JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Original Article

Intestinal parasites and sexually transmitted infections in a socially vulnerable rural community in southern Bahia, Brazil

Nilo MPV Barreto[1], Marina MB Farias[1], Weslei AC Araújo[1], Joelma N de Souza[1], Cíntia de L Oliveira[1], Larissa M Sampaio[1], Alex B da S Souza[1], Noilson LS Gonçalves[2], Bernardo Galvão-Castro[2], Márcia CA Teixeira[1], Neci M Soares[1]

[1] *Department of Clinical and Toxicological Analysis, Faculty of Pharmacy, Federal University of Bahia-UFBA, Salvador, BA, Brazil*
[2] *Bahiana School of Medicine and Public Health (EBMSP), Center for Integrative and Multidisciplinary Care for HTLV Patients, Salvador, Brazil*

Abstract

Introduction: Intestinal parasites and sexually transmitted infections (STI) are frequent among people living in conditions of social vulnerability. The aim of this study was to investigate the prevalence of parasitic infections, STIs (human T lymphotropic virus (HTLV), human immunodeficiency virus, hepatitis B virus, hepatitis C virus, and *T. pallidum*/syphilis) in the residents of a rural community in southern Bahia, Brazil.
Methodology: The study was conducted from March 2018 to September 2019, and 88.8% of residents of the rural community (n = 223/251) participated. Diagnosis was performed by parasitological examination and by detection of specific antibodies in sera. Data on socioeconomic and health conditions were obtained with a questionnaire.
Results: The prevalence of parasitic infection was 73.9%. *Trichuris trichiura* (26.9%) and *Ascaris lumbricoides* (25.6%) were the most frequent, with a higher occurrence in children and adolescents ($p < 0.05\%$). The prevalence of anti-*Strongyloides stercoralis* antibodies (22.9%) was about 3 times higher than the presence of larvae in feces (7.2%; $p < 0.05\%$). Seroprevalence for STI was 19.3%, mostly syphilis (11.7%) in the elderly participants ($p < 0.05\%$), followed by HTLV-1 (8.1%; 18/223). The co-infection rate of *S. stercoralis* and HTLV-1 was 1.3% (3/223), based on parasitological diagnosis alone, but when the detection of IgG4 anti-*S. stercoralis* was considered, it increased to 6.7% (15/223).
Conclusions: Illnesses associated with poverty, such as intestinal parasite infections and STI, trigger a vicious cycle of socioeconomic exclusion and persistent poverty. Therefore, it is essential to break the social determinants that perpetuate both poverty and diseases.

Key words: *Strongyloides stercoralis*; HTLV-1; coinfection; rural population; social vulnerability.

J Infect Dev Ctries 2025; 19(7):1121-1131. doi:10.3855/jidc.20121

(Received 17 March 2024 – Accepted 05 December 2024)

Introduction

Intestinal parasitic infections are considered an important public health issue, especially in developing countries where sanitary conditions are often precarious, particularly in tropical and subtropical climates [1]. It is estimated that out of the 3.5 billion people infected with intestinal parasites, 155,000 die annually [2]. The geohelminths stand out among enteroparasites in areas with hot and humid climates. These climates are suitable for the development of parasitic cycles that infect approximately 1.5 billion people, corresponding to about 24% of the world's population [3].

Strongyloides stercoralis affects approximately 613 million individuals worldwide [3,4] and is noteworthy among the helminths for developing severe forms of strongyloidiasis. Hyperinfection can be disseminated among individuals with compromised immunity (such as those infected with human T-cell lymphotropic virus type 1 – HTLV-1), those taking high doses of glucocorticoid therapy for prolonged periods, and alcoholics [5–7]. The diagnosis of *S. stercoralis* infection is usually performed by searching for larvae in fresh feces, using agar plate culture and Baermann-Moraes methods, which are more sensitive than other parasitological diagnostic methods [8,9]. The most commonly used method for antibiotic detection has been the indirect enzyme-linked immunosorbent assay (ELISA) using semi-purified antigens. ELISA exhibits a sensitivity of around 82.5% and a specificity of around 95%, while also allowing the testing of several samples simultaneously [7–12]. A recent study conducted by our group demonstrated that among the classes and subclasses of circulating anti-*S. stercoralis* antibodies tested (IgG, IgG1, IgG4, IgE, and IgA1) by ELISA, and IgG4, there existed the greatest potential for the diagnosis of strongyloidiasis, with a sensitivity and specificity of 96% and 93%, respectively [6].

Another group of diseases of importance to public health are the sexually transmitted infections (STI). These diseases are caused by various microorganisms, which affect more than 1 million people worldwide. Besides a low socioeconomic status, vulnerable rural populations face specific challenges that increase the risk of STI infections, such as limited, or lack of, sexual health care [11,12].

One of the most notable STIs is HTLV-1, which is distributed globally and affects 15 to 20 million people [13–15], with Brazil having the highest absolute number of cases of approximately 800,000 people [13]. HTLV-1 transmission can occur through sex (60% of transmissions, predominantly from man to woman), through blood (sharing syringes, contaminated needles, and blood transfusions), and vertical transmission (from mother to child, mainly during pregnancy and breastfeeding) [16,17]. It can also occur, less frequently, through organ transplants from infected donors [13,16].

The CD4+ helper T cells (Th) can be divided into two subgroups, type I helper T lymphocytes (Thl) and type II helper T cells (Th2). The Th2 response is host protective, reducing the number of parasites either through direct killing in the tissues, or expulsion from the intestine [18]. The association between *S. stercoralis* and HTLV-1 infections was first reported in Okinawa, Japan, in 1984 [19], and since then, several studies have reported cases of hyperinfection and dissemination by *S. stercoralis* in patients with HTLV-1 [7,14,20–21], resulting from the modulation of the Th2-type cellular immune response [20,22]. The adaptive immune system in *S. stercoralis* infection specifically stimulates Th2 cell responses, secreting IL-4, IL-5, and IL-13, which act in host defense [20]. Conversely, HTLV-1 infection generally stimulates increased production of cytokines, such as interferon-gamma (IFN-γ) and tumor necrosis factor-alpha (TNF-α), which can negatively modulate the immunoprotective Th2 response to *S. stercoralis* [7,20].

Syphilis is a systemic, reemerging bacterial STI caused by *Treponema pallidum*. It is estimated that approximately 7.1 million adults aged 15 to 49 years were infected worldwide in 2020 [23]. According to the Notifiable Diseases Information System (SINAN), between 2011 and 2021, 1,035,942 cases of acquired syphilis were reported in Brazil, with 167,523 cases reported only in 2021. Syphilis is a highly infectious disease, whose symptoms may go unnoticed by the carrier. However, if left untreated, it can result in severe clinical conditions such as neurosyphilis. Additionally, it can also cause complications in pregnancy, childbirth, and children's health, including fetal death [24].

The correlation between STIs and intestinal parasitic infections is a growing public health challenge that significantly affects vulnerable communities. Coinfection, such as with HTLV-1 and *S. stercoralis*, can lead to synergistic effects, where the immune response to one infection can influence the susceptibility or severity of another. Individuals with coinfection tend to develop more severe forms of these diseases, which can result in situations of hyperinfection and spread, generating an increase in morbidity and mortality. Therefore, the joint analysis of these themes is crucial to improve the understanding of related risks and to create more efficient diagnostic and intervention strategies.

