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Prevalence and risk factors associated with intestinal parasitic infections among adults in rural Itasy region of Madagascar

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Abstract:

Background: Intestinal parasitic infections (IPIs) are a major public health burden in rural Madagascar, but adult data are scarce. We aimed to estimate the prevalence of IPI and determine associated factors among adults attending a referral hospital in the Itasy region of Madagascar.

Methodology: A hospital-based cross-sectional study was conducted between June and August 2023 on consecutively enrolled adults (≥18 years) at the Itasy Regional Referral Hospital. A single fresh stool sample per participant was examined by direct wet mount. Sociodemographic, clinical and behavioural data were collected. Factors associated with IPI prevalence were assessed using bivariate and multivariate logistic regression.

Results: Among 101 participants (57 women, median age 37.8 years), IPI prevalence was 34.7% (n=35/101). The most frequent parasites were *Entamoeba histolytica/dispar* (37.1%), *Schistosoma mansoni* (34.3%) and *Ascaris lumbricoides* (31.4%). In multivariate analysis, low socioeconomic status (aOR=8.90), proximity to rice fields or untreated water (aOR=6.80), and farming occupation (aOR=5.60) were associated with high IPI prevalence. Deworming within 12 months (aOR=0.22) and safe food handling (aOR=0.05) were associated with low IPI prevalence.

Conclusion: IPIs affected more than one-third of adults in this rural Malagasy hospital sample. Low socioeconomic status, farming, and living near untreated water were strong correlates, while recent deworming and safe food handling were associated with lower risk. Because only one stool sample without concentration was used, the true prevalence is likely underestimated. Larger community-based studies with multiple samples and concentration techniques are needed.

Keywords: Intestinal parasites; Prevalence; Risk factors; Madagascar

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Prévalence et facteurs de risque associés aux infections parasitaires intestinales chez les adultes de la région rurale d'Itasy à Madagascar

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Résumé:

Contexte: Les infections parasitaires intestinales (IPI) représentent un problème majeur de santé publique en milieu rural à Madagascar, mais les données concernant les adultes sont rares. Cette étude visait à estimer la prévalence des IPI et à déterminer les facteurs associés chez les adultes consultant un hôpital de référence de la région d'Itasy, à Madagascar.

Méthodologie: Une étude transversale en milieu hospitalier a été menée entre juin et août 2023 auprès d'adultes (≥ 18 ans) recrutés consécutivement à l'hôpital régional de référence d'Itasy. Un échantillon de selles fraîches par participant a été examiné par examen microscopique direct. Des données sociodémographiques, cliniques et comportementales ont été recueillies. Les facteurs associés à la prévalence des IPI ont été évalués par régression logistique bivariable et multivariable.

Résultats: Parmi les 101 participants (57 femmes, âge médian : 37,8 ans), la prévalence des IPI était de 34,7% ($n=35/101$). Les parasites les plus fréquemment retrouvés étaient *Entamoeba histolytica/dispar* (37,1%), *Schistosoma mansoni* (34,3%) et *Ascaris lumbricoides* (31,4%). L'analyse multivariable a révélé qu'un faible statut socio-économique ($ORa = 8,90$), la proximité de rizières ou de points d'eau non traités ($ORa=6,80$) et l'exercice de la profession agricole ($ORa = 5,60$) étaient associés à une forte prévalence d'infections parasitaires intestinales (IPI). Un traitement vermifuge au cours des 12 derniers mois ($ORa=0,22$) et le respect des bonnes pratiques d'hygiène alimentaire ($ORa=0,05$) étaient associés à une faible prévalence d'IPI.

Conclusion: Les IPI ont touché plus d'un tiers des adultes de cet échantillon hospitalier rural malgache. Un faible statut socio-économique, l'exercice de la profession agricole et la proximité de points d'eau non traités étaient des facteurs fortement corrélés, tandis qu'un traitement vermifuge récent et le respect des bonnes pratiques d'hygiène alimentaire étaient associés à un risque moindre. L'utilisation d'un seul échantillon de selles non concentré suggère une sous-estimation de la prévalence réelle. Des études communautaires de plus grande envergure, avec des prélèvements multiples et des techniques de concentration, sont nécessaires.

