

Original Article

Asian Pacific Journal of Tropical Medicine

apjtm.org

doi: 10.4103/apjtm.apjtm_18_26

Epidemiology and temporal trends of intestinal parasitic infections in Tizi-Ouzou, North-central Algeria: A 7-year retrospective hospital-based study

Safia Yousfi[1,2], Nassim Ouchene[3], Nadjet Amina Khelifi Touhami[3]✉, Omar Salhi[3], Ilhem Bouali[1], Randa Bouali[1], Sonia Saidani[2,4], Nacera Seklaoui[4]

[1]*Department of Biology, Faculty of Biological and Agronomical Sciences, Mouloud Mammeri University of Tizi Ouzou, BP 17 RP, 15000 Tizi Ouzou, Algeria*

[2]*Laboratory of Ecology and Biology of Terrestrial Ecosystems (LEBET), Faculty of Biological and Agronomical Sciences, Mouloud Mammeri University of Tizi Ouzou, BP 17 RP, 15000 Tizi Ouzou, Algeria*

[3]*Institute of Veterinary Sciences, Saad Dahlab University of Blida 1, BP 270, Road of Soumaa, 09000 Blida, Algeria*

[4]*Nedir Mohamed University Hospital Center, BP 100, 15000 Tizi Ouzou, Algeria*

ABSTRACT

Objective: To investigate the prevalence, species distribution, temporal trends, and associated demographic and clinical factors of intestinal parasitic infections (IPIs) among symptomatic patients attending a tertiary hospital in Tizi-Ouzou Province, North-central Algeria, over a seven-year period (2018–2024).

Methods: A retrospective analysis was conducted using laboratory records of 2 568 stool examinations performed at the Parasitology-Mycology Laboratory of the Nedir Mohamed University Hospital Center. Parasitological diagnoses had been established using standard techniques, including direct wet mount, formol-ether concentration, and Scotch tape test. Prevalence rates were calculated, and associations with sex, age, hospital status, and hospital unit were evaluated using *Chi*-square or Fisher's exact tests.

Results: The overall prevalence of IPIs was 28.4% (95% *CI* 26.7-30.2). Infection rates were higher in males (30.8%) than females (24.9%), in adults compared with children (30.8% *vs.* 21.9%), and in outpatients compared with inpatients (30.3% *vs.* 19.9%). Protozoa predominated (94.4%), with *Blastocystis* spp. as the most frequently detected parasite, increasing from 7.3% in 2018 to 22.2% in 2024. *Dientamoeba fragilis* also showed a rising trend (2.2% to 7.2%). Co-infections were observed in 5.3% of cases, mainly involving *Blastocystis* spp. A decline in prevalence was noted in 2020, likely related to COVID-19 hygiene measures.

Conclusions: IPIs remain highly prevalent among symptomatic patients in this region, with emerging protozoan species representing a growing public health concern. further prospective, multicenter studies incorporating molecular diagnostics and environmental investigations are essential to better understand the transmission dynamics of IPIs and validate these findings across diverse geographical regions and healthcare settings.

KEYWORDS: Intestinal parasite; Prevalence; *Blastocystis* spp.; *Dientamoeba fragilis*; Protozoa; Algeria

Summary

Question: What are the prevalence, species distribution, temporal trends, and associated factors of intestinal parasitic infections (IPIs) among symptomatic hospital-attending patients in Tizi-Ouzou Province, Algeria, between 2018 and 2024?

Findings: In this retrospective hospital-based study including 2 568 stool examinations from symptomatic patients, the overall prevalence of IPIs was 28.4% and was significantly higher in males, adults, and outpatients. Protozoa predominated, with *Blastocystis* spp. and *Dientamoeba fragilis* showing significant increases over time, while helminths remained uncommon.

Meaning: IPIs remain a substantial public health concern in North-central Algeria, with emerging protozoan species highlighting the need for enhanced surveillance and targeted prevention strategies.

✉To whom correspondence may be addressed. E-mail: khelifi_nadjet@univ-blida.dz

This is an open access article distributed under the terms of the Creative Commons Attribution-Non-Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

For reprints contact: reprints@medknow.com

©2026 *Asian Pacific Journal of Tropical Medicine* Produced by Wolters Kluwer-Medknow.

How to cite this article: Yousfi S, Ouchene N, Touhami NAK, Salhi O, Bouali I, Bouali R, et al. Epidemiology and temporal trends of intestinal parasitic infections in Tizi-Ouzou, North-central Algeria: A 7-year retrospective hospital-based study. Asian Pac J Trop Med 2026; 19(5): 196-204.

Article history: Received 11 January 2026 Revision 14 March 2026 Accepted 21 May 2026 Available online 29 May 2026

1. Introduction

Intestinal parasitic infections (IPIs) continue to pose a major public health challenge globally, particularly in low- and middle-income countries where inadequate sanitation, unsafe drinking water, and limited health services contribute to persistent transmission[1]. Although less common, IPIs are increasingly reported in developed countries among immunocompromised individuals, travelers, and migrant populations, underscoring their global relevance[1–3]. Clinically, these infections present a broad spectrum ranging from mild gastrointestinal disturbances to severe complications such as malnutrition, anemia, and impaired physical and cognitive development in children, contributing significantly to long-term morbidity[4,5].