Vulnerability can be understood as economic and social inequality; the result of historical and cultural prejudices that place groups and individuals in socially fragile positions, which require greater protection through the implementation of public policies to reduce social inequality, improving living conditions for populations, and consequently, decrease diseases linked to poverty. Therefore, this study aimed to investigate the prevalence of STIs (HTLV-1/2; human immunodeficiency virus – HIV-1/2, Hepatitis B Virus – HBV, Hepatitis C Virus – HCV, and *T. pallidum*/syphilis), intestinal parasitic infections, and co-infection between *S. stercoralis* and HTLV-1 in a rural community (RC) in the southern part of the state of Bahia in Brazil.

Methodology

Study design and samples

This was an epidemiological, descriptive, and cross-sectional study carried out from 1 March 2018 to 30 September 2019 in the Zumbi dos Palmares Settlement (SZP), an RC, composed by 251 residents, distributed in 50 families. The SZP is located about 12 km from the municipality of Camamu, Bahia, Brazil, covering an area of 400 hectares, with restricted access to public transport to the city. Most residents are related to some degree, and many of them receive Brazilian government aid. In addition, there is a high flow of temporary migrants to other states in the country during the sugarcane and garlic harvest season, as an alternative to increasing family income. The environmental conditions in this area are characterized by sandy soil which is rich in organic matter, and a hot and humid climate with year-round rainfall.

All residents of the SZP rural community were invited to participate in the study, although, not all were included due to undelivered fecal samples or refusal to participate. The final population studied was 223/251 (88.8%).

The minimum sample size was calculated using the open-source software OpenEpi, version 3.01 for Windows 11. The sample size was calculated considering the total population of 251 residents, expected frequency of 50%, confidence interval of 95.0%, design effect equal to 1, maximum error of 5%, power of 80%, and additional loss of 20%. Based on these parameters, the minimum sample size established was 184 individuals.

Fecal and sera samples were collected from the 223 study participants for parasitological diagnosis of intestinal parasites, and immunological diagnosis of STIs (HTLV-1/2, HIV-1/2, HBV, HCV, and *T. pallidum* infection/syphilis) and *S. stercoralis* infection by detecting specific antibodies. Information on socioeconomic, health, and educational conditions was obtained through an epidemiological questionnaire.

Parasitological diagnosis

Three samples of fresh feces from each individual were examined, collected at intervals of 30 days, during visits to SZP, using different methods: spontaneous sedimentation [25], Baermann-Moraes [26], and agar plate culture (APC) [27].

Serology for detection of IgG4 anti-S. stercoralis

<u>Antigenic extract of filariform larvae of *Strongyloides venezuelensis*</u>

The antigenic extract was produced from filariform larvae of *S. venezuelensis* recovered from the feces of Wistar rats (*Rattus norvegicus*), provided by the Department of Parasitology, University of Campinas. The larvae were briefly thawed and sonicated using an ultrasound device (Branson Sonifier Cell Disruptor, Branson Ultrasonics, Danbury, USA) with 62 cycles of 3 minutes each at 60 Hz, followed by a 2 minute rest, under cooling conditions, in an ice bath. The material was observed under a microscope to confirm complete larvae rupture. Subsequently, the material was centrifuged twice at 5000 x g for 60 minutes at 4 °C. The protease inhibitors, EDTA 5 mM, phenyl-methylsulfonyl fluoride (PMSF) 1 mM, 0.05 mM Tosyl-L-phenylalanine-chloromethylketone (TPCK/TLCK), and 1 mg/mL leupeptin, were added to the supernatant (soluble antigen) and aliquots were stored at – 20 °C. The pellet was re-suspended in 1% sodium deoxycholate (5 mL) and incubated overnight in a cold chamber (at 4 ºC) under agitation. On the following day, the material was centrifuged at 5000 x g for 60 minutes at 4 ºC, and the supernatant (membrane antigen), containing protease inhibitors, was stored at – 20 ºC. Protein contents were measured using the Lowry method [28].

<u>ELISA for detection of IgG4 anti-*S. stercoralis*</u>

Microtiter plates (96-well plates, Corning Inc. Costar polystyrene EIA/RIA plates, Corning, NY, USA) were sensitized by adding 100 µL of *S. venezuelensis* membrane antigen to each well, at a concentration of 5 µg/mL, and diluted in 0.06 M bicarbonate carbonate buffer, pH 9.6. The plates were incubated overnight (18 hours) at 4 ºC and washed 4 times with 0.15M phosphate buffer saline (PBS) containing 0.05% tween, pH 7.2, and then washed once with 0.15M PBS. 100 µL of serum sample diluted 1:4 in 0.15M PBS, pH 7.2, containing 5% w/v skimmed milk (blocking buffer) was added to each well, and the plates were incubated under orbital agitation at 500 rpm for 30 minutes at room temperature. After washing, as in the previous step, 100 µL of anti-IgG4 conjugate (Invitrogen, Carlsbad, CA, USA) diluted 1:200 in blocking buffer was added to the wells, and the plates were incubated as above. After washing as in the previous steps, the reaction was revealed with the addition of 100 µL of 3,3',5,5'-tetramethyl-benzidine (TMB) substrate (IndProdBiotec Ltda, São Paulo, Brazil), followed by incubation under agitation at 500 rpm for 15 minutes. The reaction was interrupted with 30 µL/well of 8N sulfuric acid, and the optical densities were measured in a spectrophotometer (Awareness Technology Inc., Palm City, FL, USA) at 450–630 nm [10]. The cutoff point for the assay's sensitivity and specificity was established using the receiver operating characteristic (ROC) curve; utilizing 35 sera from mono-infected individuals infected with *S. stercoralis*; 30 sera from healthy adult individuals with negative parasitological tests; and 20 sera from individuals infected with other intestinal parasites, including *Schistosoma mansoni* (n = 5), hookworms (n = 5), *Enterobius vermicularis* (n = 4), *Trichuris trichiura* (n = 3), and *Ascaris lumbricoides* (n = 3).

Evaluation of S. stercoralis infection in family groups

Individuals who had at least 1 positive instance of *S. stercoralis* infection (diagnosed by the presence of larvae in the stool and/or by the detection of anti-*S. stercoralis* IgG4 in sera) were grouped into family groups to assess the risk of helminth infection among relatives living in the same residence.

Diagnosis of STIs

HTLV-1/2 and HIV-1/2 diagnoses were performed using microparticle chemiluminescence and/or ELISA, respectively (Architect system, Abbott Diagnostics, Abbott Park, IL, USA) and confirmed by Western blot (MP Biomedicals Asia Pacific, Singapore, Singapore). Hepatitis B was diagnosed by an automated ELISA (HBsAg and HBeAg tests). Serology for hepatitis C antibodies was performed by chemiluminescence (Architect anti-HCV assay, Abbott Diagnostics, Abbott Park, IL, USA). The treponemal test was adopted for syphilis, using the chemiluminescence *Treponema* screen (Diasorin®, São Paulo, Brazil), and confirmed by the non-treponemal venereal disease research laboratory (VDRL) test, with titration of sera.

Statistical analysis

Data were analyzed using the statistical program IBM SPSS software (version 23.0 for Windows, IBM Corp, Armonk, NY, USA). Quantitative variables were presented as measures of central tendency and dispersion, while categorical variables were presented as absolute and relative frequencies. Pearson's Chi-square or Fisher's exact tests were employed to test the associations between intestinal parasites and STI outcomes, individually, with the independent variables of interest. A statistical significance level of 5% was adopted. Differences between means were evaluated using the t test to compare two groups or analysis of variance (ANOVA) to compare three or more groups. The prevalence ratio (PR) was used with respective 95% confidence intervals in order to measure the magnitude of the associations.