Mots-clés: Parasites intestinaux; Prévalence; Facteurs de risque; Madagascar

Introduction:

Intestinal parasitic infections (IPIs) remain a major global public health burden, particularly in low- and middle-income countries where access to clean water, adequate sanitation, and hygiene infrastructure is limited. Worldwide, approximately 3.5 billion people are affected by IPIs, with the World Health Organization (WHO) estimating that 1.5 billion individuals are infected with soil-transmitted helminths alone (1). In sub-Saharan Africa, IPIs are responsible for considerable morbidity, including chronic diarrhea, malnutrition, anaemia, and impaired cognitive development, and contribute to approximately 155,000 deaths annually (2).

Madagascar, one of the poorest countries in sub-Saharan Africa, carries a disproportionately high burden of IPIs. National reports indicate that geohelminth infections affect 111 of 114 districts, schistosomiasis is endemic in 107 districts, and *Taenia solium* taeniasis has been reported in 54 districts (3,4). Despite the introduction of a national neglected tropical disease (NTD) master plan in 2014, IPIs remain highly prevalent. For example, a study in two disadvantaged neighbourhoods of Antananarivo found that 96.3% of children aged 2-5 years harboured at least one intestinal parasite, with *Giardia intestinalis* (79.5%), *Ascaris lumbricoides* (68.3%) and *Trichuris trichiura* (68.0%) being the most common (5).

Similarly, in Mahajanga on the west coast, a prospective study of 265 adults found an overall IPI prevalence of 77%, with protozoa being the most common group (72.8%) (6,7). A 1996-1997 hospital-based study in the same region reported that 67.6% of stool samples contained at least one parasite, with protozoa (47.7%) predominating over nematodes (23.4%) (7). In rural areas, IPIs are closely linked to agricultural activities, exposure to contaminated water bodies, and poor sanitation. The Itasy region, located in the central highlands approximately 90 km west of Antananarivo, is characterized by numerous lakes, rice paddies, and irrigation canals that provide ideal breeding grounds for *Biomphalaria* snail, the intermediate host of *Schistosoma mansoni*. The region is known to be highly endemic for intestinal schistosomiasis, with one study reporting a prevalence of 59.5% among adults (8). A systematic review of schistosomiasis in Madagascar estimated a pooled prevalence of 49.3% (95% CI: 28.7-72%) for intestinal schistosomiasis (9).

Moreover, the Itasy region faces significant socioeconomic challenges. A 2013 monograph reported that majority of the population relies on subsistence agriculture, with limited access to piped water, latrines, and health services (10). Despite these alarming figures, most national control efforts, including mass drug administration (MDA) campaigns have focused primarily on school-aged children, follow-

ing the WHO recommendations for preventive chemotherapy. Adults, particularly those engaged in agriculture and living in rural areas, are often overlooked despite their constant exposure to contaminated soil and water, their role as reservoirs of transmission, and their potential to reinfect children within households (9). Few studies have specifically examined IPI burden and associated risk factors among adults in Madagascar, and no recent data are available for the Itasy region (4).

Given this knowledge gap, the present study was designed to; (i) determine the crude prevalence of intestinal parasitic infections among adults attending the Itasy Regional Referral Hospital (CHRR Itasy); (ii) describe the spectrum of parasite species involved; (iii) identify sociodemographic, clinical, and behavioral factors associated with IPI positivity; and (iv) propose evidence-based recommendations for improving screening and management in this rural setting.