IPIs comprise a diverse group of pathogens, primarily protozoa and helminths[1]. Enteric protozoa-including *Giardia*, *Entamoeba*, *Cryptosporidium*, and coccidian parasites-are frequently associated with diarrhea. Helminths, mainly soil-transmitted nematodes and schistosomes, remain a major global burden and are responsible for profound socio-economic impacts[6,7]. Recent WHO estimates suggest that more than 1.5 billion people worldwide are infected with soil-transmitted helminths, while intestinal protozoa affect an estimated 3.5 billion individuals, highlighting the scale of the problem[8,9].

Transmission is predominantly fecal-oral, through contaminated water, food, hands, or direct contact with infective stages in the environment[10]. In North Africa, available epidemiological studies consistently indicate that protozoan infections are more frequent than helminths, reflecting climatic, environmental, and socio-behavioral factors characteristic of the region[11–13].

Despite the substantial global burden of IPIs, their distribution varies considerably across regions depending on environmental, socioeconomic, and behavioral factors. In North Africa, and particularly in Algeria, available data remain limited, heterogeneous, and often outdated. Existing studies suggest that intestinal protozoa are increasingly predominant over helminths, reflecting ongoing epidemiological transitions associated with urbanization, improved sanitation, and changing lifestyles. However, important regional disparities persist, and updated epidemiological data are lacking for several provinces, including Tizi-Ouzou.

However, in Algeria, the true epidemiological picture remains incomplete. Most available studies are outdated, localized, or limited to specific subpopulations. In addition, significant regional disparities in water quality, urbanization, hygiene practices, and access to healthcare may influence infection dynamics, yet these variations remain poorly documented. This lack of comprehensive and up-to-date data limits the development of effective prevention and control strategies, especially in provinces undergoing rapid demographic and socio-environmental changes.

The Tizi-Ouzou province, located in Central Northern Algeria, represents a particularly relevant setting for studying IPIs. It is a densely populated region with substantial rural communities, mixed urban-rural interfaces, and diverse ecological conditions-all of which may influence parasite transmission. Despite this, no longitudinal or large-scale study has provided updated epidemiological evidence over the past decade.

Against this background, the present study aimed to provide updated hospital-based epidemiological evidence on IPIs among symptomatic patients in Tizi-Ouzou over a seven-year period (2018-2024). Specifically, we analyzed prevalence, temporal trends, and species distribution, while identifying key demographic and clinical factors associated with infection in both inpatient and outpatient populations. The findings are intended to support improved hospital surveillance strategies and inform targeted public health interventions for at-risk populations in Algeria.

2. Methods

2.1. Study area

The study was conducted in Tizi Ouzou Province, located in North-central Algeria (36°43’ N; 4°3’ E), approximately 100 km east of Algiers (Figure 1). The province spans an area of 2 958-2 993 km² and lies at an average altitude of 200 m in the Oued Sebaou valley. It experiences a Mediterranean climate, with hot, dry summers and mild, wet winters. The region encompasses a heterogeneous mix of urban and rural communities, where a substantial proportion of the population relies on traditional agriculture and animal husbandry practices, creating an environment conducive to the transmission of IPIs.



Figure 1. Map of the study area.

The Nedir Mohamed University Hospital Center is a tertiary-care referral facility providing a wide range of medical and surgical services to both urban and rural populations of the region. The Parasitology-Mycology Laboratory is equipped for routine parasitological diagnosis using standard microscopic techniques and is staffed by trained laboratory technicians and medical specialists. The hospital follows national diagnostic and treatment guidelines for IPIs and serves as a reference center for surrounding healthcare facilities.

2.2. Study design and data collection

This study was based on a retrospective review of 2 568 parasitological stool examinations conducted between 2018 and 2024 at the Parasitology-Mycology Laboratory of Nedir Mohamed University Hospital Center, Tizi Ouzou. As a tertiary care and referral center, this hospital serves both urban and rural populations across the province, making it a representative site for assessing the regional burden of IPIs.

Stool samples were collected from patients referred by clinicians for parasitological investigation, mainly due to the presence of gastrointestinal symptoms including diarrhea, abdominal pain, bloating, nausea, or other digestive disorders. None of the examinations were performed as part of routine general health check-ups or asymptomatic population screening. No exclusion criteria were applied, ensuring the inclusion of a wide spectrum of both symptomatic and asymptomatic individuals. This comprehensive approach was intended to capture the full diversity of intestinal parasites circulating in the community.

For each patient, the following information was recorded: demographic characteristics (age and sex), patient status (inpatient *vs.* outpatient), hospital unit of referral for inpatients, and detailed parasitological findings. These data enabled stratified analysis of infection prevalence according to demographic, clinical, and temporal variables, providing a detailed understanding of epidemiological patterns.

2.3. Sample collection and processing

Fresh stool specimens were collected in sterile containers and promptly transported to the parasitology laboratory. Each sample underwent macroscopic and microscopic examination following standard parasitological procedures. Direct wet mounts with saline and Lugol's iodine[14] were performed to detect trophozoites, cysts, eggs, and larvae. The formol-ether concentration technique[15] was applied to enhance the detection of protozoan cysts and helminth eggs. In cases clinically suspected for *Enterobius vermicularis*, the Scotch tape test[16] was employed. Parasites were identified based on morphological characteristics using standard diagnostic keys. As this was a retrospective study including all available records over the study period, no prior sample size calculation was performed.