The Kappa coefficient was used to assess the agreement of ELISA methods for detecting anti-*S. stercoralis*, in relation to the parasitological examination, and interpretation of the concordance between the methods was performed according to Landis and Koch [29].

GraphPad 9.0 (GraphPad Software Inc., San Diego, USA) was utilized to evaluate the values of the ELISA index, which were subjected to the two-graph receiver operating characteristic (TG-ROC) analysis, simultaneously evaluating sensitivity and specificity values. ELISA index values above the optimal reaction point were considered positive.

Ethical aspects

The study complied with the recommendations of resolution no. 466, dated 12 December 2012, of the National Research Council, for the conduct of research involving human subjects. All individuals who agreed to participate in the study signed the free and informed consent form, or the free and informed assent form for minors. This project was approved (approval number 2616338) by the Research Ethics Committee of the Faculty of Pharmacy at the Federal University of Bahia (UFBA).

Results

Out of the 251 individuals in the RC, 88.8% (n = 223) participated in the study. Among them, 50.2% (112/223) were female, and 39.0% (87/223) belonged to the 0–19 years age group (children and adolescents). The average age was 30.17 ± 20.66 years, and the age range was from 1 to 80 years. Approximately 94.2% (210/223) declared themselves as black/brown; and the majority, 60.1% (134/223), did not have a spouse/partner. About 56.5% (126/223) had studied up to elementary school, and 49.8% (111/223) stated that they received up to one-quarter of the Brazilian monthly minimum wage (approximately USD 50.00). The main work activity declared by the residents was rural work (58.3%; 130/223), and the average number of members per family was 3.25 ± 1.47 individuals (Table 1).

The prevalence of infection by intestinal parasites was 73.1% (163/223). Among the parasitized individuals, 57.7% (94/164) who reported drinking water from the local river without any treatment, showed a greater predisposition to parasitic infections (p = 0.006; PR: 1.34; confidence interval (CI): 1.01–1.80). Other variables such as absence of a septic tank at home (p = 0.022; PR: 1.19; CI: 1.02–1.39), absence of a bathroom at home (p = 0.025; PR: 1.20; CI: 1.03–1.40), and keeping the garbage until collection (once in a month) (p = 0.046; PR: 1.25; CI: 1.05–1.50) were significantly related to parasitic infections (Table 1).

The prevalence of STI was 19.3% (43/223), with the mean age of infected individuals being 38.21 ± 22.14 years (p = 0.004), and the mean number of residents in the same household was 3.84 ± 1.52 (p = 0.003); both values were higher in the infected group. The prevalence of STI was 3 times higher in the above 60 years age group than in other age groups (p = 0.034, PR: 2.75; CI: 1.36–5.54) (Table 1).

Among the individuals infected with enteroparasites, 23.8% (53/223) were monoparasitized, and 49.3% (110/223) were polyparasitized, with the mean number of parasite species higher in children and adolescents (2.06 ± 1.72) than in other age groups (p = 0.030). The most frequent potentially pathogenic parasites were *T. trichiura* 26.9% (60/223) and *A. lumbricoides* 25.6% (40/223), with a higher prevalence in children and adolescents ($p \leq 0.0001$ and p = 0.022,

Table 1. Parasitic and sexually transmitted infections in individuals of a rural community of Camamu, Bahia, Brazil, according to their sociodemographic and lifestyle characteristics (N = 223).

	Enteroparasites					STI			
	Total N = 223 (100%)	**Positives N = 163 (73.1%)**	***p* value***	**PR**	**CI 95%**	**Positives N = 43 (19.3%)**	***p* value**	**PR**	**CI 95%**
Gender									
Female	112 (50.2)	76 (46.6)	0.052	1.00	–	24 (55.8)	0.259	1.00	–
Male	111 (49.8)	87 (53.4)		1.12	0.95–1.32	19 (44.2)		0.99	0.94–1.05
Age (years)									
0–19	87 (39.0)	66 (40.5)	0.607	1.00	–	12 (27.9)	**0.034**	1.00	–
20–39	66 (29.6)	45 (27.6)		0.88	0.63–1.28	11 (25.6)		1.20	0.56–2.56
40–59	41 (18.4)	29 (17.8)		0.98	0.62–1.56	9 (20.9)		1.59	0.72–3.47
60+	29 (13.0)	23 (14.1)		0.98	0.60–1.58	11 (25.6)		2.75	1.36–5.54
Middle aged	30.17 ± 20.66	30.40 ± 20.10	0.782	–	–	38.21±22.14	**0.004**	-	–
Skin color									
White	13 (5.8)	5 (3.1)	**0.004**	1.00	–	1 (2.3)	0.245	1.00	–
Black/brown	210 (94.2)	158 (96.9)		1.98	1.07–3.67	42 (97.7)		0.93	0.86–1.05
Marital status									
With partner	89 (39.9)	62 (38.0)	0.215	1.00	–	17 (39.5)	0.955	1.00	–
No partner	134 (60.1)	101 (62.0)		1.03	0.83–1.28	26 (60.5)		1.01	0.58–1.76
Level of education									
Complete high school	15 (6.7)	13 (8.0)	0.271	1.00	–	2 (4.7)	0.364	1.00	–
Incomplete high school	30 (13.5)	19 (11.7)		0.66	0.46–0.95	6 (14.0)		0.96	0.85–1.08
Up to elementary school	126 (56.5)	90 (55.2)		0.72	0.54–0.95	22 (51.2)		0.97	0.88–1.08
None	52 (23.3)	41 (25.2)		0.76	0.54–1.08	13 (30.2)		0.93	0.83–1.05
Work activities									
Rural worker	130 (58.3)	96 (58.9)	0.765	1.00	–	29 (67.4)	0.176	1.00	–
Non-worker	93 (41.7)	67 (41.1)		0.80	0.58–1.10	14 (32.6)		1.04	0.98–1.10
Monthly family income*									
2 MW[1]	22 (9.9)	15 (9.2)	0.537	1.00	–	7 (16.3)	0.068	1.00	–
1 MW	54 (24.2)	37 (22.7)		1.05	0.73–1.52	14 (32.6)		1.03	0.90–1.18
From ¼ to <1 MW	36 (16.1)	25 (15.3)		1.23	0.85–1.76	8 (18.6)		1.05	0.92–1.21
Up to ¼ MW	111 (49.8)	86 (52.8)		1.34	0.90–1.98	14 (32.6)		1.11	1.49–1.88
Average per resident	3.25 ± 1.47	3.24 ± 1.48	0.843	-	–	3.84 ± 1.52	**0.003**	-	–
Sanitary Aspects									
Access to water									
Artesian wells	34 (15.2)	20 (12.3)	**0.004**	1.00	–	–	–	–	–
River	114 (51.1)	94 (57.7)		1.34	1.01–1.80	–	–	–	–
Dam	75 (33.6)	49 (30.1)		1.03	0.74–1.43	–	–	–	–
Consumption of drinking water									
Boil/filter	18 (8.1)	12 (7.4)	0.347	1.00	–	–	–	–	–
Raw water	205 (91.9)	151 (92.6)		1.01	0.74–1.39	–	–	–	–
Have a septic tank									
Yes	150 (67.3)	103 (63.2)	**0.022**	1.00		–	–	–	–
No	73 (32.7)	60 (36.8)		1.19	1.02–1.39	–	–	–	–
Have a bathroom at home									
Yes	163 (73.1)	113 (69.3)	**0.025**	1.00	–	–	–	–	–
No	60 (26.9)	50 (30.7)		1.20	1.03–1.40	–	–	–	–
Have a sink in the bathroom									
Yes	75 (33.6)	52 (31.9)	0.228	1.00	–	–	–	–	–
No	148 (66.4)	111 (68.1)		1.09	0.82–1.46	–	–	–	–
Garbage disposal									
Collected once a month	179 (80.3)	126 (77.3)	**0.046**	1.00	–	–	–	–	–
Burnt	44 (19.7)	37 (22.7)		1.25	1.05–1.50	–	–	–	–
Life habits									
Walk barefoot									
No	40 (17.9)	28 (17.2)	0.379	1.00	–	–	–	–	–
Yes	183 (82.1)	135 (82.8)		1.00	0.85–1.24	–	–	–	–
Soil handling									
No	11 (4.9)	6 (3.7)	0.142	1.00	–	–	–	–	–
Yes	212 (95.1)	157 (96.3)		1.20	0.75–1.93	–	–	–	–
Alcoholism (socially)									
No	154 (69.1)	117 (71.8)	0.100	1.00	–	–	–	–	–
Yes	69 (30.9)	46 (28.2)		1.05	0.84–1.31	–	–	–	–
Smoker									
No	208 (93.3)	152 (93.3)	0.624	1.00	–	–	–	–	–
Yes	15 (6.7)	11 (6.7)		1.01	0.75–1.37	–	–	–	–
Antiparasitic (< 6 months)									
Yes	69 (30.9)	49 (30.1)	0.377	1.00	–	–	–	–	–
No	154 (69.1)	114 (69.9)		1.03	0.85–1.24	–	–	–	–