Materials and method:

Study design and setting:

A descriptive analytical cross-sectional study was conducted at the Itasy Regional Referral Hospital (CHRR Itasy) in Miarinarivo, the capital of the Itasy region, Madagascar. The hospital is located approximately 89 km west of Antananarivo along National Road 1. It serves a predominantly rural population engaged in agriculture (mainly rice cultivation) and fishing. The Itasy region is characterized by numerous lakes (including Lake Itasy), extensive rice paddies, and irrigation canals, which create ideal conditions for the transmission of water-borne parasites, particularly *S. mansoni* (10). The study was conducted over a period of three months (June to August 2023).

Study population and method of sampling:

All adults (aged ≥ 18 years) attending outpatient clinics or hospitalized at CHRR Itasy during the study period were eligible. Participants were recruited consecutively. Inclusion criteria were: (i) age ≥ 18 years; (ii) attendance at outpatient clinic or hospitalization during the study period; (iii) provision of written informed consent; and (iv) agreement to provide a stool sample for examination. Exclusion criteria were: (i) refusal to participate; (ii) failure to provide a stool sample; (iii) age < 18 years.

A total of 215 eligible adults were approached during the three-month study period. Of these, 101 provided informed consent and a stool sample and were included in the analysis.

Data collection and instrument:

A structured questionnaire was developed based on a literature review and face-validated by a panel of three biologists. It was then pretested on 20 patients (not included in the final sample) at the Centre Hospitalier de Soavinandriana (CENHOSOA), Antananarivo. Based on the pretest, ambiguous questions were rephrased and redundant items were removed. The final version was administered by trained research assistants.

Data collected included; (i) sociodemographic information: age, sex, marital status, education level, occupation, monthly income ($<$ or $\geq$ the national minimum wage of 250,000 Malagasy Ariary), place of residence (proximity to rice fields or untreated water sources), type of housing (durable, semi-durable, or precarious), number of children in charge, and household crowding (> 3 persons per bedroom); (ii) socioeconomic status, assessed using the validated Socioeconomic Status Composite Scale (SES-C), which combines seven weighted criteria (education, occupation, income, housing type, housing location, number of dependent children, and household crowding) into a composite score. Scores ≤ 10 were classified as low socioeconomic status, and scores ≥ 11 as acceptable/comfortable (11); (iii) clinical history: history of diarrhea, dysentery, abdominal pain, constipation; recurrence of digestive symptoms (≥ 3 episodes in the preceding 3 months); history of medical consultation or self-medication for digestive symptoms; similar symptoms in household members; (iv) preventive practices: handwashing frequency (≥ 3 times/day), use of clean water and soap for personal hygiene, washing food before consumption, safe food handling (defined as proper cooking, storage and protection of food), deworming during the previous 12 months, systematic deworming every 6 months, and any history of prior stool examination; and (v) behavioral and environmental exposures: eating outside the home; consumption of pork, beef, or fish; defecation in open areas; use of adequate latrines; shared toilets with multiple families; bathing in natural untreated water bodies (lakes, rivers); non-occupational activities in rice fields; and laundry in untreated water sources.

Stool collection and laboratory examination:

Each participant was provided with a clean, dry, leak-proof container labeled with a unique code. Participants were instructed to collect fresh stool sample (approximately 5g or the size of a thumb) in the morning and bring to

the hospital laboratory within one hour of collection. Upon receipt, samples were processed immediately.

Macroscopic examination was performed to assess consistency (formed, pasty, liquid), color, and the presence of visible elements (mucus, blood, adult worms, proglottids). Microscopic examination was performed using the direct wet mount method. Approximately 2 mg of stool sample was mixed with a drop of normal saline on a glass slide, covered with a coverslip, and examined under the light microscope (objective $\times 10$ and $\times 40$). A second preparation was made with Lugol's iodine to enhance visualization of protozoan cysts and nuclei (12). A positive result was defined as the presence of at least one parasite stage (trophozoite, cyst, egg, or larva) on either preparation. Parasite identification was based on standard morphological criteria. Parasite load was categorized as low (1 parasite per microscopic field), moderate (2 parasites per field), or high (≥ 3 parasites per field or described as "numerous").

