cats, consumption of raw meat, and raw seafood (12), other studies have shown no association (13). A recent study in Saudi Arabia also found a relatively high prevalence of T. gondii among patients with diabetes, particularly those in the 50-65 age group (14). This variability in findings underscores the need for geographically specific studies to assess the true burden of this co-infection and its associated risk factors.

Despite the growing body of evidence on the interaction between diabetes and toxoplasmosis, there is a significant gap in research, particularly in resource-limited settings (15). In Somalia, a country grappling with complex health challenges, data on the seroprevalence of *T. gondii* infection, particularly among vulnerable populations, such as diabetic patients, are exceedingly scarce. The few studies conducted in Somalia have focused primarily on infectious diseases, with limited attention paid to parasitic infections and their relationship with non-communicable diseases (16). This lack of data represents a significant gap in our understanding of the disease burden and how it intersects with the existing health challenges in Somalia. Furthermore, there is a lack of awareness about toxoplasmosis in Somalia, both among the general public and among healthcare workers (17). This gap highlights the need for basic epidemiological research to elucidate the magnitude of this problem and formulate appropriate interventions. Understanding the unique sociodemographic and environmental factors that may influence *T. gondii* transmission in Somalia is also crucial.

Therefore, this study aimed to address this gap by investigating the seroprevalence of *Toxoplasma gondii* infection and associated factors among diabetic patients attending Aden Adde and Dr. Sumati Hospitals in Mogadishu, Somalia. By providing epidemiological data from a previously understudied population, this study will contribute valuable insights to inform public health policies and ultimately improve the management of diabetes and associated infections in Somalia.

Material and Methods

Study design

1. This is a cross-sectional study designed to assess the seroprevalence of toxoplasmosis and its associated factors among diabetic patients.

Study Area

The study was conducted at Adan Adde hospital, Wadajir and Dr. Sumait hospital, Hodan, Mogadishu, Somalia, Adan Adde is considered as central hospital for diabetic Miletus and Dr. Sumait it is one of the common hospitals that regulate diabetes patients.

Study Period

The study was conducted between December 2022 and July 2023.

Target Population

The target population of this study was all patients with diabetes mellitus during the study period who attended Adan Adde and Dr. Sumait hospitals

Inclusion and Exclusion Criteria Inclusion Criteria

All patients with diabetes mellitus who were willing to participate in the study were included Patients with diabetes who refused to participate in the study were also excluded.

Sampling Techniques

The sampling technique was non-probability sampling, which is a convenient sampling technique for selecting study participants from the study population.

Sample Size Determination

In this study, 384 respondents were included in our sample size using a single proportion population formula (18).

n= (z^2 α_2 p(1-p))/e^2 n = sample size

Z-score = 1.96

α_2=related to confident interval (CI) = 95%

P = population proportion (assumed to be 50% = 0.5) e = margin of error = 5% = 0.05

n= (1.96) ^2*(0.5) *(1-0.5))/ (0.05) ^2

= ((3.8416) × (0.5) *(0.5))/ ((0.00025)) = 384.16 ≈ 384 patients.

Sample Type and Method

Blood samples were collected and processed to obtain serum or plasma, which were used for the detection of *Toxoplasma gondii* antibodies using the TOXO IgG/IgM Rapid Test Cassette (Atlas Medical, Germany). This qualitative lateral flow immunoassay detects and differentiates IgG and IgM antibodies. One drop of serum/plasma and one drop of buffer were added to the cassette, and results were read after 15 minutes (19).

Quality Assurance Procedure / Validity and Reliability

To ensure content validity, research instruments were developed based on the study's variables and objectives. The instruments were reviewed by the researcher's supervisor to confirm that they adequately measured the intended constructs. Data quality was maintained through measures that ensured completeness, reliability, accuracy, and reproducibility, supporting both internal and external validity. Interview questions and consent forms were verbally translated into Somali by fluent researchers, and completed forms were reviewed daily for accuracy and completeness.

Data Analysis

The collected data were entered into Microsoft Excel and subsequently exported to SPSS version 25 for analysis. Descriptive statistics, including frequencies and percentages, were used to summarize the sociodemographic, behavioral, medical, and environmental characteristics of the study participants. Binary logistic regression analysis was used to assess the association between the independent variables and toxoplasmosis seropositivity. The findings are presented in the form of tables and figures to illustrate the key patterns, relationships, and prevalence rates among patients with diabetes.