CI: confidence interval; MW: minimum wage; PR: prevalence ratio; STI sexually transmitted infection. *Minimum wage in Brazil in 2018 was R$ 954.00 reals, equivalent to approximately USD 200. ***p* < 0.05 values were considered significant and are marked in **bold font**.

respectively). Hookworms and *S. stercoralis* had a prevalence of 17.9% (40/223) (p = 0.961) and 7.2% (16/223) (p = 0.920), respectively. Among the potentially pathogenic intestinal protozoa, *Giardia duodenalis* was the most prevalent at 7.6% (17/223), primarily in children and adolescents (p = 0.06) (Table 2).

The frequency of IgG4 anti-*S. stercoralis* in the studied population was 22.9% (51/223), approximately 3 times higher than the detection of larvae in feces. All patients who tested positive in the parasitological examination were also positive in the ELISA, which showed a sensitivity of 97.1% (29/30) and a specificity of 94.0% (47/50). The concordance index between the parasitological and immunological diagnoses was moderate (Kappa = 0.414; CI: 0.26–0.55; $p < 0.0001$).

The prevalence of *T. pallidum*/syphilis infection was 11.7% (26/223), affecting mainly the elderly (60 years or older) ($p < 0.0001$); followed by 8.1% of HTLV-1 infection (18/223), showing no significant difference between age groups (p = 0.607). Only 1 case (0.4%; 1/223) of hepatitis B was identified, and no instances of HCV and HIV-1/2 infections were diagnosed. Co-infection between *T. pallidum*/syphilis and HTLV-1 accounted for 0.9% (2/223) of the cases (Table 2).

Cases of co-infection of *S. stercoralis* and HTLV-1 were diagnosed in 1.3% (3/223) (p = 0.127; PR: 2.68; CI: 0.82–8.37) of RC residents when only the parasitological diagnosis was considered. When considering both parasitological and immunological diagnoses, co-infection was diagnosed in 6.7% (15/223) ($p < 0.001$; PR: 4.75; CI: 3.30–6.81) of cases.

Of the 18 individuals infected with HTLV-1, 94.4% (17/18) belonged to the same family nucleus (first and second-degree relatives); and, the majority, 52.9% (9/17), were children and adolescents. The co-infection of *S. stercoralis* and HTLV-1 among these individuals was 16.7% (3/18) when considering only the parasitological diagnosis, and 83.3% (15/18) when considering both parasitological and immunological diagnoses.

Out of the total of 50 families residing in the RC, 50% (25/50) had at least one case of *S. stercoralis* infection (positive parasitological and/or serological test). The rate of infection was 2.45 times higher in

Table 2. Frequency of parasitic and sexually transmitted infections (STIs) in individuals residing in the rural community in Camamu, Bahia, according to age group (N = 223).

Parasitic infection	Population age range (years)				*p* value**
	0–19 N = 87 (39.0%)	**20–59 N = 107 (48.0%)**	**≥ 60 N = 29 (13.0%)**	**Total N = 223 (100%)**	
Positivity					
Positive	66 (75.9%)	74 (69.2)	23 (79.3)	163 (73.1)	0.115
Negative	21 (24.1)	33 (30.8)	6 (20.7)	60 (26.9)	
Parasitism					
Monoparasitism	16 (18.4)	26 (24.3)	11 (37.9)	53 (23.8)	–
Polyparasitism	50 (57.5)	48 (44.9)	12 (41.4)	110 (49.3)	–
Average of parasite species	2.06 ± 1.72	1.50 ± 1.43	1.48 ± 1.18	1.72 ± 1.53	**0.030**
Helminth					
Hookworms	15 (17.2)	20 (18.7)	5 (17.2)	40 (17.9)	0.961
Ascaris lumbricoides	31 (35.6)	20 (18.7)	6 (20.7)	57 (25.6)	**0.022**
Enterobius vermicularis	8 (9.2)	1 (0.9)	1 (3.4)	10 (4.5)	**0.021**
Strongyloides stercoralis	7 (8.0)	7 (6.5)	2 (6.9)	16 (7.2)	0.920
Trichuris trichiura	38 (43.7)	19 (17.8)	3 (10.3)	60 (26.9)	**< 0.0001**
Protozoa					
Entamoeba histolytica/dispar	1 (1.1)	7 (6.5)	1 (3.4)	9 (4.0)	0.163
Giardia duodenalis	11 (12.6)	4 (3.7)	2 (6.9)	17 (7.6)	0.066
Entamoeba coli	35 (40.2)	40 (37.4)	11 (37.9)	86 (38.6)	0.919
Endolimax nana	30 (34.5)	37 (34.6)	11 (37.9)	75 (35.0)	0.938
Iodamoeba butschlli	4 (4.6)	13 (12.1)	3 (10.3)	20 (9.0)	0.180
STI					
Positive	11 (12.6)	21 (19.6)	11 (37.9)	43 (19.3)	**0.011**
Negative	76 (84.4)	86 (80.4)	18 (62.1)	180 (80.7)	
Presence of coinfection					
Monoinfected	11 (12.6)	21 (19.6)	9 (31.0)	41 (18.4)	–
Coinfected[1]	–	–	2 (6.9)	2 (0.9)	–
Average age of those infected	11.25 ± 5.75	39.20 ± 12.61	65.82 ± 2.75	38.21 ± 22.14	**< 0.0001**
STI*					
Human T-Lymphotropic Virus type-1/2[2]	9 (10.3)	7 (6.5)	2 (6.9)	18 (8.1)	0.607
Hepatitis B Virus (HBV)	–	1 (0.9)	–	1 (0.4)	–
Treponema pallidum (Syphilis)	2 (2.3)	13 (12.1)	11 (37.9)	26 (11.7)	**< 0.0001**

[1] Co-infected with *T. pallidum*/syphilis and human T-lymphotropic virus type 1 (HTLV-1).[2] Only cases of HTLV-1 were identified; * No cases of human immunodeficiency virus types 1 and 2 (HIV-1/2) and hepatitis C virus (HCV) were found in the rural community. ** Values in **bold** were considered significant ($p < 0.05$).

families with 5 to 12 residents, compared to families with 2 to 4 residents ($p = 0.028$; PR: 2.45; CI: 1.03–6.30) (Table 3). All participants diagnosed with infections were referred for medical treatment and follow-up at health units.

