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INTESTINAL PARASITE INFECTIONS FREQUENCY AND ASSOCIATED RISK FACTORS IN INHABITANTS OF THE CITY OF YAOUNDÉ, CAMEROON

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Abstract: *Intestinal parasite infections are still prevalent in developing countries and in Cameroon where over 90% of the population is at high risk. To assess the distribution of intestinal parasitic infections and risk factors in the city of Yaoundé, both household and parasitological surveys were conducted from October to December 2019 among inhabitants of lowlands aged 15 years and over. Stools samples were collected and screened for intestinal parasite presence using Kato Katz and Formol-Ether methods. Sociodemographic status, prevention measures against intestinal parasitic diseases, and practices with increased exposition to risky environments were then recorded.*

A total of 229 participants (142 females: 62.0%; 87 males: 38.0%) were enrolled in the study, and 24.02% (55/229) were found infected by helminthes (ten species) and/or protozoans (one species). Participant infection rates and risk varied by parasite species and socio-demographic factors. Global risk analysis showed that age (OR ranges: 3.78-15.96), anti-parasitic drug consumption (OR: 2.53), eating behavior, hygiene (OR: 22.4), occupation (OR ranges: 1.92-3.53), and type of toilets (OR: 3.4) were strongly associated with risk of infection by intestinal parasites. The risk increased in the 15-30 years age group for Ascaris lumbricoïdes, Trichuris trichiura, and Schistosoma mansoni, unpredictably in those washing their hands before meals for A. lumbricoïdes and Hymenolepis nana, in respondents using antiparasitic drugs as auto-medication for H. nana and in those using traditional toilets for A. lumbricoïdes. However, other variables with high OR values (>5.0) might be a potential risk factor for the occurrence of specific parasite infections. The study suggests the need for household sensitization and community actions including integrated environmental management as a complementary strategy to reduce intestinal parasite transmission in the city of Yaoundé.

Keywords*: Intestinal-parasites, Infection-risk, inhabitants, Yaoundé, Cameroon.*

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1. Introduction

Intestinal parasitic infections caused by helminthes and protozoans affect around 3.5 billion people across the world [1]. These diseases of global health concern i.e. ascariasis, hookworm infection, trichuriasis and amoebiasis are among the main public health problems in developing countries particularly sub-Saharan Africa countries, where poor housing, inadequate water supplies, open defecation, poor waste management contribute to their transmission and persistence. The high density of the population in cities and close contact between people also constitute hot spots for the rapid emergence and spread of such diseases [2]. Although a significant reduction of these diseases' burden has been reported during the last decades, several factors closely linked to unplanned urbanization in Africa are maintaining the diseases present in urban settings. Lack of resources for the implementation of good wastewater management and landscape profiles in some locations from low and middle-income countries are also driven factors of these infections, particularly among school-age children, people with poor personal hygiene, and food service workers [3- 5]. Although intestinal parasite infections are not often associated with clinical signs and symptoms, some parasite infections may cause serious damage and occasionally the death of their hosts [6]. The high number and diversity of potential carriers of these parasites make them difficult to eradicate and control [7]. For the control of these infections in school-age children, WHO recommends preventive chemotherapy with albendazole/mebendazole against Soil Transmitted Helminthes (STH) and praziquantel against schistosomiasis [8]. Preventive chemotherapy primarily aims at reducing worm loads and associated morbidity [9]. However, this chemotherapy does not protect from re-infection [10], and due to an increased risk of infection observed among adults with low protective immunity, the global epidemiology of this disease and its social significance need to be also investigated for sustainable control and elimination [11]. Thus, it is necessary to complement preventive chemotherapy with other measures including wastewater management, sanitation, and hygiene (WASH), as well as social mobilization [12]. In Cameroon, around 16.1 million inhabitants are at risk and 10 million are infected with helminth parasites [13], notably *Ascaris lumbricoides*, hookworm, *and Trichuris trichiura* [14]. Thus, up to 10 million people are deprived of access to safe water sources, basic health services, essential medications, and suitable sanitation and living standards in rural areas as well as in main city of the country [15]. It is therefore important to check whether current practices and attitudes of the people living in the lowlands increase the risk of infection by intestinal parasites in the city of Yaoundé, Centre Region of Cameroon.