Ethical Statement Approval

In this study, the researchers strictly followed ethical communication principles related to the research guidelines set at Simad University. Both assured that the data that the researcher collected from the respondents were not used for any academic purpose and remained confidential, and we shall use for the fulfillment of the requirement for the award of bachelor's degree of Education and Medical Laboratory Science.

Results

Sociodemographic Characteristics among study participants

The age distribution among participants indicated a concentration in the older age groups, with 39.3% over 51 years and 25% between 31 and 40 years. The gender distribution showed a higher proportion of females (59.4%) than males (40.6%), potentially influencing health-seeking behaviors and the study's disease profile. Most participants were married (70.3%), which might reflect stable household dynamics impacting health practices and support for managing diabetes and its associated infections.

The educational background revealed that a majority were uneducated (56.5%), possibly limiting access to health information and affecting preventive practices against infections such as toxoplasmosis. Employment was relatively balanced, with 53.9% employed and 46.1% unemployed, which may influence healthcare accessibility and adherence to medical guidance. Family size showed a predominance of smaller households (<7 members, 78.6%), while family income distribution was weighted towards the mid-range (54.4% earning 300–400), indicating moderate socioeconomic status among participants.

Behavioral, Medical and Environmental Factors among study participants

Concerning behavioral factors, the majority of participants reported consuming well-cooked meat (99.2%), with a smaller proportion eating meat daily (59.6%). Notably, 79.4% of participants washed meat prior to cooking, and 74.7% practiced washing vegetables before consumption, reflecting considerable food hygiene awareness. However, only 60.4% had access to handwashing facilities at home, and fewer (25.5%) consistently used soap or shampoo before meals,

indicating areas for improved hygiene practices. Additionally, 90.6% of participants consumed pasteurized milk, a practice associated with a reduced risk of foodborne infections. Regarding medical factors**, type 2 diabetes was predominant in the diabetic cohort** (88.5%), with a minority having gestational diabetes (11.5%). The duration of diabetes was largely measured in years (88.3%), indicating a chronic condition. About half of the participants reported other chronic illnesses besides diabetes (47.1%), and a small portion (18.0%) had a history of toxoplasmosis infection. Most participants (95.8%) used diabetes medications, demonstrating high adherence to diabetic management. Regarding environmental Factors, Over half of the participants maintained domestic pets (54.7%), with cats being the most common (94.8%). Given the zoonotic transmission potential of toxoplasmosis in cats, this pet ownership statistic may warrant further exploration regarding the risk of infection. A significant proportion (74.5%) of the participants used filtered water, which is indicative of awareness regarding safe drinking water practices.

Regression analysis of sociodemographic factors and toxoplasmosis

The analysis explored potential associations between sociodemographic characteristics and toxoplasmosis status among patients with diabetes. Age did not show a statistically significant association with toxoplasmosis positivity, although the odds ratios slightly increased with age (OR = 1.63, ages 41–50, p = 0.167). Gender, however, demonstrated a strong association, with females having significantly higher odds of toxoplasmosis positivity than males (OR = 0.27, 95% CI: 0.17–0.42, p < 0.001), suggesting that gender may play a role in susceptibility or exposure patterns.

Marital status, educational level, occupational status, family size, and family income were not significantly associated with the toxoplasmosis status. Although widowed participants had slightly higher odds ratios (OR = 1.08), this finding was not statistically significant (p = 0.915). Similarly, the comparison of education level showed no significant association (p = 0.306), indicating that educational attainment may not be a strong predictor of toxoplasmosis risk in this population.These findings highlight gender as a key factor, potentially reflecting differences in exposure due to lifestyle or household roles. Future research could delve deeper into specific behavioral and environmental factors to uncover the mechanisms underlying these associations.

Regression Analysis of Behavioral, Medical, and Environmental Factors with Toxoplasmosis Status.

