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Latent *Toxoplasma gondii* infection, general health, and academic performance in veterinary students

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Abstract

Emerging evidence increasingly links latent *Toxoplasma gondii* (*T. gondii*) infection to a range of physical, psychological, and behavioral disorders. Simultaneously, higher education environments, particularly in veterinary programs, are known to exert considerable psychological pressure, potentially compromising the health and well-being of students. Therefore, this study aimed to explore the interplay between latent *T. gondii* infection, general health status, impulsivity, and academic performance among veterinary students at Shiraz University, in southern Iran. A total of 99 students participated in this cross-sectional study. Latent toxoplasmosis was assessed using an ELISA to detect IgG antibodies. General health and impulsivity were evaluated using the validated shortened General Health Questionnaire (GHQ-28) and the revised Barratt Impulsiveness Scale (BIS), respectively. Demographic and academic data, including grade point average (GPA), were also collected. Eight students (8%; 95% CI: 3–14%) tested positive for latent *T. gondii* infection, suggesting a decreasing trend compared with previous studies. Elevated general health scores, indicating potential psychological distress, were observed in 32.3% of participants (95% CI: 23–42%), while 45.5% (95% CI: 36–55%) exhibited high impulsivity scores. No statistically significant associations were found between latent toxoplasmosis and general health, impulsivity, or GPA. However, GPA was significantly and negatively correlated with both general health and impulsivity scores. These findings highlight the decreasing trend in *T. gondii* seroprevalence. However, simultaneously raise significant concern in student well-being and emphasize the urgent need for targeted interventions and supportive policies to promote the general health and academic success of veterinary students as future professionals in the field.

Introduction

Toxoplasma gondii (*T. gondii*) is a zoonotic parasite whose life cycle can be completed only in cats and other felids, as definitive hosts, and human and various other warm-blooded animals are its intermediate hosts (1). *Toxoplasma gondii* infects approximately 30% of the world's population with marked global variability. Seroprevalence can reach almost 90% in certain demographic groups in some parts of Africa and 60% in some European

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populations (2, 3). The latent infection by *T. gondii*, defined by positive serology for anti-*T. gondii* IgG antibodies and by an almost always asymptomatic persistence of cysts in the tissues of the host, including the brain (4). Latent toxoplasmosis is a common infection in both developed and developing countries and has historically been considered asymptomatic in immunocompetent persons (5).

Rodent studies have shown that *T. gondii* infection can impair learning in mice and, by altering host behavior, increase the likelihood of mice being eaten by cats, enabling the parasite to complete its life cycle (6). However, the relationship between this parasitic infection and behavioral disorders in humans remains challenging. Growing evidence links latent *T. gondii* infection to various neuropsychiatric disorders such as schizophrenia and obsessive–compulsive disorder, and behavioral conditions including suicidal attempts (3, 7-9). In addition, epidemiologic research demonstrates the association of latent toxoplasmosis with a broad spectrum of physical health issues including cardiovascular diseases, and certain cancers (9). It has been suggested that the public health burden of latent infection may far outweigh that caused by acute and congenital toxoplasmosis (3).

On the other hand, higher education programs are associated with psychological pressure, and this can affect the overall mental well-being of university students. Veterinary medicine is a form of professional education in which students experience high levels of stress and strain on their mental health (10). Studies show that students are coping poorly with their high stress levels, with notably high levels of psychological problems and substance use (10). Notably, there is a significant prevalence of depression and anxiety disorders among veterinary professionals and undergraduate students (11-13). For faculty and educators in this field to be able to think and plan to improve the mental health of current students and future veterinarians, understanding the general health status, both physical and mental, of veterinary students can be considered an essential step.

Previous research has explored the association between toxoplasma infection and behavioral changes, also the general and mental health of university students and its association with their academic performance. However, no study has simultaneously examined these aspects to provide a more comprehensive understanding of the complex interplay among latent toxoplasma infection, general well-being, and academic outcomes in veterinary students.

Taken together, the main purpose of the present study was to explore the seroprevalence and risk factors of *T. gondii* infection as well as general health and well-being of veterinary students at school of veterinary medicine, Shiraz University, southern Iran. We hypothesized that infection with *T. gondii* may affect the general health and wellbeing of the veterinary students, also their academic performance.