2. Material and Methods

2.1. Study sites and population

The study took place in seven administrative subdivisions of the capital of Cameroon, Yaoundé (3°51'N; 11°30'E). The city area belongs to the Mfoundi administrative division and covers ~ 200 Km^2 with an estimate of nearly 3 million inhabitants in 2020 [16]. The river Mfoundi and its tributaries form the hydrograph network. The selection of sampling locations was based on their distribution in the different subdivisions, and the presence of lowland areas, streams, and/or market gardening activities. They were Nkolondom and Etoa Meki (Yaoundé I), Tsinga and Cité verte (Yaoundé II), Efoulan and Ngoa Ekelle (Yaoundé III), Ekounou and Nkodengui (Yaoundé IV), Essos (Yaoundé V), Mvog Betsi and Etoug Ebe (Yaoundé VI), Nkolbisson and Oyom Abang (Yaoundé VII). Participants were asymptomatic people above 15 years old living in the seven selected subdivisions, representing about 55% of the total population.

2.2. Household investigation and ethical considerations

A cross-sectional study was carried out from October to December 2019, based on household surveys which included interviews and stool samples. A non-random sampling method was applied using a combination of a convenient selection of households and "quota sampling" of representative age groups of subjects per household. The minimum household size was randomly set at 30 per subdivision, with at least one participant enrolled per household. Therefore, the “minimal effective population size” was 210 participants across the seven study subdivisions of Yaounde, representing 1.3 per 10.000 inhabitants of the targeted population. The interview consisted of a pretested questionnaire applied to participants either in English, French, or the local language for 30 minutes. Each questionnaire was made up of combined questions and included sociodemographic data (sex, age, level of education, family size, occupation), preventive measures against IPD (sources of drinking water, hand washing before meals, automedicated drugs consumption, treatment of drinking water and proper food handling) and daily practices (market gardening and livestock activities, eating with hands, types of toilets and direct contact with soils/rivers). Participants were given containers for stool sample collection. Participants received advice on when to collect tools samples and how to store them. Stool samples were collected the next day between 8:00 to 10:00 am and were immediately stored at +4°C and transported to the laboratory for standard parasitological analysis. The research protocol has received approval from the Centre Regional Ethical Committee of Cameroon under the ethical clearance document N°/200-1/CRERSHC/2019 signed on the 8th February 2019. Administrative authorities and household heads provided their clearances for the study at the levels of subdivision and community, respectively. All the participants signed a consent form to participate after being informed of the purpose and objectives of the study.

2.3. Laboratory analysis

Parasites in stool samples were detected after microscopic examination using Kato-Katz (KK) method [17] and the Formalin-Ether Concentration (FEC) technique [18]. A slide was "positive" or "negative" based on the crosschecking examination of 41.7 mg of fresh material per sample mounted with distilled water for KK thick smears and with lugol's iodine for FEC thick smears. The combination of FE method along with the standard KK method increases the sensitivity of the diagnosis [19]. A qualified technician checked for the presence of intestinal parasites (protozoans and helminthes) in both sets of thick smears under a light microscope at 100X and 400 X magnifications.

2.4. Data analysis

The "Quota method" to determine the lowest sample size proposed for the analysis of the questionnaire in Cameroon i.e. 64 (15-30 years), 53 (31-50 years), and 21 (more than 50 years). The total number of parasites (eggs or larvae) was the overall parasite load (N) in stools expressed as egg per gram of stool was given following the WHO formula i.e. N=nx24, with n as the number of parasites counted in thick smear (41.7 mg of the pellet). The parasite intensity assessment was by "median", "arithmetic mean" and "geometric mean" using Excel 2016 package. The "median" was the middle number in a given sequence of numbers ranked by order from lowest to highest and the "arithmetic mean" as the sum of individual density divided by the total of individuals. The "geometric mean", was the nth root of the product obtained by multiplying each individual parasite density of the set of data, where "n" is the total number of individuals. Medcalc® and SPSS software calculated confidence intervals and Odd ratio rates. Assuming the "normal distribution” of our study participants, we applied parametric tests like Pearson’s Chi-square and ANOVA to compare the infection rates and mean parasite densities among parameters or variables, respectively. Data were considered significant at a rate of $P<0.05$. Whereas, odd ratios (OR) were calculated to estimate the risk of infection among groups in the study population. Values of OR>1.0 were indicative of a positive association with an increased risk of infection by intestinal parasites. Factors associated with increased risk of infection were those showing significant p-values and ORs.