Washing meat before cooking and having a handwashing facility at home were both associated with a reduced toxoplasmosis risk. Participants who did not wash their meat before cooking had significantly higher odds of infection (OR = 0.38, p < 0.001), underscoring the importance of proper food preparation practices. Similarly, the absence of a handwashing facility was correlated with a higher risk of infection (OR = 0.54, p < 0.005). Regular vegetable washing was also significant: participants who did not wash vegetables had a higher likelihood of toxoplasmosis (OR = 1.70, p = 0.0241). Type 2 diabetes was strongly associated with toxoplasmosis compared to gestational diabetes (OR = 6.08, p < 0.001), suggesting that long-term management of diabetes could be linked to increased exposure risks. The duration of diabetes also played a significant role, as those with a longer history of diabetes had a higher odds of infection (OR = 5.94, p < 0.001). Previous toxoplasmosis infection appeared to be protective (OR = 0.16, p < 0.001), possibly because of acquired immunity. Pet ownership is associated with the risk of toxoplasmosis. Owning a pet, especially a cat, increased the odds of infection (OR = 0.14, p < 0.001), reflecting the zoonotic transmission potential of Toxoplasma gondii in cats. The use of filtered water and pet type showed no significant correlation, suggesting a limited impact of water filtration and pet types other than cats on infection status. These findings highlight specific lifestyle, medical, and environmental factors that influence toxoplasmosis risk in diabetic populations, particularly practices related to food preparation and pet ownership. This analysis suggests areas for potential intervention, such as promoting hygiene practices and addressing the zoonotic risks associated with pet ownership.

Table 1. Sociodemographic Characteristics among study participants.

Sociodemographic Characteristics	Frequency	percent
Age		
< 30 years	57	14.8
31-40 years	96	25.0
41-50 years	80	20.8
> 51 years	151	39.3
Gender		
Male	156	40.6
Female	228	59.4
Marital Status		
Single	9	2.3
Married	270	70.3
Divorced	65	16.9
Widowed	40	10.4
Educational level		
Non educated	217	56.5
Educated	167	43.5
Occupation		
Employed	207	53.9
Unemployed	177	46.1
Family Membrane		
<7	302	78.6
>7	82	21.4
Family Income		
≤ 250	52	13.5
300-400	209	54.4
500-600	99	25.8
≥700	24	6.3

Table 2. Behavioral, medical and environmental factors among study participants.

Behavioral Factor	Frequency	Percentage
Is the meat you eat well cooked		
Yes	381	99.2
No	3	0.8
Do you eat meat every day		
Yes	229	59.6
No	155	40.4
Do you wash meat before cooking		
Yes	305	79.4
No	79	20.6
Do you wash vegetable before eating		
Yes	287	74.7
No	97	25.3
Is there a hand washing facility in your house		
Yes	232	60.4
No	152	39.6
Before eating, do you use soap or shampoo to wash hands		
Yes	98	25.5
No	286	74.5
Do you pasteurized milk		
Yes	348	90.6
No	36	9.4
What of diabetic do you have		
Type 1	0	0
Type 2	340	88.5
Gestational diabetes	44	11.5
What is the duration of your diabetes		
Months	45	11.7
Years	339	88.3
Do you have any other chronic disease other than diabetic		
Yes	181	47.1
No	203	52.9
Have you been infected with toxoplasmosis disease before and treated		
Yes	69	18.0
No	315	82.0
Do you use diabetic medication		
Yes	368	95.8
No	16	4.2
Do you have a domestic pet at home		
Yes	210	54.7
No	174	45.3
If yes, which type of domestic pets do you have		
Cat	199	94.8
Dog	3	1.4
Rabbit	8	3.8
Do you use filtered water		
Yes	286	74.5
No	98	25.5

Table 3. Regression analysis of Sociodemographic Characteristics of the Study Groups compared with their toxoplasmosis status.