The general health of students was evaluated using the standard shortened General Health Questionnaire (GHQ-28) and revised Barratt Impulsiveness Scale (BIS). The GHQ-28 was developed by Goldberg in 1979 (14), and has since been translated into 38 languages. It is a screening tool to detect those likely to have or to be at risk of developing psychiatric disorders (14). The Barratt Impulsiveness Scale (BIS) was developed to measure a person's level of impulsivity and ways they act and think under various situations (15). Impulsivity is the tendency to take risks; a behavior characterized by doing things suddenly without any planning and without considering the potential consequences. A better understanding of the general health and wellbeing issues in veterinary students and contributing factors enable educators to implement strategies that enhance student welfare, ultimately benefiting the future veterinary workforce.

Materials and Methods

Study population

This cross-sectional study targeted veterinary medical students enrolled at the School of Veterinary Medicine, Shiraz University, Shiraz, southern Iran. Participation was voluntary, and students were invited to join the study based on their willingness. A total of 106 students agreed to participate. The study was conducted between January and March 2018, with informed consent obtained from all participants prior to enrollment.

Serological examination

To investigate the status of *T. gondii* infection, 5 ml of blood samples were taken from the students. The isolated sera were stored at 20°C until use. Serological examination and detection of IgG antibodies were accomplished using a commercial enzyme-linked immunosorbent assay (ELISA) kit (Vircell, Spain) according to the manufacturer's instructions. Each sample was tested in duplicate.

Data Collection

General information including age, sex, ABO and Rh blood group, living in a university dormitory or with family, educational level including DVM and postgraduate, and the academic year were collected using a questionnaire. The Grade Point Average (GPA) for each student was also determined. The GHQ-28 and revised BIS were used to determine the general health and impulsiveness of students. The GHQ-28 is a 28-item measure in four categories: somatic symptoms (items 1–7); anxiety/insomnia (items 8–14); social dysfunction (items 15–21), and depression (items 22–28). Using a 0-3 scoring system, the total score ranges from zero to 84, and using this method, the scores of the individuals were calculated (14). The modified BIS with 10 items was used to determine the impulsivity status of students. The questionnaires were scored using a 1 to 4 scoring system (15). In both questionnaires, lower scores were generally considered better.

Statistical analysis

The responses were scored in the completed questionnaires and, along with other general information, were entered into IBM SPSS Statistics for Windows, version 26, for statistical analysis. Normality of quantitative data was examined using the Kolmogorov-Smirnov test. Seroprevalence of *T. gondii* was determined along with 95% confidence interval (CI). The univariable relationship between potential qualitative and quantitative risk factors with *T. gondii* infection was evaluated using the chi-square test and independent two-sample t-test, respectively. For the shortened GHQ-28, a total score of 23 and above was considered the threshold for the possibility of a mental disorder (14). The revised BIS, the students were categorized into two groups based on the median score. Univariable association of categorized general health and impulsivity scores with GPA, *T. gondii* infection and other explanatory variables were evaluated using chi-square test, independent two- samples t-test, and Pearson's correlation coefficient. Variables with a P-value < 0.20 in the univariable analysis were included in the multivariable logistic regression model. Three separate multivariable models were constructed, each corresponding to a different dependent variable: *T. gondii* infection, categorized general health, and impulsivity scores; and associated factors were identified by calculating odds ratios (ORs). The final regression models were constructed using the backward elimination method. In all cases, a P-value less than 0.05 was considered statistically significant at the final step.

Results

Seroprevalence of T. gondii and its risk factors

Among 106 subjects, a total of seven questionnaires were incomplete and removed from further analyses. Of the 99 students studied, eight students, or approximately 8%, were infected with *T. gondii* (95% CI: 3-14%). The mean age of the participants was 23.9, and the standard deviation was 3.4 years. A univariable comparison of the general characteristics of students based on *T. gondii* infection is shown in Table 1. As can be seen, there was no difference between the seropositive and seronegative groups in terms of gender, residence in the dormitory or with family, and ABO or Rh blood

types. A near-significant or significant difference was observed for age (P= 0.11), academic year (P= 0.01), and between DVM and postgraduate students (6% vs 20%, P= 0.09). Using multiple logistic regression, age, level of education, and academic year were entered in the model. And only, academic year remained in the final model (OR= 1.7, 95% CI: 1.1-2.6, P= 0.024), indicating an increase in the odds of seropositivity for *T. gondii* by each excess academic year (Supplementary Table s1).