3. Results

3.1. Socio-demographic profiles of respondents

Profiles of the 229 respondents included demographic parameters, preventive measures against IPD and daily practices were summarized (Table 1). The average number of people per household was 2.0 and families with up to 5 individuals were more represented (74.7%). The age varied from 15 to 82 years (mean ± SD: 33.96±15.58) and included three age groups: youths (15-30 years), active adults (31-50 years), and old people (>50 years). Female participants represented 62.0% (n=142) and males 38.0% (n=87). Almost 56% of respondents were from the informal sector. Proper food handling (85.6%), hand washing before meals (62.5%), drinking of potable water (58.1%), and treatment of drinking water (54.1%) were mainly adopted by respondents as preventive measures against intestinal parasite infections. On the practices, over 60% had direct contact with traditional toilets, contaminated soils, and water.

3.2. Overall parasite infection rates and risk association

Different parasite stages (eggs, larvae, or cysts) representing at least 11 species were recorded in stool samples. They included 10 helminthes (*Ascaris lumbricoides*, *Trichuris trichiura*, *Hymenolepis nana*, *Necator americanus*, *Paragonimus westermanii*, *Schistosoma mansoni*, *Schistosoma sp*., *Taenia sp*., *Trichostrongylus sp*. and *Enterobius vermicularis*) and one protozoan (*Balantidium coli*). The global infection rate was 24.02% (55/229), i.e. 23.58% (54/229) for helminthes and 0.44% (1/229) for *Balantidium* protozoan. The single infection rate was 20.52% (47/229) and the co-infection rate reached 3.49% (8/229), mainly by *A. lumbricoïdes/H. nana*, *A. lumbricoïdes/T. trichiura* and *S. mansoni/H. nana* (37.5% each), *A. lumbricoïdes/N. americanus* (12.5%) and *A. lumbricoïdes/H. nana/T. trichiura* (12.5%). Global risk analysis of investigated factors did not show any significantly increased risk of intestinal parasite infection according to sex (p=0.356, OR: 0.75), level of education (p=0.128, OR ranges: 1.48-3.18), family size (p=0.235, OR ranges: 1.27-2.42) and household preventive measures and practices (p values: 0.137-0.414, OR ranges: 0.23-2.53). Though significant variations on the overall infection rates were recorded across age, anti-parasitic drug consumption, eating behavior, occupation, and type of toilets, OR values revealed increased infection risk only in 15-30 years age groups (OR ranges: 3.78-15.96), in those practicing antiparasitic auto-medication (OR: 2.53) and in civil servant groups (OR ranges: 1.92-3.53) (Table 1).

3.3. Infection risk by parasite species

The trends of infection risk also varied according to parasite species detected (Table 2). The risk has increased significantly for *A. lumbricoïdes* among the 15-30 years age group (18.2% prevalence, OR: 5.9), unexpectedly among those washing their hands before meals (11.2% prevalence, OR: 22.4), and in those using traditional toilets (10.1% prevalence, OR: 3.4). For *T. trichiura* (6.8% prevalence, OR: 23.4) and *Schistosoma mansoni* (18.2% prevalence, OR: 10.2) infections, only 15-30 years age group was the riskiest factor. *Hymenolepis nana* infections were more often associated with respondents practicing hand washing before eating (18.2% prevalence, OR: 39.0) and antiparasitic auto-medication (14.8% prevalence, OR: 4.7). Other factors with high OR values might stand up at increased risk of infection, notable sex for *S. mansoni*, *E. vermicularis* and *B. coli* (ORs: 4.94) and agricultural activities (market gardening and livestock) for *P. westermanii* (OR: 7.82) and *Trichostrongylus* sp (OR: 7.70).