Discussion

Brazilian rural populations are typically exposed to various risk factors for acquiring parasitic and infectious diseases. Many live in conditions of extreme poverty without access to basic sanitation, education, and health services. Some studies, undertaken mainly in developing countries, have demonstrated high rates of intestinal parasite infection [30,31] and STI [11,12].

The rate of enteroparasite infections in this study was 73.1%. A high rate of commensal protozoa was also detected, probably transmitted by oral-fecal contamination through water and food, associated with living habits and sanitary conditions [31], including the potentially pathogenic protozoa, *G. duodenalis* (7.6%), and *Entamoeba histolytica*/*E. dispar* (4.0%). Other studies have demonstrated a high prevalence of intestinal parasites in countries/regions such as Pakistan, 73.3% [32]; Chaco, Bolivia, 85.5% [33]; El Marques in Queretaro, Mexico, 59.9% [34]; Orang Asli, Malaysia, 90.3% [35]; and the Niger River Delta, Nigeria, 55.0% [36]. Studies have also shown a high prevalence of enteroparasites in rural communities in Brazil, as demonstrated in Parnaíba, Piauí, 73.0% [37]; São Mateus, Espírito Santo, 52.9% [38]; and Terena, Mato Grosso do Sul, 76.9% [39].

The risk factors for the acquisition of intestinal parasites in rural areas include environmental conditions (sandy soil, rich in organic matter, hot and humid climate, high rainfall), associated with poor sanitation conditions (absence of sanitary sewage systems and potable drinking water), and the habit of defecating on open ground; and make the residents vulnerable to infections by intestinal parasites [31]. In SZP, 82.8% of the residents reported walking barefoot, and 96.3% handled the land during agricultural work or recreational activities, which possibly favored the transmission of parasites; mainly those acquired by penetration of larvae present in the soil, such as hookworms and *S. stercoralis*. The prevalence of hookworms and *S. stercoralis* in SZP was 17.9% and 7.2%, respectively. These are higher rates than those found in other studies, which ranged from 10.7% to 14.6% for hookworms and from 0.3% to 1.9% for *S. stercoralis* [33,38,40–41]. The parasitological diagnosis, performed with three samples from each individual and using three different methods (including the agar plate), is considered the most sensitive method for diagnosing larvae in feces, and possibly contributed to the results achieved in this study.

Seroprevalence for IgG4 anti-*S. stercoralis* in this study was about three times greater than the presence of larvae in the stool ($\kappa = 0.414$), which suggests greater sensitivity of serodiagnosis for infection by *S. stercoralis*, as demonstrated in other studies [6]. Most individuals infected with *S. stercoralis* are asymptomatic and shed a low parasite load, making the sensitivity of parasitological diagnosis low [9]. It is necessary to combine the parasite diagnosis with the detection of IgG4 anti-*S. stercoralis* [6,10], since the IgG-4 ELISA for diagnosing *S. stercoralis* infection presents greater sensitivity and specificity when compared with other isotypes and subtypes of antibodies [6]. Some studies have already suggested that serological tests should be mandatory for the diagnosis and follow-up of treatment efficacy [42,43].

This study demonstrated that the risk of IgG4 anti-*S. stercoralis* seroconversion was 2.45 times higher among families who live with more than 5 individuals in the same household. This suggests greater exposure of individuals who share common areas with one or more infected individuals.

The high prevalence of STI in this study was more significant among the elderly, which corroborates with other studies, and probably reflects greater exposure throughout life [12,44–46]. HTLV-1 infection has a wide geographic distribution in Brazil, mainly affecting low-income populations [7,47]. In this study, the prevalence of HTLV-1 was 8.1%; similar to other studies in rural populations, which reported rates ranging from 5.2% to 8.7% [48,49]. In the cases of

Table 3. *Strongyloides stercoralis* infection evaluated by parasitological examination and anti-*S. stercoralis* IgG4 detection in sera of family groups living in the same household.

Number of members per family	Number of families with cases of *S. stercoralis**					
	1 case n (%)	2 or more cases n (%)	Total n (%)	*p* value**	PR	CI
2 to 4	10 (40.0)	4 (16.0)	14 (56.0)		1.00	–
5 to 12	3 (23.1)	8 (32.0)**	11 (44.0)	**0.028**		
Total	13 (52.0)	12 (48.0)	25 (100)		2.45	1.03–6.30

* Values presented in relative frequencies of the total of 25 families (119 individuals). ** Significant rate of *S. stercoralis* infection in families with 5–12 members, compared to families with 2–4 members living in the same house. Values in **bold** were considered significant ($p < 0.05$). PR: prevalence ratio; CI: confidence interval.

individuals infected with HTLV-1, 94.5% (17/18) were concentrated within the same family nucleus, residing in 4 houses. This suggests the possibility of transmission occurring through the vertical route, which has been a major concern in Brazil. Vertical transmission rates have ranged from 0.1% to 1.05% in pregnant women [50], and approximately 30% through breastfeeding [51].

Some studies suggest that individuals infected with HTLV-1 have a greater predisposition to *S. stercoralis* infection; approximately 2.4 times higher than in the uninfected population [52–54]. In this study, the cases of *S. stercoralis*, diagnosed through parasitological and IgG4-ELISA methods, were approximately 5 times higher in HTLV-1 infected individuals compared to those without HTLV-1 infection ($p < 0.001$; CI: 3.30–6.81). These differences may possibly reflect the concentration of infection cases within the same family nucleus and the distinct methodologies used for parasitological diagnosis.

Studies conducted among individuals in blood banks in São Paulo and Salvador, Brazil, reported *S. stercoralis* infection and HTLV-1 co-infection frequencies of 12.1% (11/91) and 15.7% (24/150), respectively [55,56]. In a study conducted by Furtado *et al.* in Belém, Brazil reported a 14.3% prevalence rate of carriers [57]. In this study, the prevalence of co-infection was 16.7%, which is consistent with findings in other studies.

In this study, the prevalence of syphilis was 11.7%; a higher rate than in other Brazilian rural populations, where the prevalence ranged from 1.2% to 5.3% [45,58–59]. These differences are possibly due to growth in the number of infected people in recent years. There was an increase of acquired syphilis in Brazil from 2011 to 2021. Most of the notified cases were concentrated in males (60.6%) and in the age groups of 20 to 29 years (35.6%) and 30 to 39 years (22.3%); however, all individuals with a positive diagnosis did not report symptoms related to syphilis, which probably suggests that the infection is in the latent phase in Brazil [58]. The prevalence of HBV infection (0.4%) in this study was similar to that observed in rural workers in Minas Gerais, Brazil [59]. However, a higher prevalence than this study was reported by Asghar *et al.* in Pakistan (3.9%) [60].

Individuals infected with enteroparasitosis and STI received treatment based on medical prescriptions following the clinical protocols of the Brazilian Ministry of Health. Those infected with HTLV-1 were referred for follow-up at a reference center with integrative and multidisciplinary care in Salvador, Bahia. Educational activities to provide guidance on the prevention of parasitic infections and STI were conducted through health education and workshops with the RC residents.