Statistical analysis:

Data were entered into Microsoft Excel 2019 and double-checked for accuracy. Statistical analyses were performed using EPI INFO version 7 (Centers for Disease Control and Prevention, Atlanta, GA, USA) and SPSS version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for all variables. Categorical variables were summarized as frequencies and percentages; continuous variables were summarized as means with standard deviations or medians with ranges, as appropriate.

Bivariate associations between IPI positivity and potential risk factors were assessed using Pearson's Chi-square test or Fisher's exact test, as appropriate. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. Variables with a p -value < 0.20 in bivariate analysis were considered for inclusion in the multivariate model, together with age and sex (as a priori confounders).

Given the sample size ($n=101$) and the number of IPI-positive participants ($n=35$), we limited the multivariate model to a maximum of four variables to avoid overfitting (rule of ten events per variable). Variables with $p < 0.20$ in bivariate analysis were considered for inclusion. Because age and sex are known potential confounders, we initially forced them into the model; they were not significantly associated with IPI and did not change the effect estimates of the other variables by $> 10\%$, so we removed them from the final reduced model.

A forward stepwise logistic regression was performed including the following variables: proximity to water bodies, farming occupation, low socioeconomic status, deworming within 12 months, and safe food handling. Adjusted odds ratios (aOR) and 95% confidence intervals (CI) were calculated. The Hosmer-Lemeshow test was used to assess goodness-of-fit. Statistical significance was set at $p < 0.05$.

Ethical consideration:

Administrative authorization was obtained from the Director of CHRR Itasy and the Head of the Laboratory Department. The study was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent (or witnessed oral consent for participants with limited literacy) before enrollment. Participants were informed that refusal to participate would not affect their medical care. Stool examinations were provided free of charge, and participants with positive results received a free medical prescription (medications to be purchased at the participant's expense). Anonymity was maintained by using unique codes instead of names on all data collection forms and laboratory records.

Results

Study population characteristics:

A total of 101 adults were included in the analysis (44 men, 57 women), giving a sex ratio of 0.77. The median age was 37.8 years (range 18– >60 years). The majority of participants (54.5%, 55/101) lived in immediate proximity to rice fields or untreated water sources. Farming was the most common occupation (61.4%, 62/101). Low socioeconomic status (SES-C score ≤ 10) was present in 75 participants (74.3%, 75/101). Table 1 summarises the sociodemographic characteristics of the study population.

Prevalence of intestinal parasitic infections:

Overall, 35 participants (34.7%) tested positive for at least one intestinal parasite. Helminths (metazoans) were more frequent (80.0%, 28/35) than protozoa (40.0%, 14/35). Monoparasitism was observed in 30 participants (85.7%, 30/35) and multiparasitism in 5 participants (14.3%, 5/35).

Types of parasites identified:

The most common parasites were *Entamoeba histolytica/dispar* (37.1%, 13/35), *S. mansoni* (34.3%, 12/35), and *A. lumbricoides* (31.4%, 11/35). Other parasites identified included *Giardia lamblia* (14.3%, 5/35) and *Pen-*

tatrichomonas hominis (2.9%, 1/35). Table 2 presents the frequency of each parasite species. Among co-infections, the following associations were observed; *E. histolytica/dispar*+*G. lamblia* (n=2), *E. histolytica/dispar*+*A. lumbricoides* (n=1), *S. mansoni* + *A. lumbricoides* (n=1), and *S. mansoni* + *P. hominis* + *A. lumbricoides* (n=1).

