Journal of Posthumanism
2025
Volume: 5, No: 9, pp. 386–394
ISSN: 2634-3576 (Print) | ISSN 2634-3584 (Online)
posthumanism.co.uk

DOI: https://doi.org/10.63332/joph.v5i9.3337

Predisposing Factors and Predictors of Igg and Igm Antibody Seroprevalence Against Toxoplasma Gondii in Medical Students from A Coastal University in Ecuador

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Abstract

Background: Toxoplasmosis, caused by Toxoplasma gondii, poses substantial risk in pregnancy and immunocompromise. Medical students face combined environmental exposure, variable hygiene, and academic practices. Objective: To examine predisposing factors associated with IgG/IgM seroprevalence in students from a coastal Ecuadorian university and identify independent predictors. Methods: Cross-sectional study of 640 randomly selected students; validated questionnaire (α=0.927) and ELISA for IgG/IgM. Descriptive statistics, chi-square/Fisher, Mann-Whitney U, and logistic regression were applied. Results: Seroprevalence 58.3% (IgM 39.7%; IgG 27.5%). Associations: rural residence, cat contact, undercooked meat, untreated water, and poor food hygiene. Predictors: untreated water (OR=21.9; 95%CI 13.9–34.6), cat contact (OR=3.2; 2.0–5.0), and undercooked meat (OR=2.18; 1.39–3.41). Conclusions: Findings indicate ongoing transmission in university settings. Priorities include ensuring safe water, strengthening food hygiene, and biosafety training. The predictive model supports targeted prevention and surveillance strategies.

Keywords: *Toxoplasma Gondii, Seroprevalence, Medical Students, Predisposing Factors, Ecuador.*

Introduction

Toxoplasmosis is a parasitic zoonosis of worldwide distribution caused by *Toxoplasma gondii,* an obligate intracellular protozoan of the phylum Apicomplexa with a heteroxenous cycle in which felines act as definitive hosts and mammals (including humans) as intermediate hosts (Dubey, 2021; Tenter et al., 2000). Infection occurs mainly by ingestion of sporulated oocysts present in contaminated water or food, by consumption of tissue cysts in raw or undercooked meat and, less frequently, by congenital or transfusion routes (Tenter et al., 2000). Globally, approximately one third of the population has been exposed, although with notable geographical gradients determined by climate, cultural practices and sanitary conditions (Pappas et al., 2009). In most immunocompetent individuals, the course is asymptomatic; However, in pregnant women it can cause congenital toxoplasmosis with severe sequelae and, in immunocompromised patients, highly fatal meningoencephalitis (Robert-Gangneux & Dardé, 2012).

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In Latin America, seroprevalence typically exceeds that of temperate or cold regions due to favorable environmental conditions for oocyst survival, dietary habits, and deficiencies in basic sanitation (Pappas et al., 2009). Waterborne transmission has been documented in urban outbreaks linked to municipal supply systems, highlighting the critical role of safe water in prevention (Bowie et al., 1997). In Ecuador, available reports show variable prevalence by territory and population, with intermediate-high reports in university groups; 37.9% were reported in students at an Andean university (Sánchez Artigas et al., 2018). This pattern suggests sustained circulation of the parasite and recurrent exposure in young people.

The most consistently described risk factors include the consumption of raw or undercooked meat, household contact with cats, and poor food hygiene; These factors also include the consumption of untreated water, which emerges as a key risk factor in contexts with infrastructure gaps (Cook et al., 2000; Jones et al., 2009). The convergence of these determinants with the region's specific socioenvironmental conditions creates a differential risk scenario that warrants targeted preventive approaches.

In this context, medical students constitute a population of high epidemiological and strategic interest (Khattak et al., 2024). They share community risks (water and food) and, simultaneously, carry out academic and preclinical activities that require rigorous biosafety standards. This dual exposure—environmental and educational—has implications not only for their individual health but also for the safety of patients and communities with whom they will interact throughout their training and professional practice. Regional evidence on this subgroup is still fragmented and with limited integration of behavioral, academic, and contextual determinants.