No difference was observed in GPA between seropositive and seronegative groups (P= 0.89).

Table 1. Seroprevalence of *Toxoplasma gondii* infection among veterinary students at Shiraz University by demographic and academic characteristics

		Toxoplasma gondii		
Categorical variables	Total	Positive (%)	Negative (%)	P-value
Gender				0.40
Female	59	4 (6.8)	55 (93.2)	
Male	40	4 (10.0)	36 (90.0)	
ABO blood groups				0.91
A	33	2 (6.1)	31 (93.9)	
B	25	2 (8.0)	23 (92.0)	
AB	9	1 (11.1)	8 (88.9)	
O	31	3 (9.7)	28 (90.3)	
Rh blood groups [a]				0.59
Positive	84	8 (9.5)	76 (90.5)	
Negative	10	0 (0.0)	10 (100)	
Living status				0.43
Dormitory	68	7 (10.3)	61 (89.7)	
With family	31	1 (3.2)	30 (96.8)	
Educational level				0.09
DVM	84	5 (6.0)	79 (94.0)	
Post graduate	15	3 (20.0)	12 (80.0)	
Numerical variables	Total	Positive (mean±SD)	Negative (mean±SD)	P-value
Age (years)	99	25.8 ± 2.6	23.7 ± 3.5	0.11
Academic year	99	5.6 ± 1.8	3.6 ± 2.2	0.01
Grade point average	99	15.9 ± 1.7	15.8 ± 1.8	0.89

[a] There was a small number of missing values for this variable

General health and impulsivity scores

The mean of the general health score for all students was 20.5 with a standard deviation of 9.3 and a median of 19. The corresponding values for impulsivity scores were 20.9, 4.3 and 21, respectively. No significant difference was observed between seropositive and seronegative groups. A similar non-significant difference was found when four subcategories of GHQ-28 were compared based on *T. gondii* infection (Table 2).

Table 2. Comparison of general health and impulsivity scores among veterinary students at Shiraz University based on *Toxoplasma gondii* serostatus

	Toxoplasma gondii					
	Positive			Negative		
General health categories (GHQ-28)	Mean	SD	Median	Mean	SD	Median
Somatic symptoms	4.0	2.3	3.5	5.2	2.8	5.0
Anxiety/insomnia	4.3	2.8	3.5	6.0	3.9	5.0
Social dysfunction	6.3	2.3	7.0	6.5	2.5	7.0
Depression	1.8	1.5	1.5	3.2	3.6	2.0
Total	16.2	5.2	15.5	20.9	9.4	19.0
Barratt Impulsiveness Scale (BIS)						
Impulsivity (thinking and behavior)	19.4	4.9	20.0	21.1	4.2	21.0

No significant difference was observed between positive and negative groups (P>0.05 in all cases).

When the general health scores were categorized into two groups based on the threshold of 23 (<23 and ≥ 23), it was found that 32 students, or about one-third of the study group, had scores above the threshold (32.3%, 95% CI: 23-42%), indicating the likely presence of mental disorders. Based on this threshold, students were compared in terms of *T. gondii* status, gender, living status, academic year, level of education, and GPA (Table 3). The frequency of students above the threshold in DVM students was higher than in postgraduate students (36% vs 13%, P= 0.13). Moreover, 40 percent of boys were in the group above the threshold, compared to 27 percent of girls (P= 0.18). Average GPA was significantly higher in the normal (below threshold) group (P= 0.051). In the final multivariable model, only GPA was significant and remained in the model (OR= 0.8, 95% CI: 0.6-1.0, P= 0.054), indicating better general health in students with higher GPA (Supplementary Table s1).