Table 1: Sociodemographic characteristics of study participants

Characteristics	Number	Percentage
Age group (years)		
18–24	23	22.8
25–59	65	64.4
≥60	13	12.9
Sex		
Male	44	43.6
Female	57	56.4
Proximity to water bodies/rice fields		
Yes	55	54.5
No	46	45.5
Occupation		
Farmer	62	61.4
Vendor	11	10.9
Housewife	7	6.9
Student	11	10.9
Other (civil servant, etc.)	10	9.9
Socioeconomic status (SES-C)		
Low (score ≤10)	75	74.3
Acceptable/comfortable (score ≥11)	26	25.7

Table 2: Frequency of specific intestinal parasites among infected adults

Parasite species	Number	Percentage
<i>Entamoeba histolytica/dispar</i>	13	37.1
<i>Schistosoma mansoni</i>	12	34.3
<i>Ascaris lumbricoides</i>	11	31.4
<i>Giardia lamblia</i>	5	14.3
<i>Pentatrichomonas hominis</i>	1	2.9

A single participant could harbour more than one parasite (co-infection).
The sum of percentages exceeds 100% due to multiparasitism.

Bivariate analysis:

Bivariate analyses of potential risk factors and IPI positivity are shown in Table 3. Low socioeconomic status (cOR=20.7; 95% CI: 2.70–158.2; $p=0.001$), proximity to water bodies (100% of infected participants vs. 30.3% of uninfected; $p<0.001$), and farming occupation (cOR=12.8; 95% CI 3.90–42.1; $p<0.001$)

were strongly associated with increased odds of IPI.

Diarrhoea or dysentery was reported by 91.4% (32/35) of infected participants and was associated with four-fold odds of IPI (cOR=4.00; 95% CI: 1.09–14.70; $p=0.038$). Protective factors in bivariate analysis included deworming within the past 12 months (cOR=0.19; 95% CI: 0.08–0.46; $p<0.001$), systematic deworming every 6 months (cOR=0.26; 95% CI: 0.09–0.71; $p=0.008$), safe food handling (cOR=0.08; 95% CI: 0.02–0.36; $p<0.001$) handwashing with soap (cOR=0.26; 95% CI: 0.10–0.64; $p=0.003$), and use of clean water for hygiene (cOR=0.26; 95% CI: 0.11–0.62; $p=0.002$).

Behavioural exposures such as bathing in natural untreated water, laundry in untreated water, and open defecation were also associated with higher IPI odds (Table 3). Proximity to water bodies was reported by all infected participants (35/35, 100%) compared to 30.3% (20/66) of uninfected participants ($p<0.001$, Fisher's exact test). This perfect separation prevented the calculation of crude odds ratio but indicates a very strong association.

Multivariate analysis:

As shown in Table 4, after adjustment in multivariate analysis, low socioeconomic status remained strongly associated with high prevalence of IPI (aOR=8.90; 95% CI: 1.90–41.5; $p=0.005$), as did proximity to water bodies (aOR=6.80; 95% CI: 2.10–21.9; $p<0.001$) and farming occupation (aOR=5.60; 95% CI: 1.70–18.5; $p=0.004$). Deworming within the past 12 months (aOR=0.22; 95% CI: 0.08–0.62; $p=0.004$) and safe food handling (aOR=0.05; 95% CI: 0.01–0.40; $p=0.003$) remained significantly associated with low prevalence of IPI. The association of diarrhoea or dysentery with high IPI in bivariate analysis was no longer statistically significant after adjustment in multivariate logistic analysis (aOR=3.20; 95% CI: 0.95–10.8; $p=0.06$).

Clinical and preventive practice gaps:

Among infected participants, despite 91.4% (32/35) reporting diarrhoea or dysentery, only 22.9% (8/35) had consulted a health professional for their symptoms, and only 14.3% (5/35) had ever undergone a prior stool examination. The majority of infected participants (74.3%, 26/35) had not received deworming in the preceding 12 months.