Some limitations in this study must be considered, as it is a cross-sectional study that does not allow for causal inference. The coronavirus disease 2019 (COVID-19) pandemic disrupted activities and interrupted the planned activities; thus preventing further data collection. However, it should be noted that the situational diagnosis of the population is the first step in proposing health interventions.

The high prevalence rates of intestinal infections and STIs observed in this study are in line with existing literature, which documents high prevalences in rural populations in Brazil and other developing regions. These data not only emphasize the urgent need for targeted interventions; but also serve as an indicator for policy makers and health managers, highlighting the importance of allocating adequate resources to improve sanitation conditions, expand access to health services, and promote educational campaigns. Based on the evidence presented, it is recommended that public health strategies prioritize vulnerable populations, considering the harmful effects of co-infections, such as HTLV-1 and *S. stercoralis*, to ensure a positive impact on the health of individuals in rural communities, as well as others living in the same conditions.

Conclusions

The high prevalence of the diseases studied in this population is similar to the rates reported in other studies with rural populations in Brazil and other developing countries. Risk factors such as poverty, low level of education, and poor sanitation are directly related to enteroparasitic infections and STI. Vertical transmission is an important route for STI, as demonstrated by the concentration of HTLV-1 cases in a family nucleus. Co-infections such as *S. stercoralis* and HTLV-1 can occur in populations living in environments with risk factors for acquiring both groups of diseases, requiring better healthcare to avoid serious clinical conditions. Therefore, subsistence becomes a priority in poor communities, such as the one observed in SZP, where the majority of the population has a monthly income of less than half the minimum wage. In addition, restrictive government measures adopted prior to 2022 contributed to the increase in social inequalities in Brazil. While this study provides valuable insights, more research is needed to explore the socioeconomic factors that influence the prevalence and impact of these infections in rural populations.

Acknowledgements
We would like to express our gratitude to the residents of the Zumbi dos Palmares Settlement for their participation in this study, and the Secretary of Municipal Health of Camamu and the Secretary of Health of Bahia State for their collaboration in the development of this work.

Funding
Financial support was provided by the Research Support Foundation of the State of Bahia/Research Program for the Unified Health System (SUS): Shared Management in Health (FAPESB/PPSUS) and Ministry of Health (MS), nº 5263/2017; the National Research Council (CNPq) — Research Productivity Scholarships; and the Coordination for the Improvement of Higher Education Personnel (CAPES) — Research and Post-graduate Scholarships.

Authors' contributions
NMPVB, experiments, data interpretation, manuscript preparation; WACA, CLO, MMBF, LMS, ABSS, NLSG, epidemiological survey, parasitological diagnosis, antigen production; BG-C, MCAT, JNS, data interpretation, manuscript revision; NMS, study design, supervision, data interpretation, manuscript review. All authors approved the final version of the manuscript for publication.

Corresponding author
Neci Matos Soares
Department of Clinical and Toxicological Analysis, Faculty of Pharmacy, Federal University of Bahia, Rua Barão de Jeremoabo, s/n Campus Universitário de Ondina, Ondina, 40170-115, Salvador, Bahia, Brazil.
Tel: +55 71 999753308
Email: necisoares@gmail.com

Conflict of interests
No conflict of interests is declared.

References
1. Ahmed M (2023) Intestinal parasitic infections in 2023. Gastroenterology Res 16: 127–140. doi: 10.14740/gr1622.
2. Alemu AS, Baraki AG, Alemayehu M, Yenit MK (2019) The prevalence of intestinal parasite infection and associated factors among food handlers in eating and drinking establishments in Chagni Town, Northwest Ethiopia. BMC Res Notes 12: 302. doi: 10.1186/s13104-019-4338-5.
3. World Health Organization (2023) Soil-transmitted helminth infections. Available: https://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections. Accessed: 3 August 2023.
4. Buonfrate D, Bisanzio D, Giorli G, Odermatt P, Fürst T, Greenaway C, French M, Reithinger R, Gobbi F, Montresor A, Bisoffi Z (2020) The global prevalence of *Strongyloides stercoralis* infection. Pathogens 9: 468. doi: 10.3390/pathogens9060468.
5. Barreto NMPV, de Souza JN, Araújo WAC, Khouri NA, de Oliveira EP, Teixeira MCA, Soares NM (2018) Urinary tract infection by *Strongyloides stercoralis*: a case report. J Parasitol 104: 433–437. doi: 10.1645/17-88.
6. De Souza JN, Cruz AV, Araújo WAC, Sampaio LM, Allegretti SM, Teixeira MCA, Handali S, Galvão-Castro B, Soares NM (2020) Alcohol consumption alters anti-*Strongyloides stercoralis* antibodies production. Immunobiology 225: 151898. doi: 10.1016/j.imbio.2019.151898.
7. Barreto NMPV, Brito Farias MM, Oliveira CL, Araujo WAC, Grassi MFR, Souza JN, Jacobina BS, Teixeira MCA, Galvão-Castro B, Soares NM (2022) Evaluation of *Strongyloides stercoralis* infection in patients with HTLV-1. Biomedica: 42: 31–40. doi: 10.7705/biomedica.5888.
8. Oliveira CL, de Souza JN, Souza AB da S, Barreto NMPV, Ribeiro ID, Sampaio LM, Araújo WAC, dos Santos JSB, Teixeira MCA, Soares NM (2022) Ineffectiveness of TF-Test® and Coproplus® methods in *Strongyloides stercoralis* infection diagnosis. Acta Parasitol 67: 732–739. doi: 10.1007/s11686-021-00484-3.
9. Oliveira CL, Farias MMB, Barreto NMPV, Souza JN de, Sampaio LM, Teixeira MCA, Soares NM (2018) Enteroparasitoses and socioeconomic aspects in alcoholic patients. Revista de Ciências Médicas e Biológicas 17: 345–349. doi: 10.9771/cmbio.v17i3.28665.
10. Inês E de J, Souza JN, Santos RC, Souza ES, Santos FL, Silva MLS, Silva MP, Teixeira MCA, Soares NM (2011) Efficacy of parasitological methods for the diagnosis of *Strongyloides stercoralis* and hookworm in faecal specimens. Acta Trop 120: 206–210. doi: 10.1016/j.actatropica.2011.08.010.
11. Ezeonwu MC, Stecher HA, Carrick RN, Smith LA, Hoock J, Bain CE, Kamboj S (2020) Risk factors and prevalence of symptoms of sexually transmitted infections in rural Mayan villages in Guatemala. Health Care Women Int 41: 1166–1181. doi: 10.1080/07399332.2020.1791119.
12. Soares JP, Teles SA, Caetano KAA, Amorim TF, Freire MEM, Nogueira J de A, Oliveira BR de, Leadebal ODC P, Araújo P da S, Silva AC de O e (2020) Factors associated with sexually transmitted infections among sugarcane cutters: contributions to healthcare. Revista Latino-Americana de Enfermagem 28: e3306. doi: 10.1590/1518-8345.3425.3306.
13. Gessain A, Cassar O (2012) Epidemiological aspects and world distribution of HTLV-1 infection. Front Microbiol 3: 388. doi: 10.3389/fmicb.2012.00388.
14. Glória LM, Damasceno S de A, Rodrigues LR, Santos M do S B dos, Medeiros R, Dias G A da S, Pinto D da S (2015) Clinical and epidemiological profile of patients infected with HTLV-1 in Belém, Pará. Cadernos de Saúde Coletiva 23: 157–162. doi: 10.1590/1414-462X201400050087.
15. Proietti FA, Carneiro-Proietti ABF, Catalan-Soares BC, Murphy EL (2005) Global epidemiology of HTLV-I infection and associated diseases. Oncogene 24: 6058–6068. doi: 10.1038/sj.onc.1208968.
16. Rosadas C, Malik B, Taylor GP, Puccioni-Sohler M (2018) Estimation of HTLV-1 vertical transmission cases in Brazil per annum. PLoS Negl Trop Dis 12: e0006913. doi: 10.1371/journal.pntd.0006913.
17. Rosadas C, Taylor GP (2022) Current interventions to prevent HTLV-1 mother-to-child transmission and their effectiveness: a systematic review and meta-analysis. Microorganisms 10: 2227. doi: 10.3390/microorganisms10112227.
18. Allen JE, Sutherland TE (2014) Host protective roles of type 2 immunity: parasite killing and tissue repair, flip sides of the same coin. Semin Immunol 26: 329–340. doi: 10.1016/j.smim.2014.06.003.
19. Nakada K, Kohakura M, Komoda H, Hinuma Y (1984) High incidence of HTLV antibody in carriers of *Strongyloides*