Table 3. Comparison of general health and impulsivity scores after categorization among veterinary students at Shiraz University by demographic and academic characteristics

		General Health score			Impulsivity score		
Categorical var.	Total	< 23 (%)	≥ 23 (%)	P-value	≤ 21 (%)	> 21 (%)	P-value
Toxoplasma gondii				0.43[b]			0.72[b]
Positive	8	7 (87.5)	1 (12.5)		5 (62.5)	3 (37.5)	
Negative	91	60 (65.9)	31 (34.1)		49 (53.8)	42 (46.2)	
Gender				0.18			0.005
Female	59	43 (72.9)	16(27.1)		39 (66.1)	20(33.9)	
Male	40	24 (60.0)	16 (40.0)		15 (37.5)	25 (62.5)	
ABO blood groups				0.66			0.23 [b]
A	33	24 (72.7)	9 (27.3)		13 (39.4)	20 (60.6)	
B	25	15(60.0)	10 (40.0)		15(60.0)	10 (40.0)	
AB	9	7 (77.8)	2 (22.2)		6 (66.7)	3 (33.3)	
O	31	20 (64.5)	11 (35.5)		19 (61.3)	12 (38.7)	
Rh blood groups [a]				0.73[b]			0.51[b]
Positive	84	56 (66.7)	28 (33.3)		46 (54.8)	38 (45.2)	
Negative	10	6 (60.0)	4 (40.0)		4 (40.0)	6 (60.0)	
Living status				0.36			0.21
Dormitory	68	48 (70.6)	20 (29.4)		40 (58.8)	28 (41.2)	
With family	31	19 (61.3)	12 (38.7)		14 (45.2)	17 (54.8)	
Educational level				0.13[b]			0.11
DVM	84	54 (64.3)	30 (35.7)		43 (51.2)	41 (48.8)	
Post graduate	15	13 (86.7)	2 (13.3)		11 (73.3)	4 (26.7)	

		Mean ± SD		P-value	Mean ± SD		P-value
Numerical var.	Total	< 23	≥ 23		≤ 21	> 21	
Age (years)	99	24.2 ± 3.7	23.3 ±2.7	0.27	24.5 ± 3.8	23.2 ± 2.8	0.049
Academic year	99	3.7 ± 2.3	3.8 ± 2.0	0.77	3.9 ± 2.4	3.6 ± 1.9	0.54
Grade point average	99	16.1 ± 1.8	15.4 ±1.6	0.051	16.4 ± 1.8	15.3 ± 1.5	0.001

[a] There was a small number of missing values for this variable. [b] Fisher's exact test

Based on the median of the impulsivity score (21), students were divided into two groups: ≤ 21 and >21. Forty-five students representing 45.5% of the students (95% CI: 36–55%) exhibited high impulsivity scores. Examining the relationship between these groups and suggested risk factors (Table 3) showed that female students were significantly better than boys in terms of impulsivity scores, so that the frequency of girls in the group above 21 was almost half that of boys (34% vs. 63%, P=0.005). Furthermore, 49 percent of DVM students were in the group above the threshold, compared to 27 percent of postgraduate students (P= 0.11). Here again, there was a significant association between average GPA with impulsivity; below the threshold group had higher grade (P= 0.001). Gender (OR= 2.4, 95% CI: 1.0-5.7, P= 0.056) and GPA (OR= 0.7, 95% CI: 0.6-0.9, P= 0.016) remained in the final multivariable logistic model (Supplementary Table s1). None of

the general health and impulsivity scores showed a relationship with Toxoplasma infection after classification (Table 3).

Figure 1 displays a correlation matrix illustrating Pearson's correlation coefficients among *T. gondii* serostatus, general health scores, and impulsivity scores, in relation to students' demographic and academic variables. Notably, stronger correlations between *T. gondii* infection and academic year, as well as between GPA and both general health and impulsivity scores, align with and reinforce the findings from the multivariable logistic regression models.