In case of discrepant results between the applied diagnostic techniques, findings were interpreted based on the most sensitive method (formol-ether concentration) and confirmed by repeat microscopic examination when necessary. Quality control was ensured through adherence to standard operating procedures, regular maintenance of laboratory equipment, and verification of doubtful cases by experienced laboratory personnel. The use of multiple complementary diagnostic techniques increased the sensitivity and reliability of parasite detection, thereby supporting the validity of the reported prevalence estimates.

2.4. Data analysis

Survey data were entered into Microsoft Excel (version 2019) to facilitate processing. Prevalence was calculated as the proportion of positive samples among all examined specimens and expressed as percentages with 95% confidence intervals (95% *CI*). Annual prevalence was analyzed to evaluate temporal trends from 2018 to 2024. Comparisons between groups (sex, age, inpatient *vs.* outpatient, and hospital units) were performed using the *Chi*-square test or Fisher's exact test, as appropriate. A P-value <0.05 was considered statistically significant. All analysis were conducted using R software version 4.1.3 (R Foundation for Statistical Computing, Vienna, Austria).

This study analyzed factors associated with infection using bivariate analysis; no multivariate risk estimation (*e.g.*, odds ratios) was performed. Cases with missing or incomplete data were excluded from specific analysis where relevant variables were unavailable.

Temporal trends in annual prevalence and co-infection rates were analyzed using Pearson correlation for continuous variables and the *Chi*-square test for trend for proportions. The analysis accounted for varying yearly sample sizes by using proportion-based prevalence estimates for each year rather than raw counts.

Temporal trends in parasite prevalence were evaluated using the Cochran-Armitage *Chi*-square test for trend across the seven-year study period. This test assesses whether there is a significant increase or decrease in annual proportions, accounting for the ordinal nature of the study years. Parasites showing no statistically significant change (P>0.05) were classified as "Stable."

Annual prevalence of IPIs and co-infection rates were analyzed for temporal trends. For continuous outcomes, Pearson correlation coefficients were calculated to evaluate associations over time. For categorical outcomes, the Cochran-Armitage *Chi*-square test for trend was applied. Prevalence rates were used to standardize for unequal yearly sample sizes, ensuring that trend estimates were not biased by variations in the number of samples analyzed each year.

2.5. Ethical considerations

This study was conducted using anonymized laboratory records, and no personal identifiers were accessed or collected. The study complied with institutional and national ethical standards for retrospective research. Ethical approval was obtained from the appropriate institutional review board of the Nedir Mohamed University Hospital Center (Approval No. 98-11, Act of August 22, 1998). The requirement for informed consent was waived due to the retrospective nature of the study and the use of anonymized data, in accordance with the Declaration of Helsinki.

3. Results

3.1. Prevalence of intestinal parasitic infections in the study population

Over the study period (2018-2024), 2 568 stool samples were examined for intestinal parasites. The overall infection rate was 28.4% (95% *CI* 26.7%-30.2%). Temporal analysis revealed significant annual fluctuations ($P<0.01$), with prevalence ranging from 21.1% in 2020 to a peak of 32.6% in 2023 (Figure 2A). The number of stool samples analyzed increased substantially in 2023, likely due to increased post-pandemic healthcare utilization and testing activities.

The prevalence of IPIs varied significantly across demographic and clinical factors. Males exhibited a higher infection rate than females (30.8% *vs.* 24.9%, $P<0.01$), and adults were more frequently infected than children (30.8% *vs.* 21.9%, $P<0.01$). Outpatients had a significantly higher prevalence than inpatients (30.3% *vs.* 19.9%, $P<0.01$). Across hospital units, infection rates ranged from 14.0% in pediatrics to 33.3% in infectious diseases ($P<0.01$) (Table 1).

3.2. Prevalence of individual intestinal parasite species

Among the 2 568 stool samples analyzed, 12 parasitic species were identified. The most frequently detected parasite was *Blastocystis* spp., found in 504 cases (19.6%). This species showed an increase over the study period, rising from 7.3% in 2018 (26 cases) to 22.2% in 2024 (74 cases), confirming its emergence as the dominant intestinal parasite in this population (Figure 2B).

A similar upward trend was observed for *Dientamoeba* (*D.*)*fragilis* (115 cases; 4.5%), which increased steadily from 2.2% in 2018 (8 cases) to 7.2% in 2024 (24 cases), highlighting its role as an increasingly detected protozoan species (Figure 2C). Other protozoa, such as *Endolimax* (*E.*) *nana* (124 cases; 4.8%) and *Entamoeba coli* (52 cases; 2.0%), were also detected. In contrast, helminthic infections were relatively uncommon, with *Enterobius vermicularis* detected in only 36 cases (1.4%). Overall, protozoa were far more prevalent than helminths in this setting.