Table 1. Parasite infection and risk ratio range by sociodemographic factors and household practices

Factors/groups		Participants (%)	NP	Infection Rate % (± 95% CI)	P	OR (95% CI)
Age range (years)	15-30	44 (19.21)	26	59.09 (38.6-86.58)	<0.001*	0.59-9.05 (NC)
	31-50	138 (60.3)	19	13.77 (8.29-21.5)		1
	> 50	47 (20.52)	10	21.28 (10.2-39.13)		
Gender	Male	87 (37.99)	18	20.69 (12.26-32.7)	0.356	0.75 (0.39-1.40)
	Female	142 (62.01)	37	26.06 (18.35-35.92)		1
Levels of education	Primary	44 (19.21)	12	27.27 (14.09-47.64)	0.128	1.48-3.18 (NC)
	Secondary	138 (60.3)	37	26.81 (18.88-36.96)		1
	University	47 (20.52)	6	12.77 (4.68-27.79)		
Occupation	Student	77 (33.63)	22	28.57 (17.91-43.26)	0.015*	0.52-3.55 (NC)
	Civil servant	23 (10.04)	10	43.47 (20.85-79.96)		1
	Informal sector	129 (56.33)	23	17.83 (11.3-26.75)		
Family size (number per household)	<5	58 (25.33)	17	29.31 (17.07-46.93)	0.235	1.27-2.42 (NC)
	05-10	130 (56.77)	32	24.62 (16.84-34.75)		1
	>10	41 (17.90)	6	14.63 (5.37-31.85)		
Type of toilets	Traditional	148 (64.63)	28	18.92 (12.57-27.34)	0.015*	0.47 (0.25-0.87)
	Modern	81 (35.37)	27	33.33 (21.97-48.5)		1
Sources of drinking water	Tap/Mineral	133 (58.08)	36	27.07 (18.96-37.47)	0.203	1.50 (0.80-2.82)
	Spring	96 (41.92)	19	19.79 (11.92-30.91)		1
Treatment of drinking water	Filtration	31 (13.54)	4	12.90 (3.52-33.04)	0.593	0.92a (0.50-1.70)
	Boiling	7 (3.06)	0	0		1
	Decantation	3 (1.31)	0	0		
	Biodisc	3 (1.31)	0	0		
	Chloration	58 (25.33)	11	18.97 (9.47-33.93)		
	SODIS	22 (9.60)	14	63.64 (34.79-106.77)		
	None	105 (45.85)	26	24.76 (16.18-36.28)		
Eating with hands	Yes	186 (81.22)	34	18.28 (12.66-25.54)	< 0.001*	0.23 (0.11-0.47)
	No	43 (18.78)	21	48.84 (30.23-74.65)		1
Hand washing before meals	Yes	143 (62.45)	39	27.27 (19.39-37.28)	0.137	1.64 (0.85-1.40)
	No	86 (37.55)	16	18.60 (10.63-30.21)		1
Proper food handling (wash vegetables and fruits)	Yes	196 (85.59)	45	22.96 (16.75-30.72)	0.361	0.69 (0.31-1.56)
	No	33 (14.41)	10	30.30 (14.53-55.73)		1
Direct contact with soils/rivers	Yes	146 (63.76)	37	25.34 (18.35-34.41)	0.534	1.23 (0.65-2.34)
	No	83 (36.24)	18	21.69 (12.85-34.27)		1
Market gardening & Livestock activities	Yes	64 (27.95)	13	20.31 (10.82-34.73)	0.414	0.75 (0.37-1.51)
	No	165 (72.05)	42	25.45 (18.35-34.41)		1
Regular deworming (at least twice a year)	Yes	58 (25.33)	11	18.97 (9.47-33.93)	0.297	0.68 (0.32-1.43)
	No	171 (74.67)	44	25.73 (18.7-34.54)		1
Auto medicated drugs consumption	Albendazole	36 (15.72)	12	33.33 (17.22-58.23)	0.032*	2.53a (1.34-4.79)
	Mebendazole	60 (26.20)	18	30.00 (17.78-47.41)		1
	Metronidazole	19 (8.30)	7	36.84 (14.81-75.91)		
	None	114 (49.78)	18	15.79 (9.36-24.95)		