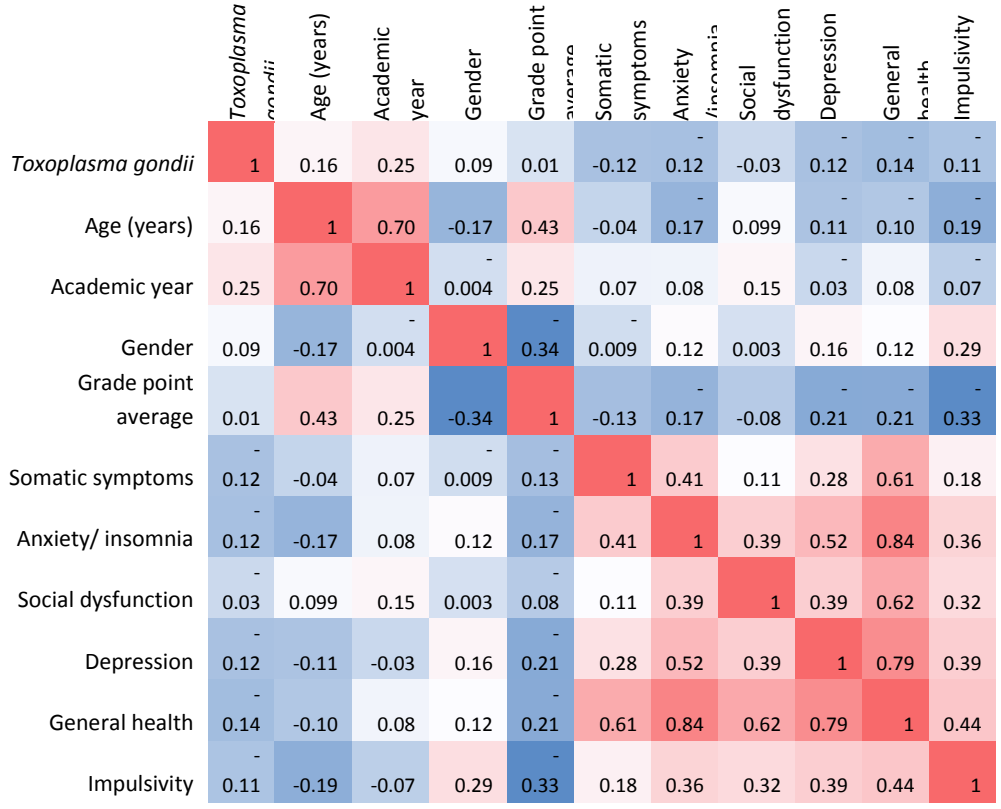

Fig. 1. Correlation heatmap showing associations among *Toxoplasma gondii* (*T. gondii*), general health items, impulsivity, and explanatory demographic and academic variables. Variables coding: *T. Gondii*, 0= seronegative, 1= seropositive; gender, 1= female and 2= male; educational level, 1= DVM, 2= postgraduate. General health indicates the sum of somatic symptoms, anxiety/insomnia, social dysfunction and depression.

Discussion

The seroprevalence of latent *T. gondii* infection among veterinary medical students in the present study was 8%. In comparison, previous research conducted in Iran has reported a minimum infection rate of approximately 12% in the general population, with average estimates ranging between 33% and 46% (16). The notably lower prevalence observed in this study may suggest a declining trend in *T. gondii* infection, potentially reflecting significant advancements in public health infrastructure and hygiene practices across the country in recent decades. Additionally, the relatively young age of the study participants (mean age 23.9 years) may have contributed to the low infection rate, as younger individuals are less likely to have accumulated exposure over time. This interpretation is further supported by findings

from a recent study at Shiraz University of Medical Sciences, which reported a seroprevalence of 7.4% among female university students with a mean age of 22.2 years (17).

In the final multivariable model, academic year demonstrated a significant positive association with *T. gondii* seropositivity. This finding may reflect increased exposure to potential sources of infection, particularly cats, during internships and clinical training, which typically increase in the later stages of veterinary education.

No significant association was observed between *T. gondii* seropositivity and measures of general health or impulsivity in the present study. Consequently, our hypothesis suggesting a link between latent toxoplasmosis and the overall health and well-being of veterinary students was not supported by the findings. The potential link between *T. gondii* infection and impulsivity warrants attention, particularly given that impulsivity is recognized as an intermediate phenotype for suicidal behavior (18). Several previous studies have reported associations between latent toxoplasmosis and increased levels of aggressiveness and impulsivity (9). However, the populations examined in those studies, such as healthy adults with a mean age of 54 years (18), psychiatric patients (7), and autistic children (19), differ substantially from the students investigated in the present study. Therefore, further research is needed to clarify the nature and extent of the relationship between impulsivity and latent *T. gondii* infection, particularly across diverse age groups and clinical backgrounds.

Contrary to our initial hypothesis, that latent toxoplasma infection might negatively impact students' academic performance through its associated behavioral alterations, we found no significant difference in GPAs between seropositive and seronegative individuals. Our hypothesis was grounded in prior observations, including studies that have identified associations between *T. gondii* infection and diminished performance in cognitive domains such as reaction time, processing speed, working memory, and executive function (9). As no comparable studies currently exist, direct comparison with our findings is not possible, and further research is needed to draw more definitive conclusions in this area.