The lack of updated estimates and multivariate models that differentiate the relative weight of key factors among medical students at Ecuadorian universities constitutes a critical gap for university public health. Robust data would allow for cost-effective interventions—from improving water quality and nutritional education to strengthening biosafety practices—aligned with ethical standards and the protection of vulnerable populations (World Medical Association, 2013).

The objective of this study was to analyze the association between predisposing factors and the seroprevalence of IgG and IgM antibodies against *T. gondii* in medical students at a coastal university in Ecuador, and to identify independent predictors of seropositivity using logistic regression, in order to inform prevention and surveillance strategies in university settings.

Methods

Study Design

Observational, cross-sectional, correlational study-analytical and quantitative approach. The methodological classification follows Hernández-Sampieri and Mendoza (2018).

Population and Sample

Target population: 1,977 students from the Universidad San Gregorio de Portoviejo (USGP), 2024–2025. The optimal sample size was 640, calculated with 95% power and α=0.05 using Epi Info™, OpenEpi, and Stata.

Inclusion and exclusion criteria

Inclusion: Students aged 18–25 years, both sexes, enrolled and with informed consent.

Exclusion: Previous treatment for toxoplasmosis (<6 months) or conditions that prevent reliable participation.

Data Collection

1) Structured survey validated by experts; Cronbach's alpha = 0.927. 2) ELISA IgM/IgG serology for *T. gondii* in a certified laboratory.

Statistical Analysis

Descriptive analyses were applied; χ^2/Fisher for categorical associations; Student's t or Mann's U test.-Whitney for continuous variables; and binary logistic regression for predictors of seropositivity. OR, 95% CI, and $p \leq 0.05$ are reported.

Ethical considerations

Approval by the Ethics Committee of the Technical University of Manabí; procedure in accordance with the Declaration of Helsinki (WMA, 2013). Informed consent, anonymity, and confidentiality are guaranteed.

Results

OE1. Prevalence of IgG and IgM antibodies

The sample consisted of 640 students (mean age 20.37±2.13; 65.2% female). 39.7% (n=254) were IgM positive, 27.5% (n=176) were IgG positive; 41.7% were seronegative for both.

SEROLOGICAL MARKER	NEGATIVE N (%)	POSITIVE N (%)	TOTAL
IGM (ACTIVE INFECTION)	386 (60.3)	254 (39.7)	640
IGG (PAST INFECTION)	464 (72.5)	176 (27.5)	640

Table 1. Distribution of IgM and IgG antibodies in medical students (n=640)

OE2. Association between predisposing factors and seroprevalence

Significant associations: rural residence (χ^2=11.86; p=0.001), academic semester (χ^2=21.86; p=0.003), cat ownership (χ^2=31.27; p<0.001), raw meat consumption/average (χ^2=7.75; p=0.021), untreated water (χ^2=100.36; p<0.001), and poor washing/disinfection of fruits/vegetables (χ^2=46.59; p<0.001).

PREDISPOSING FACTOR	NEGATIVE N (%)	POSITIVE N (%)	X²	P
URBAN RESIDENCE	64 (56.1)	50 (43.9)	11.86	0.001
RURAL RESIDENCE	203 (38.6)	323 (61.4)		

WELL-COOKED MEAT	60 (47.2)	67 (52.8)	7.75	0.021
RAW/MEDIUM MEAT	207 (39.5)	306 (60.5)		
TREATED WATER	218 (58.1)	157 (41.9)	100.36	<0.001
UNTREATED WATER	49 (18.5)	216 (81.5)		
ALWAYS WASH FRUITS	75 (67.6)	36 (32.4)	46.59	<0.001
WASH FRUITS SOMETIMES/NEVER	192 (35.8)	337 (64.2)		

Table 2. Predisposing Factors Associated with T. Gondii Seroprevalence

OE3. Predictors of seropositivity (binary logistic regression)

Independent predictors: rural residence (OR=0.087; 95%CI: 0.045–0.168; p<0.001), cat ownership (OR=3.21; 95%CI: 2.03–4.89; p<0.001), consumption of semi-raw/raw meat (OR=2.18; 95%CI: 1.41–3.36; p=0.001) and untreated water (OR=21.94; 95%CI: 13.8–34.7; p<0.001).