Some parasites, including *Giardia* (*G.*) *intestinalis* and *Entamoeba histolytica*, remained stable over time, in agreement with the trend analysis (Table 2). While rare species such as *E. hartmanni*, *Taenia saginata*, and *Iodamoeba butschlii* were sporadically detected in 2018 and disappeared by 2024. Occasional cases of *Chilomastix mesnili* and *Hymenolepis nana* were reported but were too limited to establish a trend (Table 2). Statistical significance of changes over time was

Table 1. Prevalence of intestinal parasites among studied population.

Variable	Category	Number tested (*n*)	Number positive (*n*)	Rate (95% *CI*)	*P*-value
Sex	Male	1 527	470	30.8 (28.6-33.0)	<0.01
	Female	1 041	259	24.9 (22.2-27.7)	
Age	Adult (⩾16 years)	1 866	575	30.8 (28.6-33.1)	<0.01
	Children (<16 years)	702	154	21.9 (19.0-25.1)	
Hospital status	Outpatient	2 091	634	30.3 (28.3-32.4)	<0.01
	Inpatient	477	95	19.9 (16.6-23.7)	
Hospital units	Pediatrics	228	32	14.0 (10.0-19.2)	<0.01
	Internal medicine	133	30	22.6 (16.4-30.2)	
	Infectious diseases	84	28	33.3 (24.1-44.2)	
	Others	32	5	15.6 (6.9-31.0)	
Year	2018	358	76	21.2 (17.3-25.8)	<0.01
	2019	272	73	26.8 (21.9-32.4)	
	2020	209	44	21.1 (15.9-27.3)	
	2021	197	56	28.4 (22.4-35.3)	
	2022	158	40	25.3 (18.9-33.0)	
	2023	1 040	339	32.6 (29.7-35.6)	
	2024	334	101	30.2 (25.4-35.6)	
Overall prevalence	2018-2024	2 568	729	28.4 (26.7-30.2)	-

Chi-square test was used for comparisons of categorical variables, and Fisher's exact test was applied when expected cell counts were <5. Statistical significance was set at $P<0.05$.