stercoralis. Lancet 1: 633. doi: 10.1016/S0140-6736(84)91030-4.
20. De Souza JN, Soares BNRR, Goes LL, Lima CdS, Barreto NMPV, Jacobina BS, Gonçalves N, Teixeira MCA, Galvão-Castro B, Grassi MFR, Soares NM (2018) Case report: *Strongyloides stercoralis* hyperinfection in a patient with HTLV-1: an infection with filariform and rhabditiform larvae, eggs, and free-living adult females output. Am J Trop Med Hyg 99: 1583–1586. doi: 10.4269/ajtmh.18-0402.
21. Ye L, Taylor GP, Rosadas C (2022) Human T-cell lymphotropic virus type 1 and *Strongyloides stercoralis* co-infection: a systematic review and meta-analysis. Front Med 9: 832430. doi: 10.3389/fmed.2022.832430.
22. Souza AB da S, de Souza JN, Oliveira C de L, Barreto NMPV, Costa WA, Oliveira RR, Teixeira MCA, Soares NM (2023) Modulation of circulating cytokine production in alcoholic patients infected with *Strongyloides stercoralis*. Parasite Immunol 45: e12977. doi: 10.1111/pim.12977.
23. Tao Y-T, Gao T-Y, Li H-Y, Ma Y-T, Li H-J, Xian-Yu C-Y, Deng N-J, Zhang C (2023) Global, regional, and national trends of syphilis from 1990 to 2019: the 2019 global burden of disease study. BMC Public Health 23: 754. doi: 10.1186/s12889-023-15510-4.
24. Brasil, Ministério da Saúde (2022) Syphilis epidemiological bulletin — special edition Out. 2022 Ministry of Health of Brazil. Available: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/boletins/epidemiologicos/especiais/2022/boletim-epidemiologico-de-sifilis-numero-especial-out-2022/view. Accessed: 1 January 2021. [Article in Portuguese].
25. Hoffman W, Pons JA, Janer JL (1934) The sedimentation-concentration method in Schistosomiasis mansoni. Puerto Rico J Public Health Trop Med 9: 283–298.
26. Moaraes R (1948) Contribution to the study of *Strongyloides stercoralis* and strongyloidiasis in Brazil. Rev Serv Espec Saúde Pública 1: 507–624.
27. Arakaki T, Hasegawa H, Asato R, Ikeshiro T, Kinjo F, Saito A, Iwanaga M (1988) A new method to detect *Strongyloides stercoralis* from human stool. Japanese J Trop Med Hyg 16: 11–17. doi: 10.2149/tmh1973.16.11.
28. Lowry OH, Rosebrough NJ, Farr AL, Randall RJ (1951) Protein measurement with the Folin phenol reagent. J Biol Chem 193: 265–275. doi: 10.1016/S0021-9258(19)52451-6.
29. Landis JR, Koch GG (1977) An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. Biometrics 33: 363–374. doi: 10.2307/2529786.
30. Langbang D, Dhodapkar R, Parija SC, Premarajan KC, Rajkumari N (2019) Prevalence of intestinal parasites among rural and urban population in Puducherry, South India — a community-based study. J Fam Med Prim Care 8: 1607–1612. doi: 10.4103/jfmpc.jfmpc_196_19.
31. Vilar ME, Barreto NMPV, Soares NM, Teixeira MCA, Mendes CMC (2021) Epidemiological profile of intestinal parasites in residents of a community on Boipeba Island, Bahia, Brazil. Rev Ciênc Méd Biol 20: 14–21. doi: 10.9771/cmbio.v20i1.37580.
32. Bharti B, Bharti S, Khurana S (2018) Worm infestation: diagnosis, treatment and prevention. Indian J Pediatr 85: 1017–1024. doi: 10.1007/s12098-017-2505-z.
33. Macchioni F, Segundo H, Totino V, Gabrielli S, Rojas P, Roselli M, Paredes GA, Masana M, Bartoloni A, Cancrini G (2016) Intestinal parasitic infections and associated epidemiological drivers in two rural communities of the Bolivian Chaco. J Infect Dev Ctries 10: 1012–1019. doi: 10.3855/jidc.7657.
34. Zavala GA, Rosado JL, Doak CM, Caamaño MDC, Campos-Ponce M, Ronquillo D, Polman K, García OP (2017) Energy and food intake are associated with specific intestinal parasitic infections in children of rural Mexico. Parasitol Int 66: 831–836. doi: 10.1016/j.parint.2017.07.005.
35. Elyana FN, Al-Mekhlafi HM, Ithoi I, Abdulsalam AM, Dawaki S, Nasr NA, Atroosh WM, Abd-Basher MH, Al-Areeqi MA, Sady H, Subramaniam LR, Anuar TS, Lau YL, Moktar N, Surin J (2016) A tale of two communities: intestinal polyparasitism among Orang Asli and Malay communities in rural Terengganu, Malaysia. Parasites Vectors 9: 398. doi: 10.1186/s13071-016-1678-z.
36. Ugbomeh AP, Goodhead DA, Green A, Onwuteaka J (2018) Prevalence of human intestinal nematode parasites in three rural communities of the Niger Delta, Nigeria. Asian J Biol 6: 1–10. doi: 10.9734/AJOB/2018/42616.
37. Souza AC, Alves FV, Guimarães HR, Amorim ACS, Cruz M de A, Santos B da S, Borges EP, Trindade RA da, Melo ACFL (2016) Epidemiological profile of intestinal parasites and assessment of risk factors in individuals living in a rural settlement in the Brazilian Northeast. Rev Conex UEPG 12: 26–37. doi: 10.5212/Rev.Conexao.v.12.i1.0002.
38. Souza MAA de (2016). Parasitological profile of schoolchildren from the locality of Santa Maria, rural area of the municipality of São Mateus, Espírito Santo, Brazil. Rev APS 19: 261–267.
39. Neres-Norberg A, Guerra-Sanches F, Blanco Moreira-Norberg PR, Madeira-Oliveira JT, Santa-Helena AA, Serra-Freire NM (2014) Intestinal parasitism in Terena indigenous people of the Province of Mato Grosso do Sul, Brazil. Rev Salud Publica (Bogotá, Colombia) 16: 859–870. doi: 10.15446/rsap.v16n6.40031.
40. Ac F, Ml Z, Jm U, Gt N (2020) Parasitic risk factors in migrant horticultural families from Bolivia settled in the rural area of La Plata, Buenos Aires, Argentina. One Health 11: 100179. doi: 10.1016/j.onehlt.2020.100179.
41. Iasbik AF, Pinto PS de A, Guimarães-Peixoto RPM, Santos T de O, Fernandes FM, Silva LF da, Silva AR e, Vieira SE, Araújo JV (2018) Prevalence and transmission of intestinal parasitosis in human beings from Zona da Mata, Minas Gerais, Brazil. Biosci J 34: 802–809. doi: 10.14393/BJ-v34n3a2018-37037.
42. Kalantari N, Chehrazi M, Ghaffari S, Gorgani-Firouzjaee T (2020) Serological assays for the diagnosis of *Strongyloides stercoralis* infection: a systematic review and meta-analysis of diagnostic test accuracy. Trans R Soc Trop Med Hyg 114: 459–469. doi: 10.1093/trstmh/trz135.
43. Salvador F, Treviño B, Bosch-Nicolau P, Serre-Delcor N, Sánchez-Montalvá A, Oliveira I, Sulleiro E, Aznar ML, Pou D, Sao-Avilés A, Molina I (2020) Strongyloidiasis screening in migrants living in Spain: systematic review and meta-analysis. Trop Med Int Health 25: 281–290. doi: 10.1111/tmi.13352.
44. August EM, Daley E, Kromrey J, Baldwin J, Romero-Daza N, Salmeron J, Lazcano-Ponce E, Villa LL, Bryant CA, Giuliano AR (2014) Age-related variation in sexual behaviors among heterosexual men residing in Brazil, Mexico and the USA. J Fam Plann Reprod Health Care 40: 261–269. doi: 10.1136/jfprhc-2012-100564.
45. Dias JA, Luciano TV, Santos MCLFS, Musso C, Zandonade E, Spano LC, Miranda AE (2021) Sexually transmitted infections in Afro-descendant women from quilombola