Variable	N%	Toxoplasmosis Status		Odds ratio (95%CI)	P Value
		Positive	Negative		
Age					
≤ 30	57(14.8)	36(16.7)	21(12.5)	Ref	
31-40	96(25.0)	54(25.0)	42(25.0)	1.33(0.68-2.61)	0.402
41-50	80(20.8)	41(19.0)	39(23.2)	1.63(0.81-3.26)	0.167
≥ 51	151(39.3)	85(39.4)	66(39.3)	1.33(0.71-2.49)	0.371
Gender					
Male	156(40.6)	59(27.3)	97(57.7)	Ref	
Female	228(59.4)	157(72.7)	71(42.3)	0.27(0.17-0.42)	< 0.001*
Marital status					
Single	9(2.3)	4(1.9)	5(3.0)	Ref	
Married	270(70.3)	159(73.6)	111(66.1)	0.55(0.14-2.12)	0.393
Divorced	65(16.9)	36(16.7)	29(17.3)	0.64(0.15-2.62)	0.539
Widowed	40(10.4)	17(7.9)	23(13.7)	1.08(0.25-4.64)	0.915
Education Level					
Uneducated	217(56.5)	127(58.8)	90(53.6)	0.80(0.53-1.21)	0.306
Educated	167(43.5)	89(41.2)	78(46.4)	RC	
Occupational status					
Employed	207(53.9)	114(52.8)	93(55.4)	Ref	
Unemployed	177(46.1)	102(47.2)	75(44.6)	1.10(0.74-1.66)	0.615
Family size					
≤ 7	302(78.6)	167(77.3)	135(80.4)	Ref	
≥ 7	82(21.4)	49(22.7)	33(19.6)	0.83(0.50-1.36)	0.471
Family Income					
≤ 250	52(13.5)	34(15.7)	18(10.7)	0.62(0.23-1.67)	0.351
300-400	209(54.4)	111(51.4)	98(58.3)	1.04(0.44-2.43)	0.922
500-600	99(25.8)	58(26.9)	41(24.4)	0.83(0.34-2.04)	0.694
≥ 700	24(6.3)	13(6.0)	11(6.5)	Ref	

Table 4. Regression analysis of Behavioral, Medical and Environmental Factors among study participants.

Is the meat you eat well cooked?					
Yes	381 (99.2)	215 (99.5)	166 (98.2)	Ref	
No	3 (0.8)	1 (0.5)	2 (1.2)	2.59(0.23-28.81)	0.439
Do you eat meat every day?					
Yes	229(59.6)	122(56.5)	107(63.7)	0.35(0.89-2.04)	0.154
No	155(40.4)	94(43.5)	61(36.3)	Ref	
Do you wash meat before cooking?					
Yes	305(79.4)	158(73.1)	147(87.5)	Ref	
No	79(20.6)	58(26.9)	21(12.5)	0.38(0.22-0.67)	< 0.001*
Do you wash vegetable before eating?					
Yes	287(74.7)	171(79.2)	116(69.0)	Ref	
No	97(25.3)	45(20.8)	52(31.0)	1.70(1.07-2.70)	<0.0241*
Is there a hand washing facility in your house?					
Yes	232(60.4)	117(54.2)	115(68.5)	Ref	
No	152(39.6)	99(45.8)	53(31.5)	0.54(0.35-0.83)	<0.005*
Before eating, do you use soap or shampoo to wash hands?					
Yes	98(25.5)	54(25.0)	44(26.2)	Ref	
No	286(74.5)	162(75.0)	124(73.8)	0.93(0.59-1.49)	0.791
Do you pasteurized milk?					
Yes	348(90.6)	187(86.6)	161(95.8)	Ref	
No	36(9.4)	29(13.4)	7(4.2)	0.28(0.12-0.65)	<0.003*
What of diabetic do you have ?					
Gestational diabetes	44(11.5)	38(17.6)	6(3.6)	Ref	
Type 2	340(88.5)	178(82.4)	162(96.4)	6.08(2.49-14.82)	< 0.001*
What is the duration of your diabetes?					
Months	45(11.7)	31(14.4)	14(8.3)	Ref	
Years	339(88.3)	185(85.6)	154(91.7)	5.94(2.43-14.56)	< 0.001*
Do you have any other chronic disease other than diabetic?					
Yes	181(47.1)	93(43.1)	88(52.4)	1.45(0.97-2.18)	0.070
No	203(52.9)	123(56.9)	80(47.6)	Ref	
Have you been infected with toxoplasmosis disease before and treated?					
Yes	69(18.0)	59(27.3)	10(6.0)	0.16(0.08-0.34)	< 0.001*
No	315(82.0)	157(72.7)	158(94.0)	Ref	
Do you use diabetic medication?					
Yes	368(95.8)	205(94.9)	163(97.0)	Ref	
No	16(4.2)	11(5.1)	5(3.0)	0.57(0.19-0.67)	0.309
Do you have a domestic pet at home?					
Yes	210(54.7)	160(74.1)	50(29.8)	0.14(0.09-0.23)	< 0.001*
No	174(45.3)	56(25.9)	118(70.2)	Ref	
If yes, which type of domestic pets do you have?					
Cat	199(94.8)	154(96.3)	45(90.0)	0.292(0.07-1.21)	< 0.005*
Dog	3(1.4)	2(1.3)	1(2.0)	0.50(0.31-7.99)	0.624
Rabbit	8(3.8)	4(2.5)	4(8.0)	Ref	
Do you use filtered water?					
Yes	286(74.5)	162(75.0)	124(73.8)	Ref	
No	98(25.5)	54(25.0)	44(26.2)	1.06(0.67-1.68)	0.791