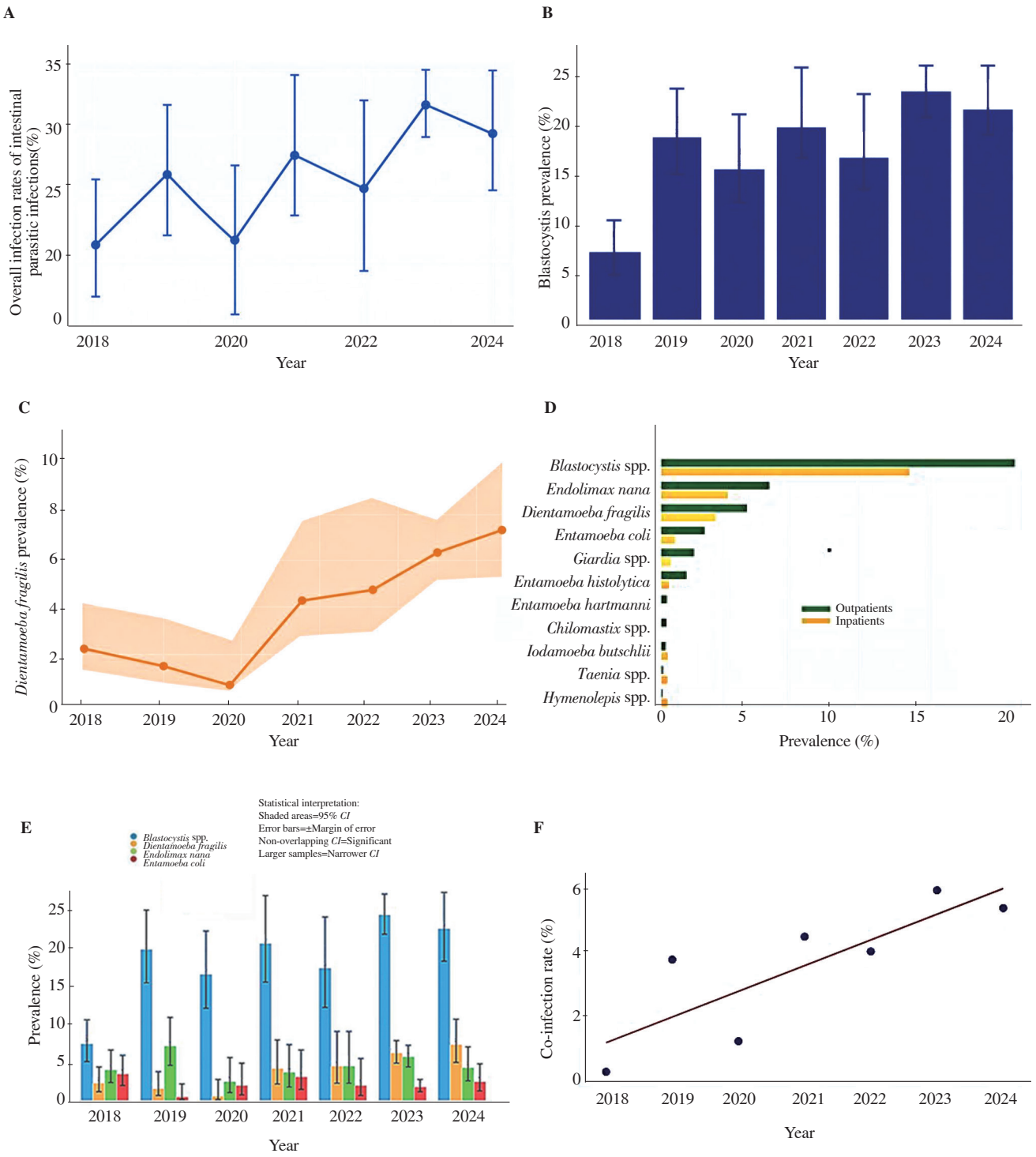

Figure 2. Temporal trends and distribution of intestinal parasitic infections from 2018 to 2024. A: The overall annual infection rate with corresponding 95% confidence intervals. B: The annual prevalence of *Blastocystis* sp. with corresponding 95% confidence intervals. C: The annual prevalence of the emerging parasite *Dientamoeba fragilis* with corresponding 95% confidence intervals. D: The prevalence of individual parasitic infections stratified by different settings. E: The prevalence of the top four most frequent parasites with corresponding 95% confidence intervals. Non-overlapping 95% *CIs* between years suggest statistically significant differences in prevalence, as supported by linear regression analysis. F: Temporal regression analysis of the co-infection rate in relation to year.

Table 2. Prevalence of intestinal parasites.

Parasite species	2018 Rate (95% *CI*)	2024 Rate (95% *CI*)	Absolute change (%)	Trend	*P* value
Common parasites					
Blastocystis spp.	7.3 (5-10.4)	22.2 (18.0-26.9)	+14.90	Significant increase	<0.001
Dientamoeba fragilis	2.2 (1.1-4.3)	7.2 (4.9-10.5)	+5.00	Significant increase	0.002
Endolimax nana	3.9 (2.3-6.5)	4.2 (2.5-6.9)	+0.30	Stable	0.78
Uncommon parasites					
Entamoeba coli	3.4 (1.9-5.8)	2.4 (1.2-4.7)	-1.00	Stable	0.41
Giardia intestinalis	0.3 (0-1.6)	0.9 (0.3-2.6)	+0.60	Stable	0.32
Enterobius vermicularis	3.1 (1.7-5.4)	0.6 (0.1-3.5)	-2.50	Significant decrease	0.01
Entamoeba histolytica	1.1 (0.3-2.2)	0.96 (0-2.4)	-0.16	Stable	0.85
Rare parasites*					
Entamoeba hartmani	0.3 (0-0.8)	0 (0-0)	-0.28	Stable	0.99
Tenia saginata	0.3 (0-0.8)	0 (0-0)	-0.28	Stable	0.99
Iodamoeba butschlii	0.3 (0-0.8)	0 (0-0)	-0.28	Stable	0.99
Co-infections	0.8 (0.3-2.4)	6.6 (4.4-9.8)	+5.80	Significant increase	<0.001

*: *Chilomastix mesnili* and *Hymenolepis nana* identified in 2023, with only two cases each. Parasites classified as "Stable" showed no statistically significant change in prevalence over the study period ($P>0.05$, *Chi*-square test for trend), supporting the descriptive label. Significant increases or decreases were identified using the same test. Rare parasites are species with very low prevalence (<1%), typically detected sporadically. A prevalence of 0% indicates no cases detected during the study period, but does not confirm true absence, as this may be influenced by sample size or diagnostic sensitivity.

determined using the *Chi*-square test for trend.

When comparing hospital status, outpatients had significantly higher prevalence of *Blastocystis* spp. (20.9% *vs.* 14.3%, $P<0.01$) and *E. nana* (5.4% *vs.* 2.3%, $P=0.01$), whereas *G. intestinalis* was more frequent among inpatients (1.9% *vs.* 0.7%, $P=0.02$). These patterns suggest that community transmission drives *Blastocystis* and *E. nana* infections, while *Giardia* may be more associated with severe clinical cases requiring hospitalization (Figure 2D).

3.3. Distribution of infection status

In this study, most participants (71.6%) were free of IPIs. Among infected individuals, single-species infections were most common (23.1%), while multiple infections were less frequent: dual infections in 4.8%, triple infections in 0.5%, and quadruple infections in 0.04% of cases. Despite their lower frequency, these co-infections highlight a small but epidemiologically important group simultaneously harboring multiple parasites (Figure 2E).

3.4. Co–infections: Temporal trends and risk factors

Co-infections were identified in 5.3% of patients (95% *CI* 4.5-6.2), mostly involving two parasites. The most frequent patterns included *Blastocystis* spp. + *E. nana* (1.8%) and *Blastocystis* spp. + *D. fragilis* (1.5%). Other combinations, including those with *Giardia*, were rare. Co-infections with three or four parasites occurred only sporadically (<0.3%), underscoring the predominant role of *Blastocystis* spp. in both single and multiple infections (Table 3).

Analysis revealed a notable upward trend in co-infections over the study period (correlation coefficient=0.83; $P=0.02$), increasing from 0.8% in 2018 to 6.6% in 2024, peaking at 7.2% in 2023 (Figure 2E). No significant differences in co-infection rates were observed by sex ($\chi^2=1.88$, $P=0.17$) or hospital status ($\chi^2=2.35$, $P=0.13$), although males showed slightly higher prevalence (5.8% *vs.* 4.5%).