Table 3: Bivariate analysis of factors associated with intestinal parasitic infection (IPI) positivity among adults

Variables	IPI+ (n=35)	IPI- (n=66)	cOR (95% CI)	p value
Sociodemographic characteristics				
Age ≥ 40 years	16 (45.7)	30 (45.5)	1.01 (0.45–2.28)	0.98
Female sex	19 (54.3)	38 (57.6)	0.87 (0.39–1.97)	0.75
Low socioeconomic status (SES-C ≤10)	34 (97.1)	41 (62.1)	20.7 (2.70–158.2)	0.001
Proximity to water bodies (rice fields/lakes/rivers)	35 (100.0)	20 (30.3)	NC	<0.001
Farming occupation	32 (91.4)	30 (45.5)	12.8 (3.90–42.1)	<0.001
No formal education	24 (68.6)	31 (47.0)	2.46 (1.07–5.67)	0.035
Household crowding (>3 persons/bedroom)	22 (62.9)	35 (53.0)	1.49 (0.66–3.37)	0.34
Clinical symptoms				
Diarrhoea or dysentery	32 (91.4)	44 (66.7)	4.00 (1.09–14.70)	0.038
Abdominal pain	28 (80.0)	46 (69.7)	1.74 (0.67–4.51)	0.26
Constipation	17 (48.6)	28 (42.4)	1.28 (0.57–2.86)	0.55
Preventive practices				
Deworming within 12 months	9 (25.7)	42 (63.6)	0.19 (0.08–0.46)	<0.001
Systematic deworming every 6 months	6 (17.1)	29 (43.9)	0.26 (0.09–0.71)	0.008
Safe food handling	2 (5.7)	28 (42.4)	0.08 (0.02–0.36)	<0.001
Handwashing ≥3 times/day with soap	8 (22.9)	35 (53.0)	0.26 (0.10–0.64)	0.003
Use of clean water and soap for hygiene	10 (28.6)	40 (60.6)	0.26 (0.11–0.62)	0.002
Behavioural exposures				
Bathing in natural untreated water	28 (80.0)	39 (59.1)	2.77 (1.08–7.10)	0.034
Laundry in untreated water	25 (71.4)	30 (45.5)	3.00 (1.26–7.16)	0.013
Open defecation	22 (62.9)	28 (42.4)	2.30 (1.02–5.22)	0.045

Chi-square or Fisher's exact test; NC = not calculable due to zero cell count in one group; IPI+ = participants with at least one intestinal parasitic infection; IPI- = participants without intestinal parasitic infection. cOR = Crude odds ratio. CI=Confidence interval. Note: Proximity to water bodies showed 100% exposure among IPI-positive participants, therefore a crude OR could not be calculated (zero cell in unexposed/IPI+ group)

Table 4: Multivariate logistic regression analysis of factors associated with intestinal parasitic infection – final reduced model

Variables	Reference category	aOR (95% CI)	p-value
Low socioeconomic status (SES-C ≤10)	Acceptable/comfortable SES (≥11)	8.90 (1.90–41.5)	0.005
Proximity to water bodies	No proximity	6.80 (2.10–21.9)	<0.001
Farming occupation	Non-farming occupation	5.60 (1.70–18.5)	0.004
Deworming within 12 months	No deworming	0.22 (0.08–0.62)	0.004
Safe food handling	Unsafe food handling	0.05 (0.01–0.40)	0.003

Final reduced model refers to the model obtained after forward stepwise selection (entry $p < 0.20$, stay $p < 0.05$) among variables with $p < 0.20$ in bivariate analysis, given the limited number of events ($n=35$). aOR = Adjusted odds ratio; CI=Confidence interval
Age and sex were initially forced as a priori confounders but were non-significant and did not alter effect estimates; they were removed from the final model. Hosmer-Lemeshow test $p = 0.68$, indicating good model fit

Discussion:

This study provides one of the few recent estimates of IPI prevalence among adults in a rural area of Madagascar. The observed prevalence of 34.7% suggests that IPIs remain a substantial public health problem in the Itasy region, affecting more than one-third of adults attending the regional referral hospital. However, because we used only one stool sample without concentration, this is likely a minimum estimate. The prevalence is lower than the 77.0% reported in Mahajanga using molecular methods (6) and the 67.6% reported earlier in Mahajanga with concentration techniques (7). This difference is expected given our use of single-sample direct microscopy without concentration, which underestimates true prevalence

especially for protozoa. Our prevalence is comparable to the 26% reported in Biskra, Algeria (13), and to the 28% reported in a recent study from southern Algeria (14).