NP= number of a positive case of infection, CI= confidence interval, OR= Odd ratios ;a: comparison is done between treated and non-treated; *:p<0.05;**:p<0.01

Table 2. Odd ratios of parasite species according to risk factors

	Age	Gender	Level of education	Occupation	Family size	Type of toilets	Source of drinking water	Treatment of drinking water	Eating with hands	Hand washing before meals	Proper food handling	Direct contact with soils/ rivers	Market gardening & Livestock activities	Regular deworming (at least twice a year)	Auto medicated drugs consumption
Ascaris lumbricoides	**0.55-5.91****	0.52	0.22-0.84	0.57-1.13	0.37-3.43	**9.02****	1.22	0.49a	1.67	**22.39****	1.19	0.71	0.57	0.98	0.95-1.64a
Trichuris trichiura	**0.07-23.36****	1.09	0.78-3.27	0.15-0.48	**0.96-9.56****	0.81	1.07	1.28a	0.34	6.87	0.24	0.85	0.23	0.73	0.17-2.05a
Necator americanus	1.04-3.27	1.63	0.61-1.74	0.92-1.82	0.32-11.55	2.78	0.72	4.30a	1.18	3.06	0.86	0.56	0.51	0.56	0.32-1.66a
Hymenolepis nana	0.49-2.57	0.70	0.49-2.56	0.40-0.73	0.82-1.30	1.56	3.41	0.58a	0.96	**39.01****	0.67	0.44	0.43	0.67	**0.27-4.67a****
Schistosoma mansoni	**1.02-10.22****	4.94	0.62-3.21	1.30-2.10	0.22-0.83	0.18	2.18	0.28a	0.70	1.82	0.51	1.72	0.85	0.97	0.15-0.62a
Schistosoma sp	1.03-1.07	0.53	1.03-1.07	0.30-1.82	0.74-0.83	0.18	2.18	2.56a	0.70	1.82	0.51	0.19	7.82	0.57	0.53-5.77a
Paragonimus westermanii	0.31-9.55	4.94	0.11-3.11	0.92-5.51	0.71-0.96	0.18	2.18	0.28a	0.70	1.82	0.51	1.72	0.85	0.97	0.32-1.66a
Trichostrongylus sp	0.34-9.55	0.54	1.03-1.07	0.92-5.51	0.11-0.74	0.18	0.24	0.28a	0.07	0.20	0.51	1.72	7.70	0.98	0.32-1.66a
Enterobius vermicularis	0.31-9.55	4.94	1.03-1.07	0.30-1.82	0.71-0.96	1.66	2.18	0.28a	0.70	1.82	0.51	1.72	0.85	0.97	0.11-1.66a
Taenia sp	1.04-3.27	1.64	0.61-1.74	0.92-1.82	0.44-1.61	0.54	0.72	0.85a	0.23	3.06	0.86	0.56	2.60	15.18	0.32-9.78a
Balantidium coli	0.35-3.11	4.94	1.03-1.07	0.30-1.82	0.71-0.96	1.66	2.18	2.56a	0.70	1.82	0.51	1.72	0.85	0.97	0.32-1.66a

a: factor with OR estimates adjusted between 2 groups (treated vs. non-treated); *:p<0.05;**:p<0.01 OR associated with significant infection rates

The overall arithmetic means parasite density was 1472.29 ± 6658.07 epg, ranging from 264.00 to 2,940.00 ppg. There were also variations according to parasite species and participant profiles. The following species *A. lumbricoides* (4,114.5 ± 12,331.92epg), *T. trichiura* (470.0±318.67epg), and *S. mansoni* (426.0±590.99epg) recorded the highest densities of parasite stages, while *N. americanus, Schistosoma sp, P. westermani, Trichostrongylus sp, E. vermicularis* and *B. coli* did not exceed 24.0ppg in samples. Moreover, the parasite density trend was not consistent with the prevalence status of participants. The mean density was high in youths (15-30 years) and old participants (>50 years), among male participants, and as expected in those using traditional toilets, drinking untreated water, eating with hands, or in absence of regular deworming (Table 3). Surprisingly, factors known to be effective against intestinal parasite infections (i.e. hand washing before meals, limited contact with soils/water) were found associated with high mean parasite densities. Therefore, we completed the estimation of parasite density using geometric mean and median as adjusted estimators. There was no consistency between arithmetic and geometric means of parasite density, geometric mean and median estimates showing alleviated discrepancies across investigated factors and species, compared to the arithmetic trends of mean parasite density. The extent of the dispersion of parasite densities (maximum-minimum) was 2,676 with arithmetic mean, 4.4 and 11.5 times higher than the median (612) and geometric mean (232.16), respectively.