VARIABLE	B	STANDARD ERROR	WALD	P	OR (95%CI)
RURAL RESIDENCE	-2.43	0.38	41.05	<0.001	0.087 (0.045–0.168)
ACADEMIC SEMESTER	0.02	0.05	0.15	0.698	1.02 (0.92–1.13)
CAT OWNERSHIP	1.16	0.23	25.67	<0.001	3.21 (2.03–4.89)
SEMI-RAW/RAW MEAT	0.77	0.22	12.65	0.001	2,18 (1,41–3,36)
UNTREATED WATER	3.09	0.24	157.17	<0.001	21.94 (13.8–34.7)

Table 3. Binary Logistic Regression Model for Predictors of Seropositivity

Discussion

Key findings and epidemiological reading.

This study documents a high seroprevalence (58.3%) in medical students, with an unusually high proportion of IgM (39.7%), suggesting recent or ongoing exposure. In line with the described Latin American gradient (Pappas et al., 2009), the results confirm sustained environmental transmission in a young population. The observed risk profile—untreated water, contact with cats, and consumption of undercooked/raw meat—matches the best-established infection routes: oocysts in water/food and tissue cysts in meat (Tenter et al., 2000; Cook et al., 2000; Jones et al., 2009; Dubey, 2021). The OR=21.9 for untreated water is consistent with waterborne outbreaks described in municipal systems (Bowie et al., 1997), and its magnitude suggests that water is the dominant vector in this context.

Comparison with the literature and biological plausibility.

The combination "untreated water + felines + undercooked meat" has been repeatedly implicated in population-based series and case-control studies in Europe and the Americas (Cook et al., 2000; Jones et al., 2009). The robust finding for contact with cats (OR=3.21) supports their role as definitive hosts that disseminate oocysts (Dubey, 2021). The association with undercooked meat (OR=2.18) is consistent with evidence of viable tissue cysts in mammalian meat (Tenter et al., 2000) and with cultural cooking patterns in the region. In Latin America, the high serological load is due to a climate favorable for oocyst survival, sanitation gaps, and dietary habits (Pappas et al., 2009), all determinants present in the study setting.

The "rural effect" and the role of environmental mediation.

Rural residence showed greater positivity in the bivariate analysis, but an OR <1 (0.087) in the adjusted model. There are two complementary methodological interpretations:

1. Mediation/collinearity: "Rurality" could operate through "untreated water" and "food hygiene." By including these proximal variables, the distal (rural) exposure loses its effect or is even reversed due to collinearity and statistical suppression.

2. Coding and referencing: The direction of the coefficient depends on the binary coding (which category is 1) and the reference category. With such a dominant water predictor, small coding asymmetries can produce apparent ORs <1 for "rural." Substantively, what is consistent with the literature is that rurality is not protective per se; rather, its effect is explained by unsafe water, sanitation, living with animals, and risky practices. We recommend assessing VIF for collinearity, exploring hierarchical models with "residence" as the contextual level, and mediation analysis (water/hygiene) to clarify causal pathways.

Elevated IgM: explanatory alternatives and need for confirmation.
Such a high IgM level warrants careful reading. Possible explanations:

- Recent heavy circulation(scenario compatible with the OR of water).

- Prolonged persistence of IgMafter infection or nonspecific reactivity (e.g., interference by rheumatoid factor), a phenomenon known in Toxoplasma serology (Robert-Gangneux & Dardé, 2012).

- False positivesor inter-kit variability. Best practices Q1: Confirm IgM with complementary tests (e.g., immunoblot) and, in particular, perform IgG avidity to discriminate recent vs. past infections more robustly (Robert-Gangneux & Dardé, 2012). This refines clinical interpretation and the appropriateness of interventions (e.g., in pregnant women).

Strengths of the study.

(i) High sample size (n=640), calculated with 95% power, (ii) random sampling that improves internal validity, (iii) validated instrument (α=0.927), and (iv) multivariate model with good overall fit (Nagelkerke R^2=0.569; classification=83.9%), which suggests useful discriminatory capacity for risk stratification on campus.

Limitations and potential biases.

- Cross-sectional design: prevents inferring temporality; the association does not prove causality.