A notable proportion of participants had general health scores above the threshold. Given that a score above the threshold indicates a likelihood of individuals developing psychiatric disorders such as anxiety and depression, the situation of students in this regard seems to be a bit worrying. A review study examining mental disorders among Iranian students using the GHQ, reported prevalence rates ranging from 23% to 52%, which are broadly consistent with the findings of the present study (20). In addition, research conducted on university students, particularly those in veterinary programs, in various countries has yielded comparable findings, highlighting notably high levels of depression and anxiety within this population (11). For instance, a study tracking three cohorts of veterinary students from two universities over their first three semesters revealed alarmingly high rates of depression, with 49%, 65%, and 69% of participants meeting or exceeding the clinical threshold for depressive symptoms (21). A review in this field highlighted that the combination of intense academic pressure, high performance expectations, and clinical responsibilities significantly contributes to elevated stress levels among veterinary students (11). This review indicated that female students consistently reported higher levels of stress, anxiety, and depression than their male counterparts, underscoring the need for gender-sensitive support strategies. However, the findings of the present study did not align with reported sex differences in this context, as no statistically significant difference was observed between male and female students. The validity of the observed sex differences, as well as the potential influence of cultural, environmental, and genetic factors, warrants further investigation in future studies.

Another noteworthy finding was the significant negative association between general health scores and students' GPA in the final multivariable logistic regression model, suggesting that individuals with higher academic performance tended to report better overall health. A similar, and even stronger, inverse relationship was observed between impulsivity and GPA, indicating that students with better academic outcomes have lower impulsivity levels. A quantitative analysis of the relationship among general health scores, impulsivity scores, and academic performance yielded consistent results, supporting the observed associations in multivariable models (Fig. 1). These results align with previous research showing that students with lower academic performance are more susceptible to anxiety disorders (12), and that those maintaining a GPA below 3.0 exhibit significantly elevated levels of stress (13).

We found that female students were significantly better than boys on the impulsivity measures. Several studies have investigated the relationship between impulsivity and biological sex among university students, revealing a complex pattern of findings. Recent literature indicates that sex differences in impulsivity are influenced by maturational, neuropharmacological, and hormonal factors throughout adolescence and adulthood. Additionally, emerging genetic evidence may offer further insight into the biological underpinnings of these differences (22). A significant correlation was observed between general health and impulsivity scores ($r = 0.44$, $P < 0.001$; Fig. 1), suggesting that students with better overall health may demonstrate enhanced self-regulation and a greater ability to manage impulsive behaviors. However, given the cross-sectional design of the present study, caution is warranted in interpreting the directionality of this and other associations, and inferring any causal relationships between variables. Additionally, the possibility of reverse causation, where for example lower impulsivity may contribute to better health outcomes, should not be overlooked.

Limitation of the study

A limitation of this study is the relatively small number of seropositive cases, which may have constrained the statistical power and reduced the ability to detect subtle associations. To strengthen the reliability and generalizability of these findings, future research involving larger sample sizes is warranted. In addition, the cross-sectional study design limits conclusions regarding causality between the associated variables. To address this, longitudinal cohort studies following veterinary students over time are needed to clarify the direction and nature of this interplay.

Conclusion

The results of this study indicated a low prevalence of *T. gondii* infection in Shiraz veterinary students, and no association was observed between this parasitic infection and the general health, impulsivity, and academic performance of veterinary students. Moreover, the prevalence of students scoring high on the general health and impulsivity screening tool, coupled with the observed association between these scores and diminished academic performance, raises significant concern and underscores the urgent need for policies that enhance students' physical and mental well-being. As a preliminary study, further research involving larger sample sizes is necessary to deepen our understanding of how *T. gondii* interacts with host physiology and influences a range of health and behavioral outcomes.

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Conflict of Interest

The authors declare no conflicts of interest.

Ethical approval

This study was approved by the Research Council Committee of the School of Veterinary Medicine, Shiraz University, in accordance with the Iranian National Committee for Ethics in Biomedical Research. Informed consent was obtained from all participants before enrollment.

Artificial Intelligence Statement

This manuscript benefited from the assistance of Microsoft Copilot, an AI companion developed by Microsoft, which was used to check and refine the English language. The AI tool was employed exclusively for linguistic editing and clarity improvement; all scientific content, interpretations, and conclusions remain the sole responsibility of the authors.

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