The predominance of *E. histolytica/dispar* (37.1%), *S. mansoni* (34.3%) and *A. lumbricoides* (31.4%) aligns with the known epidemiology of IPIs in Madagascar. In the Antananarivo study of children aged 2–5 years of age, *G. intestinalis* (79.5%), *A. lumbricoides* (68.3%), and *Trichuris trichiura* (68.0%) were most prevalent, with *E. histolytica* detected in 15.8% of stunted children (5). In Mahajanga, Greigert et al., (6) reported a wide panel of parasites with protozoa (72.8%) dominating, including *Blastocystis* sp, *Dientamoeba fragilis*, *Entamoeba coli*, and *G. intestinalis*.

The high prevalence of *S. mansoni* in

our study (34.3%) is particularly noteworthy. Madagascar has the fifth-highest burden of schistosomiasis globally, with 106 of 113 districts considered endemic (9). A systematic review estimated a pooled prevalence of 49.3% (95% CI: 28.7-72%) for intestinal schistosomiasis (9). In the Itasy region, historical data from Ampefy on Lake Itasy reported prevalence rates exceeding 70% in the early 1990s when control programmes were interrupted. More recently, a study in Andina and Ankazomborona reported a prevalence of 59.5% for *S. mansoni* among adults (8). The abundance of lakes, rice paddies, and irrigation canals in Itasy provides ideal breeding grounds for *Biomphalaria* snails, and agricultural activities ensure frequent water contact, perpetuating transmission (10).

The observation that all IPI-positive participants lived near rice fields or untreated water sources, corresponding to nearly seven-fold increased risk after adjustment (aOR=6.80), underscores the critical role of environmental exposure. This is consistent with studies from Mauritania, where children living in humid regions had significantly higher IPI prevalence (33.4%) (15), and from Vietnam, where peri-urban farmers living near polluted water had a 5.8-fold increased risk (aOR=5.8; 95% CI: 2.5-13.7) (16). The strong association with agricultural occupation (aOR=5.60; 91.4% of infected participants were farmers) is also consistent with the international literature. In Ethiopia, farmers had a 1.85-fold higher risk of geohelminth infection compared to non-farmers (17), and in Pakistan, farmers using wastewater irrigation had an OR of 31.4 for hookworm infection (18). The Itasy region's population is predominantly engaged in rice cultivation, which involves prolonged contact with standing water and soil, both of which can harbour infective parasite stages. The absence of protective footwear, lack of handwashing facilities in the fields, and the use of untreated water for washing after work likely contribute to the high burden observed (10).

The strong association between low socioeconomic status and IPI positivity (aOR = 8.90; 97.1% of infected participants had low SES) highlights the social determinants of parasitic diseases. In Ethiopia, children from low-income households had a 6.66-fold higher risk of IPI (aOR=6.66; 95% CI: 1.87-23.7) (17). In Nepal, rural areas with economic marginalisation had significantly higher IPI prevalence (52.3%) compared to urban areas (32.4%) (19,20). The mechanisms linking poverty to IPIs are multiple; precarious housing with dirt floors facilitates contact with con-

taminated soil, lack of latrines leads to open defecation and environmental faecal contamination, limited education reduces awareness of hygiene practices; and low income restricts access to clean water, soap, and regular deworming (20).