Table 3. Variations of mean and median values of parasite density associated with sociodemographic factors and practices of participants

Factors/groups		**Arithmetic mean epg ($\bar{X}$ ± SD)**	**Geometric mean epg**	**Median epg**
Age range (years)	15-30	2,136.00 (±9,335.01)	165.03	120
	31-50	382.74 (±454.91)	134.17	96
	> 50	1,816.80 (±4,426.38)	191.55	72
Gender	Male	2,940.00 (±11,219.13)	139.55	96
	Female	758.27 (±2,335.75)	180.98	168
Levels of education	Primary	504.00 (±426.18)	273.04	576
	Secondary	2,160.00 (±8,568.38)	159.14	120
	University	411.20 (±555.33)	145.12	96
Occupation	Student	313.09 (±510.86)	99.92	60
	Civil servant	1,692.00(±4,449.69)	219.69	168
	Informal sector	2,485.56 (±9,900.59)	239.59	216
Family size (number per household)	<5	1,358.12 (±3,385.42)	286.28	576
	5-10	1,675.50 (±8,430.16)	109.38	96
	>10	712.00 (±682.82)	332.08	660
Type of toilets	Traditional	2,124.00 (±8,974.59)	218.63	204
	Modern	796.44 (±2,738.04)	125.11	96
Sources of drinking water	Tap/Mineral	907.2 (±2,834.67)	150.11	96
	Spring	1,943.2 (±8,682.78)	180.96	132
Treatment of drinking water	Filtration	342.00 (±525.58)	132.89	108
	Boiling	0	0	0
	Decantation	0	0	0
	Biodisc	0	0	0
	Chloration	384.00 (±547.39)	116.46	72
	SODIS	348.00 (±432.28)	153.78	168
	None	2,712 (±9,616.17)	208.55	144
Eating with hands	Yes	2,192.47 (±8,426.53)	206.89	204
	No	306.28 (±470.11)	116.63	96
Hand washing before meals	Yes	1,517.87 (±6,780.50)	165.69	120
	No	264.00 (±271.53)	181.20	264
Proper food handling (wash vegetables and fruits)	Yes	1,432.53 (±7,092.19)	177.46	144
	No	1,651.20 (±4,475.38)	123.83	148

Table 3. continued

Factors/groups		**Arithmetic mean epg ($\bar{X}$ ± SD)**	**Geometric mean epg**	**Median epg**
Direct contact with soils/rivers	Yes	733,62 (±8,167.89)	171.00	144
	No	2,912.00 (± 6,779.03)	139.95	72
Market gardening & Livestock activities	Yes	439.38 (± 10,652.06)	162.35	120
	No	1,758.29 (±6,717.88)	150.49	96
Regular deworming (at least twice a year)	Yes	274.10 (±416.72)	107.08	72
	No	2,104.67 (±8,192.36)	209.65	192
Auto medicated drugs consumption	Albendazole	1,604.00 (±4,027.54)	320.75	420
	Mebendazole	290.67 (±430.73)	111.40	72
	Metronidazole	675.43 (±659.23)	298.31	672
	None	2,876.00 (±11,231.18)	127.48	96