Figure 1. The above figure shows that 216 (56%) of the study participants were positive, while 168 (43%) were negative for seroprevalence of toxoplasmosis among diabetic patients.

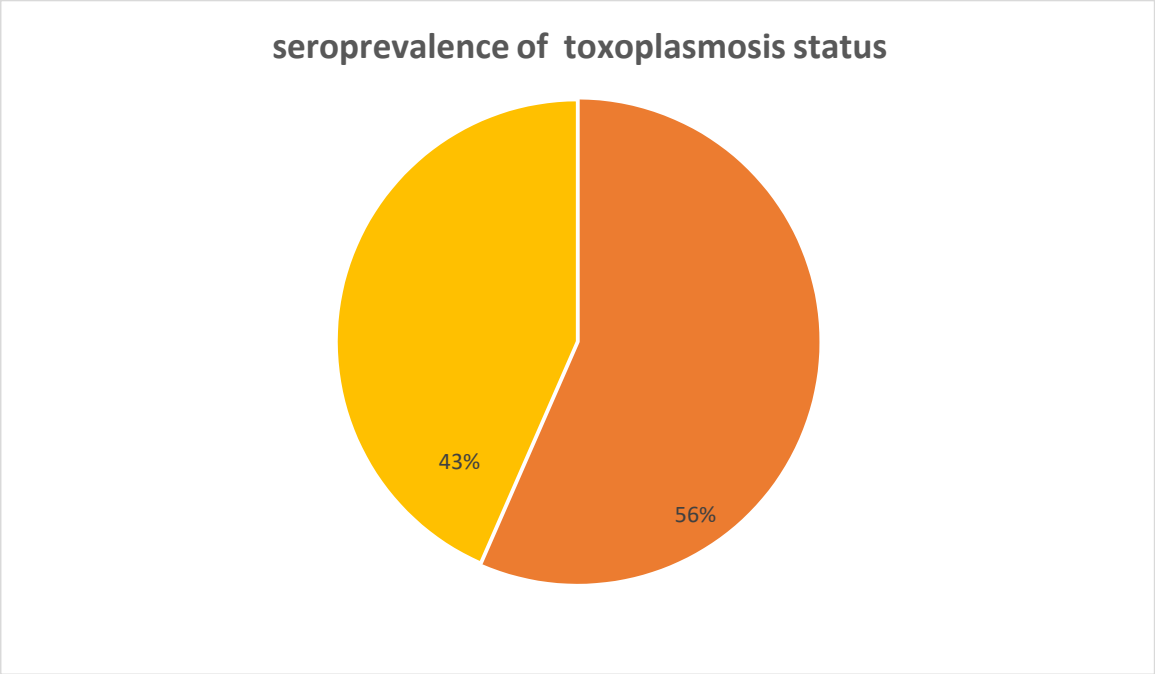
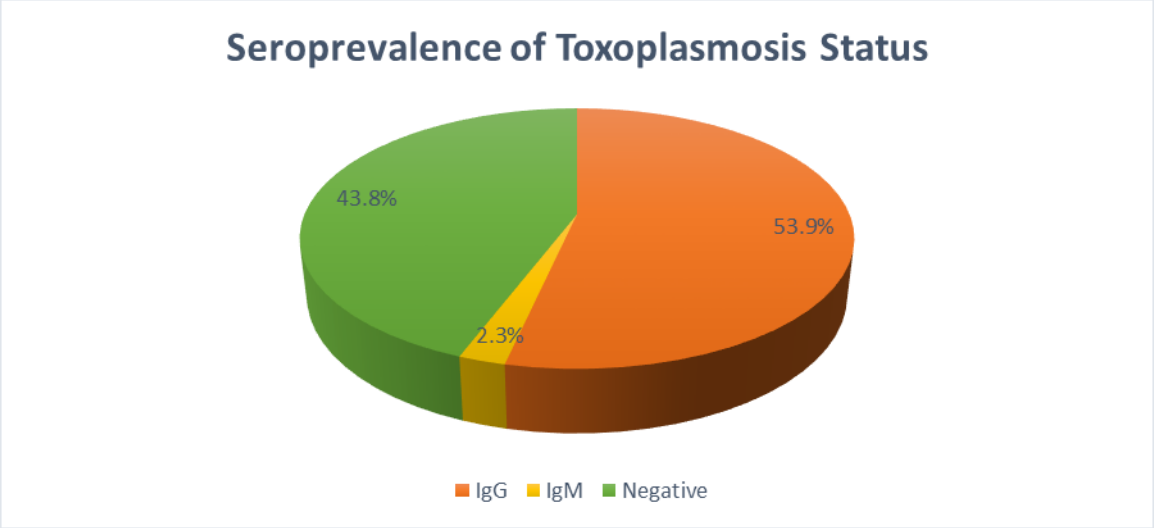