- Exposure measurementby survey: recall bias and social desirability; probably non-differential, would tend to bias associations toward the null, so true magnitudes could be higher.
- Coarse classificationof key variables: “untreated water” groups heterogeneous sources (well, cistern, sporadic network), and “undercooked meat” lacks a cooking gradient; this limits the dose-response analysis.
- IgG avidity was not evaluatedNor was strain genotyping performed (Latin American clonality/atypicality), factors that can modulate pathogenicity and serological response (Dubey, 2021).
- External validity: a single university; generalization conditioned by the local water and sanitation context.

Proposed robustness and sensitivity analysis.

To reinforce the inference:

1. Serological confirmation: IgM and IgG avidity re-test in a subsample stratified by water type.
2. Alternative models(a) hierarchical with neighborhood/sector as the contextual level; (b) Firth-logit if there is separation by categories; (c) regression with robust errors grouped by dwelling.
3. Specification checks: Hosmer–Lemeshow, AUC ROC, calibration (Brier score), and VIF for collinearity.
4. Interactions: explore water × rurality, meat × sex, cats × hygiene practices.
5. Dose-response: Ordinalize exposure (frequency of consumption of semi-raw meat; type/treatment of water; intensity of contact with cats).

Implications for university public health (One Health).

The data prioritize highly cost-effective interventions:

- Water: ensuring water purification/filtration points on campus and in residences; regular microbiological monitoring; and home chlorination campaigns. The magnitude of the OR suggests that improving water alone could substantially reduce seropositivity.
- Food: Training for food handlers and students in thorough meat cooking and preventing cross-contamination; promoting fruit/vegetable washing/disinfection.
- CatsLitter box hygiene (gloves, mask, frequent litter box changes), deworming, and waste management education; ethical measures for controlling feral cats on and around campus (a One Health approach).
- Curriculum: Integrating biosecurity and parasite risk into the network; simulations of safe laboratory practices.
- Surveillance: Incorporate periodic seroepidemiological surveillance in the student population (especially women of childbearing age) and confirmation algorithms for IgM-positive cases (Robert-Gangneux & Dardé, 2012). In certain contexts, screening programs have shown benefits (Binquet et al., 2019).

Research Directions

Prioritize (i) cohorts to establish timing and incidence, (ii) intervention studies (cluster trials) on water improvements and food education, (iii) T. gondii genotyping to profile circulating strains, and (iv) spatial analyses (e.g., Moran's I) to detect clusters that point to water- or food-related hotspots. Integrating environmental data (water quality, feline density) will strengthen preventive planning.

Synthesis

The evidence converges on an operational message: in university settings on the Ecuadorian coast, untreated water accounts for the greatest risk; contact with cats and undercooked meat increase exposure. A tiered strategy—improving water, food hygiene, and biosecurity—is feasible, ethical, and high-impact for reducing T. gondii transmission among medical students (Tenter et al., 2000; Cook et al., 2000; Jones et al., 2009; Robert-Gangneux & Dardé, 2012; Dubey, 2021; Bowie et al., 1997).

Conclusions

This study demonstrates a high seroprevalence of IgG and IgM antibodies against Toxoplasma gondii in medical students at a coastal university in Ecuador, with a pattern reflecting recent and persistent exposure. The identification of untreated water, contact with cats, and consumption of undercooked/raw meat as independent predictors underscores the importance of environmental and behavioral determinants in parasite transmission in university settings.

The findings have immediate implications for medical training and university biosecurity. Ensuring access to safe water, promoting proper feeding practices, and strengthening education in hygiene and animal handling should be priorities on the institutional and national agenda. These interventions not only reduce the burden of toxoplasmosis but also contribute to the protection of patients and communities who interact with future health professionals.

This work also provides a predictive model with good discriminatory capacity, which can serve as a tool for risk stratification and the design of targeted prevention and epidemiological surveillance programs in higher education.

Finally, progress is needed toward longitudinal cohorts, advanced serological confirmation (IgG avidity, genotyping), and intervention assessments to better understand transmission dynamics and evaluate the effectiveness of preventive measures. Such efforts, framed within a One Health approach, are essential to mitigate the impact of toxoplasmosis in young and academic populations.

Acknowledgments

To the Universidad San Gregorio de Portoviejo for its logistical support and to the participating students. To the collaborating laboratories for serological processing.

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