These findings emphasize the growing public health importance of co-infections and the need for enhanced surveillance, targeted interventions, and improved hygiene practices, particularly for high-risk parasite combinations.

Temporal changes in co-infection rates were further analyzed using simple linear regression, with year as the independent variable and co-infection rate as the dependent variable (Figure 2F).

4. Discussion

This large-scale, seven-year retrospective study provides a comprehensive overview of IPIs in Tizi-Ouzou Province, North-central Algeria, a region representing both urban and rural populations with diverse socioeconomic and hygienic conditions. The overall prevalence of 28.4% underscores that IPIs remain a significant public health concern, consistent with other studies in Algeria[12,17]. The higher prevalence reported in the Mitidja Plain[18] indicates regional variability, highlighting the influence of environmental, socioeconomic, and behavioral factors on parasite transmission.

Table 3. Co-infections distribution.

Co-infection combination	Cases (*n*)	Rate (95% *CI*)
Two-parasite co-infections[#]		
Blastocystis spp. + *Endolimax nana*	46	1.8 (1.3-2.3)
Blastocystis spp. + *Dientamoeba fragilis*	39	1.5 (1.0-2.0)
Blastocystis spp. + *Entamoeba coli*	13	0.5 (0.2-0.8)
Blastocystis spp. + *Giardia intestinalis*	4	0.2 (0.0-0.3)
Endolimax nana + *Entamoeba coli*	4	0.2 (0.0-0.3)
Three-parasite co-infections. The top 2 most frequent types among the 6 coinfections:		
Blastocystis spp. + *Endolimax nana* + *Dientamoeba fragilis*	6	0.2 (0.0-0.4)
Blastocystis spp. + *Endolimax nana* + *Entamoeba coli*	3	0.1 (0.0-0.2)
Four-parasite co-infections (1 combination):		
Blastocystis spp. + *Endolimax nana* + *Dientamoeba fragilis* + *Entamoeba hartmani*	1	0.04 (0.0-0.1)
Overall co-infections	136	5.3 (4.5-6.2)

[#]The top 5 most frequent types among the 17 coinfections.

Demographic patterns reveal that adults and males were more frequently infected, suggesting that occupational exposure, likely influence infection risk. Such disparities are in line with another regional study, where adult men engaged in outdoor activities or agricultural work exhibited higher exposure to contaminated soil and water sources[11].

A key finding of our study is the overwhelming predominance of protozoan infections (94.4%) over helminths (5.6%), reflecting urbanization, improved sanitation, and lifestyle changes that reduce soil-transmitted helminth transmission. This pattern aligns with observations from Oran and Mitidja[18,19], where protozoa accounted for the majority of IPIs.

Blastocystis spp. emerged as the dominant parasite, increasing from 7.3% in 2018 to 22.2% in 2024. This trend mirrors findings from Morocco[20] and other North African regions[21], highlighting its rapid emergence as a key public health concern. Although its pathogenicity remains debated, some studies associate *Blastocystis* with gastrointestinal disorders and irritable bowel syndrome[22]. Although *Blastocystis* spp. prevalence increased over the study period, its pathogenicity remains debated. Our findings suggest a potential association with gastrointestinal disturbances, but causation cannot be established due to lack of clinical correlation. Nonetheless, the high prevalence highlights the importance of monitoring *Blastocystis* spp. in surveillance programs. Similarly, *D. fragilis* displayed a steady increase, tripling in prevalence from 2.2% to 7.2%, consistent with global reports of its underdiagnosed status[23]. *E. nana* and *Entamoeba coli* remained frequent but clinically less significant, confirming that emerging protozoa are driving the current epidemiological landscape, while helminth infections, such as *Enterobius vermicularis*, are sporadic and limited.

Co-infections, identified in 5.3% of participants, predominantly involved *Blastocystis* spp. with *E. nana* or *D. fragilis*, underscoring the complexity of intestinal parasitic ecology. Co-infections may affect pathogenicity, transmission, and treatment outcomes, emphasizing the need for integrated parasitological monitoring[24].

The higher prevalence in outpatients compared to hospitalized patients suggests that community transmission, rather than nosocomial exposure, drives the majority of protozoan infections. Conversely, *G. intestinalis* was more frequently detected among inpatients, indicating its association with more severe or symptomatic disease.

The temporal decline in prevalence in 2020 corresponds with COVID-19 lockdown measures, including improved hygiene and reduced healthcare utilization, followed by a post-pandemic rebound. Similar patterns have been documented globally, highlighting the sensitivity of parasite transmission to behavioral and environmental changes[25–27].

Strengths of this study include the large sample size, extended seven-year surveillance, and inclusion of both in- and outpatient populations, allowing for robust analysis of temporal, demographic, and clinical factors. Several potential confounding factors should be considered when interpreting our findings. Information on prior history of IPIs, previous antiparasitic treatment, and underlying medical conditions was not available in this retrospective dataset. These factors may have influenced both the likelihood of parasite detection and the clinical indication for stool examination. In addition, variations in healthcare utilization and diagnostic practices over the study period, particularly during the COVID-19 pandemic, may have affected the observed temporal trends.