Figure 2. Seroprevalence of T. gondii in diabetic patients who were tested using the combination test cassette. The results showed that the seropositive rate of Toxoplasma tests for anti-IgG was 53%, while IgM 2% and (43.8%) of diabetic patients were negative for Toxoplasma infection.



Discussion

This study investigated the seroprevalence of *Toxoplasma gondii* (*T. gondii*) infection among diabetic patients and identified associated sociodemographic, behavioral, and medical factors. The findings revealed a seroprevalence rate of 56%, which is higher than the rates reported in Saudi Arabia (43%), but comparable to findings from studies in Egypt and Iran, where the prevalence exceeded 50% (20,21). The significant seropositivity rate underscores the impact of environmental and lifestyle factors on T. gondii exposure, particularly in a population with compromised immunity due to diabetes.

The results highlighted a pronounced sex disparity, with females showing significantly higher infection rates than males. This could be attributed to gender roles that increase women's exposure to risk factors, such as handling raw meat and preparing vegetables, which are commonly linked to

T. gondii transmission (20,22). These findings align with studies conducted in Egypt and Iraq but contrast with those in Mexico and Saudi Arabia, where no significant gender differences were observed (14,23). These variations underscore the role of cultural and regional differences in shaping the exposure patterns.

This study also found a strong association between type 2 diabetes and a higher seroprevalence of *T. gondii*. Patients with prolonged diabetes duration are more likely to be seropositive, suggesting that chronic hyperglycemia and immune dysfunction may exacerbate susceptibility to opportunistic infections (12,24). This aligns with global research indicating the vulnerability of diabetic individuals to infections due to compromised immune system. Behavioral practices, such as washing vegetables and meat before consumption and having access to handwashing facilities, were associated with reduced infection rates. Conversely, pet ownership, particularly that of cats, is strongly linked to toxoplasmosis, reflecting the zoonotic nature of *T. gondii* (25). These findings underscore the importance of promoting hygiene practices and providing health education to reduce infection risk in vulnerable populations.

While the study provides valuable insights, its cross-sectional design limits its ability to draw causal inferences. The focus on two hospitals in Mogadishu restricts generalizability, and reliance on self-reported behavioral data introduces the potential for recall bias. Future research should employ molecular diagnostic tools for greater accuracy and include larger and more diverse populations to validate these findings. Expanding the scope of research to explore broader dietary habits and longitudinal patterns of infection in patients with diabetes could yield a deeper understanding of risk factors.

In conclusion, this study highlights the high seroprevalence of *T. gondii* among diabetic patients in Mogadishu, with significant associations identified between sex, type of diabetes, duration of the disease, behavioral practices, and environmental exposure. These findings emphasize the need for targeted public health interventions, including routine screening for *T. gondii*, education on food hygiene, and addressing zoonotic risks associated with pet ownership. These measures are crucial to reduce the burden of opportunistic infections in the diabetic population.

Conflict of interests

The authors state that there is no conflict of interest in this study.

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No funding was received in this study.

Data availability

All data generated or analyzed during this study are included in this puplished article.

Authors' contribution

All authors made significant contributions to the work presented, including study design, data collection, analysis, and interpretation. They also contributed to the article's writing, revising, or critical evaluation, gave final approval for the version to be published.

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