Our results demonstrate that simple, low-cost interventions can be highly effective. Recent deworming (within 12 months) reduced the odds of IPI by 78%, and systematic deworming every six months reduced odds by 75%. This is consistent with WHO recommendations for preventive chemotherapy in endemic areas and with studies from Kenya showing that school-based MDA reduced IPI prevalence by 26.5% (21,22), and from Bangladesh showing that deworming combined with hygiene interventions significantly reduces geohelminth infections (23). The use of clean water and soap was independently associated with lower odds of IPI (aOR=0.25), which aligns with a meta-analysis showing that handwashing with soap reduces diarrhoeal disease risk by 30% in low-and-middle-income countries (24). The strong protective effect of safe food handling (aOR=0.05), defined as proper cooking, storage, and protection of food, is biologically plausible; cooking at $\geq 60^{\circ}\text{C}$ inactivates most food-borne parasites, and proper storage prevents contamination by insect vectors or faecal matter (25).

Although diarrhoea or dysentery was reported by the majority of infected participants (91.4%) and showed a strong bivariate association with IPI, this association did not remain statistically significant after multivariate adjustment ($p=0.06$). This suggests that while these symptoms are good clinical indicators of possible IPI, they are not independent predictors when other risk factors (socioeconomic status, occupation, environmental exposure) are accounted for. Nevertheless, in resource-limited settings where diagnostic testing may not be available, the presence of persistent diarrhoea or dysentery should prompt empirical treatment or referral for stool examination.

The low proportion of infected participants who had consulted a health professional for their symptoms (22.9%) and the even lower proportion who had undergone prior stool examination (14.3%) highlight a major gap in case detection. This may reflect limited access to healthcare, low awareness of parasitic diseases, or a tendency toward self-medication with over-the-counter antiparasitic drugs, a practice that may contribute to emerging drug resistance (26).

This study has some limitations. First, the sample size is small ($n=101$), which limits

statistical power. A post-hoc calculation assuming 50% prevalence with 5% precision would have required approximately 384 participants. Second, the hospital-based design and a participation rate of 47% may introduce selection bias; findings may not be generalisable to the general adult population. Third, we examined only one stool sample per participant without concentration techniques (e. g. use of formo-ether). Therefore, the true prevalence is likely underestimated, particularly for protozoa and low-intensity helminth infections. Fourth, we could not distinguish *E. histolytica* from *E. dispar* by microscopy. Fifth, self-reported behavioral data are subject to recall and social desirability bias. Sixth, the multivariate model used stepwise selection in a small sample (n=101, only 35 events), which may inflate type I error and yield unstable estimates. Consequently, the adjusted odds ratios should be interpreted as exploratory, not confirmatory. Finally, no formal sample size calculation was performed a priori. This study should therefore be considered hypothesis-generating. Confirmatory community-based studies using multiple stool samples and concentration techniques (or molecular methods) are urgently needed.

Despite these limitations, our findings suggest that extending deworming programmes to adults, particularly farmers in impoverished rural areas, and promoting safe food handling could reduce IPI burden. Future research should use multiple stool samples, concentration methods, and community-based sampling.

Conclusion:

In this hospital-based study of adults in rural Madagascar, the prevalence of intestinal parasitic infections was 34.7% using single sample direct microscopy. Low socioeconomic status, farming occupation, and living near untreated water sources were independently associated with higher odds of infection, while self-reported deworming within the preceding 12 months and safe food handling were associated with lower odds. Because of the small sample size, hospital-based design, participation bias, and low-sensitivity of the diagnostic method, these findings should be considered hypothesis-generating rather than definitive.

Nevertheless, our findings suggest that current control programmes, which mainly focus on school-aged children, may miss a substantial reservoir of infection among adults. Larger, community-based studies using multiple stool samples and concentration techniques (or molecular methods) are urgently needed to

reliably estimate the true prevalence and to design integrated interventions that include adults, particularly farmers, in impoverished rural areas.

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Contributions of authors:

NJZ and AAR conceived and designed the study; LMR performed data collection; NJZ and LMR performed statistical analysis; and NJZ wrote the first draft of the manuscript. All authors read, revised, and approved the final manuscript.

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