A marked increase in the number of stool examinations was observed in 2023 compared to previous years. This variation in sample size may have influenced the annual prevalence estimates, trend analysis, and observed co-infection rates. The higher number of samples in 2023 likely reflects increased healthcare utilization and laboratory activity following the COVID-19 pandemic. Therefore, temporal comparisons should be interpreted with caution,

as fluctuations in sample size may partly account for the observed trends.

It is important to note that the reported prevalence reflects individuals who underwent stool examination in a hospital setting and does not represent the general population. As a tertiary-care referral center, the study site may receive patients with specific clinical indications, which could introduce referral bias. Therefore, the findings should be interpreted with caution and may not be generalizable to the wider community.

It should be noted that the "Stable" classification is based on the absence of statistically significant change in our trend analysis, and small sample sizes in some years may limit detection of subtle fluctuations.

Our results support the implementation of comprehensive, multi-source surveillance strategies incorporating human, animal, soil, and water sampling across the province. Such approaches will enable identification of environmental contamination and zoonotic transmission pathways, demonstrating that environmental parasite load is a critical predictor of human infection risk.

Ultimately, strengthened monitoring, improved hygiene, and targeted public health interventions are urgently needed to mitigate the rising burden of intestinal protozoan infections in northern Algeria, particularly for high-risk populations and emerging species. These findings primarily reflect a hospital-based population and should be interpreted accordingly.

Our findings demonstrate a clear epidemiological shift in Tizi-Ouzou, with protozoan parasites, particularly *Blastocystis* spp. and *D. fragilis*, emerging as primary public health threats. These data emphasize the need for enhanced surveillance programs, molecular diagnostics for emerging protozoa, and targeted public health interventions, including hygiene promotion, water and food safety, and community education.

This study has several limitations. First, the retrospective data were obtained from symptomatic patients with gastrointestinal complaints rather than a population-based random sample, so the observed IPI prevalence may be overestimated and cannot be generalized to the general population, highlighting the need for population-based surveys to determine the true regional burden of IPIs. Second, laboratory records lacked consistent information on patients' prior antiparasitic treatment and IPI history, which could not be incorporated into the analysis. Third, residential data (urban/rural) were not systematically recorded, limiting residential subgroup analyses. Additionally, limited detailed clinical data prevented stratified assessments among vulnerable groups, including children, the elderly, and immunocompromised individuals. Furthermore, the reliance on conventional microscopy may underestimate protozoan prevalence and preclude parasite subtyping, while a lack of systematic clinical correlation restricts definitive judgments on the pathogenicity of detected parasites. Nevertheless, all eligible seven-year stool records were included without exclusion, minimizing selection bias. To address these limitations, further multicenter and prospective studies across different Algerian regions and healthcare settings, incorporating molecular diagnostics and environmental data, are required to better elucidate the transmission dynamics and risk factors of IPIs.

This study highlights a notable prevalence of IPIs in Tizi-Ouzou, affecting nearly one-third of the studied population. Protozoa accounted for the vast majority of infections, with *Blastocystis* spp. emerging as the predominant species. Adults and males were disproportionately affected, and outpatients exhibited higher prevalence, suggesting community-driven transmission.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval

This study was conducted using anonymized laboratory records, and no personal identifiers were accessed or collected. The study complied with institutional and national ethical standards for retrospective research. Ethical approval was obtained from the appropriate institutional review board of the Nedir Mohamed University Hospital Center (reference number 235/01/2020/DG). The requirement for informed consent was waived due to the retrospective nature of the study and the use of anonymized data, in accordance with the Declaration of Helsinki.

Data availability

Data will be made available on request.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

SY, OS and NAKT: editing, writing-original draft, visualization, data curation, conceptualization; IB and RB: data curation; ON, SS, NS: visualization, writing-review & editing, validation.

References

[1] Ahmed M. Intestinal parasitic infections in 2023. *Gastroenterol Res* 2023; **16**(3): 127-140.

[2] Herwaldt BL. Laboratory-acquired parasitic infections from accidental exposures. *Clin Microbiol Rev* 2001; **14**(4): 659-688.

[3] Wong LW, Ong KS, Khoo JR, Goh CBS, Hor JW, Lee SM. Human intestinal parasitic infection: A narrative review on global prevalence and epidemiological insights on preventive, therapeutic and diagnostic strategies. *Expert Rev Gastroenterol Hepatol* 2020; **14**(11): 1093-1105.

[4] Hataminejad M, Basirpour B, Baharlou M, Gholami KM, Ziaei HH, Rahimi EB, et al. Global prevalence and correlation of intestinal parasitic infections in patients with colorectal cancer: A systematic review and meta-analysis. *BMC Gastroenterol* 2025; **25**: 584.

[5] Kaminsky R, Mäser P. Global impact of parasitic infections and the importance of parasite control. *Front Parasitol* 2025; **4**: 1546195.

[6] Hechenbleikner EM, McQuade JA. Parasitic colitis. *Clin Colon Rectal Surg* 2015; **28**(2): 79-86.

[7] Torgerson PR, Devleesschauwer B, Praet N, Speybroeck N, Willingham AL, Kasuga F, et al. World Health Organization estimates of the global and regional disease burden of 11 foodborne parasitic diseases, 2010: A data synthesis. *PLoS Med* 2015; **12**(12): e1001920.