epg= number of eggs per gram of stool; SD: standard deviation

4. Discussion

Following Hippocrates, several centuries before, addressing human health in relation to its living environments is increasing worldwide through various integrated approaches or concepts [19]. Among them, the "One Health" concept, as an integrated approach that recognizes this fundamental relationship between the health of people, animals, plants, and the environment, is complementing in-country and regional actions for the control and elimination of various diseases including intestinal parasitic soil/water-borne diseases. Our study aimed at providing probable responses on whether there is a linkage between intestinal parasitic infections among humans and their living conditions in the lowlands of Yaoundé, the capital city of Cameroun. The environments of study locations were dominated by flooding areas, rivers, and wells usually used for domestic duties and agriculture during the study period lasting from October to December. These environments situated in lowlands are covered by market gardens where perishable crops such as lettuce (*Letica sativa*), tomatoes (*Lycopersicon esculenta*), parsley, and bitter leaf (*Vernonia amygdalina*) amongst other vegetables are cultivated for household consumption and neighboring markets. In a negative way, these lands are also among the sources of vulnerability to intestinal parasitic infections addressed in this paper, along with sociodemographic status, preventive measures taken by people (regular deworming, WASH principles, and personal hygiene), and daily duties (i.e. market gardening, livestock). Our main findings indicated a high prevalence of intestinal parasite infections among study participants (~24%), especially caused by the dwarf tapeworm (*Hymenolepis nana*), *Ascaris lumbricoïdes* roundworm, and *Schistosoma mansoni*. This parasitological profile was similar to what was previously observed in many regions of Cameroon as well in humans [20] as in environment samples [21]. In fact, it was shown that the environment and the behaviour influenced the rate of infection among local communities [22, 23]. Thus, some occupations (i.e. tea pickers, miners) and various factors including humid tropical climate, lack of access to potable water, poor hygiene, illiteracy, and poverty increase the vulnerability to intestinal parasite infections [24, 25]. In study locations, this vulnerability was significantly associated with youths of 15-30 years age group, poor hygiene and sanitation standards (hand washing before meals, type of toilets), improper use of anti-parasitic drug prophylaxis, and occupation, principally for specific intestinal parasitic diseases, i.e. hymenolepiasis, ascariasis, and *Schistosoma mansoni* infection. These outcomes follow the findings from other regions of Cameroun [26, 27] and the WHO's concerns on school and preschool-age children, and adults involved in occupations like tea pickers, miners [28]. Otherwise, some factors like sources of drinking water, direct contact with soils/rivers and family size displayed high OR values, and might be increasingly addressed in future studies as a potential risk for intestinal infections in targeted sites. In this paper, we also estimated the parasite load as the intensity of infection using the arithmetic mean, geometric mean, and median. However, the trend of arithmetic means estimates showed significant variations compared with geometric mean and median estimates. These latest estimates (geometric mean and median) mitigated variations of parasite intensity among sex, age, level of education, and other factors. These significant discrepancies between the arithmetic mean and geometric mean estimates have been highlighted by Ojja [29]. Some authors trying to explain the rightful use of the arithmetic mean instead of geometric mean and/or median suggest that it overestimates the distribution of data while geometric mean or median allows an appropriate quantification of the distribution as the well realistic extent of values [30]. The size of our positive sample (less than 100) might also affect the accuracy of parasite density estimates regardless of the mode of calculation. Addressing all biases and sampling constraints might improve the outcomes of research studies on the relationships between intestinal parasitic infections, host reservoirs, and environments.

5. Conclusion

The main finding of this research provides further evidence of the endemicity of intestinal parasite infections in Yaoundé, the capital city of Cameroon. Prevalence of such intestinal parasite infections was high (~ 24%) with increased risk associated with living conditions, poor sanitation, and hygiene standards in lowlands. Globally, the vulnerability to infection by roundworms, whipworms, and flukes increased for respondents from 15-30 years old, as well as those washing hands before meals, using antiparasitic drugs as auto-medication, and traditional toilets. However, our study showed some limitations (low sample size, sampling method, cross-sectional study) that might mitigate the significance and accuracy of findings, or not allow to point out other risk factors of intestinal parasite infections in study locations. Thus, the study suggests the need for household sensitization and community actions including integrated environmental management as a complementary strategy to reduce intestinal parasite transmission in the city of Yaoundé.

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Ethical statement

The Centre Regional Ethical Committee of Cameroon approved the research protocol by the ethical clearance document N°/200-1/CRERSHC/2019 signed on the 8th February 2019.

Conflict of interest

The authors declare not to have any conflict of interest.

Author’s contributions

All the authors mentioned in this paper have significantly contributed to this research. They contributed to setting up the study design, performing the laboratory analyses, and collaborating on the written and proofreading parts of the final document.

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