communities in Brazil: prevalence and associated factors. Cad Saude Publica 37: e00174919. doi: 10.1590/0102-311x00174919.

46. Monsell E, McLuskey J (2016) Factors influencing STI transmission in middle-aged heterosexual individuals. Br J Nurs 25: 676–680. doi: 10.12968/bjon.2016.25.12.676.
47. Pereira FM, Almeida M da C C de, Santos FL N, Carreiro RP, Galvão-Castro B, Grassi MF R (2020) Distribution of human T-lymphotropic virus (HTLV) and hepatitis C co-infection in Bahia, Brazil. PLoS One 15: e0223087. doi: 10.1371/journal.pone.0223087.
48. Djuicy DD, Mouinga-Ondémé A, Cassar O, Ramassamy J-L, Idam Mamimandjiami A, Bikangui R, Fontanet A, Gessain A (2018) Risk factors for HTLV-1 infection in Central Africa: a rural population-based survey in Gabon. PLoS Negl Trop Dis 12: e0006832. doi: 10.1371/journal.pntd.0006832.
49. van Tienen C, van der Loeff MFS, Peterson I, Cotten M, Holmgren B, Andersson S, Vincent T, Sarge-Njie R, Rowland-Jones S, Jaye A, Aaby P, Whittle H (2010) HTLV-1 in rural Guinea-Bissau: prevalence, incidence and a continued association with HIV between 1990 and 2007. Retrovirology 7: 50. doi: 10.1186/1742-4690-7-50.
50. Rosadas C, Brites C, Arakaki-Sánchez D, Casseb J, Ishak R (2021) Brazilian protocol for sexually transmitted infections 2020: infection by human T-lymphotropic virus (HTLV). Epidemiologia e Serviços de Saúde 30: e2020605. doi: 10.1590/0037-8682-605-2020.
51. Brasil MS (2022) Clinical protocol and therapeutic guidelines for comprehensive care for people with sexually transmitted infections (STIs) - Department of HIV/AIDS, Tuberculosis, Viral Hepatitis, and Sexually Transmitted Infections. Available: https://www.gov.br/aids/pt-br/centrais-de-conteudo/pcdts/2022/ist/pcdt-ist-2022_isbn-1.pdf/view. Accessed: 3 August 2023. [Article in Portuguese].
52. Hirata T, Uchima N, Kishimoto K, Zaha O, Kinjo N, Hokama A, Sakugawa H, Kinjo F, Fujita J (2006) Impairment of host immune response against *Strongyloides stercoralis* by human T cell lymphotropic virus type 1 infection. Am J Trop Med Hyg 74: 246–249. doi: 10.4269/ajtmh.2006.74.246.
53. Schär F, Trostdorf U, Giardina F, Khieu V, Muth S, Marti H, Vounatsou P, Odermatt P (2013) *Strongyloides stercoralis*: global distribution and risk factors. PLoS Negl Trop Dis 7: e2288. doi: 10.1371/journal.pntd.0002288.
54. Tanaka T, Hirata T, Parrott G, Higashiarakawa M, Kinjo T, Hokama A, Fujita J (2016) Relationship among *Strongyloides stercoralis* infection, human T-cell lymphotropic virus type 1 infection, and cancer: a 24-year cohort inpatient study in Okinawa, Japan. Am J Trop Med Hyg 94: 365–370. doi: 10.4269/ajtmh.15-0556.
55. Carvalho EM, Da Fonseca Porto A (2004) Epidemiological and clinical interaction between HTLV-1 and *Strongyloides stercoralis*. Parasite Immunol 26: 487–497. doi: 10.1111/j.0141-9838.2004.00726.x.
56. Chieffi PP, Chiattone CS, Feltrim EN, Alves RC, Paschoalotti MA (2000) Coinfection by *Strongyloides stercoralis* in blood donors infected with human T-cell leukemia/lymphoma virus type 1 in São Paulo city, Brazil. Memórias do Instituto Oswaldo Cruz 95: 711–712. doi: 10.1590/S0074-02762000000500017.
57. Furtado KCYO, Costa CAD, Ferreira L de SC, Martins LC, Linhares A da C, Ishikawa EA Y, Batista E de JO, Sousa MS de (2013) Occurrence of strongyloidiasis among patients with HTLV-1/2 seen at the outpatient clinic of the Núcleo de Medicina Tropical, Belém, State of Pará, Brazil. Rev Soc Bras Med Trop 46: 241–243. doi: 10.1590/0037-8682-981-2013.
58. Barbosa KF, Batista AP, Nacife MBPSL, Vianna VN, Oliveira WW de, Machado EL, Marinho CC, Machado-Coelho GLL (2019) Factors associated with non-use of condoms and prevalence of HIV, hepatitis B and C, and syphilis: a cross-sectional study in rural communities of Ouro Preto, Minas Gerais, between 2014 and 2016. Epidemiologia e Serviços de Saúde 28: e2018408. doi: 10.5123/S1679-49742019000200023.
59. de Castro Rocha DFN, da Cunha Rosa LR, de Almeida Silva C, de Oliveira BR, Martins TLS, Martins RMB, de Matos MA, dos Santos Carneiro MA, Soares JP, de Oliveira e Silva AC, de Souza MM, Cook RL, Caetano KAA, Teles SA (2018) Epidemiology of HIV, syphilis, and hepatitis B and C among manual cane cutters in low-income regions of Brazil. BMC Infect Dis 18: 546. doi: 10.1186/s12879-018-3439-4.
60. Asghar MS, Rasheed U, Hassan M, Akram M, Yaseen R, Fayaz B (2021) A cross-sectional survey on the seroprevalence of hepatitis B and hepatitis C among the general population of rural districts in Sindh, Pakistan. Arquivos de Gastroenterologia 58: 150–156. doi: 10.1590/s0004-2803.202100000-26.