[8] World Health Organization. *Soil–transmitted helminth infections. WHO Fact Sheet. 2023.* [Online]. Available from: https://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections/. [Accessed on 25 December 2025].

[9] Abu-Madi M, Boughattas S, Behnke JM, Sharma A, Ismail A. Coproscopy and molecular screening for detection of intestinal protozoa. *Parasites Vectors* 2017; **10**: 414.

[10] Schmidlin T, Hürlimann E, Silué KD, Yapi RB, Houngbedji C, Kouadio BA, et al. Effects of hygiene and defecation behavior on helminths and intestinal protozoa infections in Taabo, Côte d'Ivoire. *PLoS One* 2013; **8**(6): e65722.

[11] Tagajdid R, Lemkhente Z, Errami M, El Mellouki W, Lmimouni B. Portage parasitaire intestinal chez l'enfant scolarisé à Salé, Maroc. *Bull Soc Pathol Exot* 2012; **105**(1): 40-45.

[12] Sebaa S, Behnke JM, Baroudi D, Hakem A, Abu-Madi MA. Prevalence and risk factors of intestinal protozoan infection in rural and urban southern Algeria. *BMC Infect Dis* 2021; **21**: 888.

[13] Ba O, Sy O, Mbareck AM, Mohamed Issa S, Fofana M, Sidi Baba W. Epidemiology of intestinal parasitosis in schoolchildren in Riyadh (Nouakchott). *Tunisie Med* 2024; **102**(10): 671-676.

[14] Kaswi N. Comparison of eosin, physiological saline and lugol solutions by using a native method for detection of all soil-transmitted helminths (STH). *Hayyan J* 2025; **2**(1): 5-11.

[15] Oguoma V, Ekwunife CA. The need for a better method: Comparison of direct smear and formol-ether concentration techniques in diagnosing intestinal parasites. *Internet J Trop Med* 2007; **3**(2): 1-6.

[16] Jayakody N, Gordon CA, Wickramasinghe N, Silva A, Wickramasinghe S, Weerakoon K. Diagnostic accuracy of nucleic acid amplification tests for human intestinal nematode infections: A systematic review and meta-analysis. *PLoS Negl Trop Dis* 2026; **20**(2): e0013974.

[17] Belkessa S, Ait-Salem E, Laatamna A, Houali K, Sönksen UW, Hakem A, et al. Prevalence and clinical manifestations of *Giardia intestinalis* and other intestinal parasites in Algeria. *Am J Trop Med Hyg* 2021; **104**(3): 910-916.

[18] Zamiche S. Prevalence and epidemiology of gastrointestinal parasitic infections in the Mitidja plain (Algeria). *Stud Health Sci* 2024; **5**(4): e11463.

[19] Benouis A, Bekkouche Z, Benmansour Z. Epidemiological study of human intestinal parasitosis in the Hospital of Oran (Algeria). *Int J Innov Appl Stud* 2013; **2**(4): 613-620.

[20] Boutahar M, Belaouni M, Ibrahimi A, Eljaoudi R, Aanniz T, Er-Rami M et al. Unveiling *Blastocystis* epidemiology in Morocco: Subtype diversity among clinical patients with and without gastrointestinal manifestations. *Parasitol Res* 2024; **123**: 273.

[21] Boutahar M, Belaouni M, Ibrahimi A, Eljaoudi R, Aanniz T, Er-Rami M. Prevalence of *Blastocystis* sp. in Morocco: Comparative assessment of three diagnostic methods and characterization of parasite forms in Jones' culture medium. *Parasite* 2023; **30**: 64.

[22] Poirier P, Wawrzyniak I, Vivarès CP, Delbac F, El Alaoui H. New insights into *Blastocystis* spp.: A potential link with irritable bowel syndrome. *PLoS Pathog* 2012; **8**(3): e1002545.

[23] Pietilä JP, Meri T, Siikamäki H, Tyyni E, Kerttula AM, Pakarinen L, et al. *Dientamoeba fragilis*: The most common intestinal protozoan in Helsinki (2007-2017). *Euro Surveill* 2019; **24**(29): 1800546.

[24] Frisan T. Co- and polymicrobial infections in the gut mucosa: The host-microbiota-pathogen perspective. *Cell Microbiol* 2021; **23**: e13279.

[25] Seid M, Yohanes T, Goshu Y, Jemal K, Siraj M. Effect of hand hygiene compliance during COVID-19 on intestinal parasitic infection in Ethiopia. *PLoS One* 2022; **17**(6): e0270378.

[26] Aydemir S, Torkamanian Afshar M, Şahin M, Tas Cengiz Z, Elasan S, Barlik F, et al. Impact of COVID-19 pandemic on intestinal parasite frequency: A retrospective study. *East J Med* 2023; **28**(1): 82-86.

[27] Palomo-Ligas L, Gutiérrez-Gutiérrez F. Impact of COVID-19 restrictions on gastrointestinal protozoal infections in Mexico. *Parasite* 2025; **32**: 52.

Publisher's note

The Publisher of the *Journal* remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Edited by Pan Y, Lei Y, Zhang Q