

Prevalence and Risk Factors of Intestinal Helminth and Protozoa Infections in an Urban Setting of Cameroon: the Case of Douala

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Abstract Intestinal parasitic infections remains a public health problem in rural areas of low-income and middle-income settings of tropical and subtropical zones however epidemiological evidence is scarce in urban areas. This study aimed to assess the extent of intestinal helminths and protozoa infections among residents of Douala city in Cameroon, and to identify risk factors of their transmission. A community-based cross-sectional study was carried out in 2013 on 428 residents from two quarters of Douala city by microscopic examination of a stool sample from each participant simultaneously as fresh wet mounts, Kato-Katz thick smear and smear from formol-ether concentration technique. All participants from the selected quarters were invited to provide a stool sample, and interviewed about demographic and socioeconomic characteristics, sanitary situation, hygiene behaviors, antihelminthic chemotherapy. The overall prevalence of intestinal helminths and protozoa infection was 15,2%. The infection rate was significantly different between quarters ($p=0.003$). Dwellers harbored helminths, protozoa or both infections. The prevalence of pathogenic intestinal protozoa, namely *E.histolytica/E.dispar* and *G.intestinalis* was 8,9% and 0,7% respectively. The prevalence of the non pathogenic protozoa *E.coli* was 1,6%. Prevalences of helminth namely *A.lumbricoides*, *T.trichiura*, *S.stercoralis*, *H.nana* and *S.mansoni* were below 5%. Polyparasitic infections occurred in 2,1% of the participants. The prevalence of intestinal parasites carriage were influenced by age, educational level, dwelling area, household clustering for all parasitic infections taken together, poor sanitation and hygiene behaviors. Intestinal helminth and protozoa infections were hypoendemic in Douala urban area. Amoebiasis, giardiasis, ascariasis, trichuriasis, strongyloidiasis hymenolepiasis, and mansoni schistosomiasis were the main infections identified mostly at low prevalent rates. All helminth infections recorded were of low intensity. Provision of health education, improving personal hygiene, potable drinking water supply as well as school based deworming should be the major focus area of all institutions in Douala.

Keywords: *helminth, protozoa, intestine, risk factors, urban area, Cameroon*

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1. Introduction

Intestinal parasitic infections are fecal-derived diseases known to affect preferably the poorest and deprived communities in low and middle income countries of tropical and subtropical regions. The most common intestinal parasitic infections include worms and protozoan infections. Frequent intestinal helminthes in Tropical areas include soil-transmitted nematods namely roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*), hookworms (*Necator americanus/ Ancylostoma duodenale*), tapeworms such as *Taenia* spp and *Hymenolepis* spp and flukes. Current intestinal protozoa

which infect human beings in tropical areas include amoeba, flagellates, Ciliata, Sporozoa and Microsporidia. Age and sex-related behavioral habits, eating habits, socioeconomic status as well as inadequate access to sanitation, to clean water and personal hygiene are the commonest risk factors cited for intestinal parasitic infections [1,2]. Intestinal parasites colonize the human digestive tract, then their cysts, eggs or larvae are voided with human feces which in turn contaminate the soil in areas with poor sanitation practices. Humans ingest the cysts, or larvae either by touching contaminated ground or eating unwashed fruit and vegetables grown in such soil or while eating uncooked infected meat. Hookworm, *Strongyloides* spp and schistosomes infective larvae enter

the body by burrowing through the skin, most commonly when barefooted individuals walk on infected soil for geohelminthes [3] or when human spends time in furcocercariae-bearing water [4,5,6]. In low income settings of developing countries, polyparasitism is the norm and mixed infections by more than one helminth and/or many protozoan species likely occur in the same individual owing to a significant morbidity in the infected subject. Hundreds of millions of people are thought to be affected by neglected tropical diseases (NTDs), particularly in the developing world due to intestinal worm as well as protozoan parasitic infections [7,8,9,10,11]. Estimates according to parasites species suggest that *A. lumbricoides* infects 1.221 billion people, *T. trichiura* 795 million, and hookworms 740 million [12,13]. Few estimates are available on tapeworms and protozoan infections.

In endemic areas, heavy soil-transmitted helminthiasis (STH) and schistosomiasis are shown to induce severe morbidity that for 8.5 million disability-adjusted life years (DALYs). Apart from causing morbidity and sometimes mortality, heavy infections with intestinal parasites have been associated with iron-deficiency anemia, stunting, impair physical and mental development during childhood, thwart educational advancement, and hinder economic development [3,4,5,14,15,16,17,18,19,20,21,22]. There is also growing evidence that multiple helminth species infections of light intensities unlike heavy are associated with morbidity like anemia [23,24,25]. Unlike helminthiasis, intestinal protozoan infections such as giardiasis and amebiasis are also known to cause considerable morbidity and mortality [9,26,27,28]. Recent estimates in 2010 indicated that intestinal protozoan infections like amebiasis and cryptosporidiosis were found harmful than the most common soil-transmitted helminthiasis [1]. The burden of amebiasis was estimated in 2010 at 2.4 DALY greater than the burden of ascariasis alone [1]. Amoebic colitis and amoebic liver abscess *E. histolytica* is distributed throughout the world, and is a substantial health risk in almost all countries where the barriers between human faeces and food and water are inadequate [29]. *Giardia* spp as well as *Cryptosporidium* spp and Microsporidia infections are known to hinder human health significantly [9,27].

Since 2001, STH endemic countries have been urged to by the 54th World Health Assembly (WHA) to achieve a minimum target of periodic and regular deworming of at least 75% and up to 100% of school-aged children and other groups at risk of morbidity by 2010 [6] in order to eliminate morbidity from STH in children by 2020 through school-based deworming [13]. This periodic deworming strategy for STH control also known as preventive chemotherapy in endemic areas is based on a single or twice annual mass administration to at-risk populations, particularly school-aged children of benzimidazoles usually a single oral dose of albendazole (400 mg) or mebendazole (500 mg) [5,7,12,30,31]. Cameroon adopted the strategic plan for the control of schistosomiasis and STH in 2004, however the nationwide school-based deworming was completed three years later in 2007 [32,33]. Intestinal protozoa infections do not yet benefit any specific community-based control strategy with drug as is the case for many NTDs in low and middle income countries.

Although the intestinal parasitic infections are considered to occur predominantly in rural areas, they may develop well in every setting where residents have poor sanitation access as well as poor hygiene conditions like in African urban areas. Such environmental conditions are found in most African urban areas where the urbanization model is often characterized by a rapid demographic growth, most often with a disordered houses construction and formation of unplanned slum-households and squatter settlements as indicated by the Commission of the European Union [34]. The social and environmental conditions in such urbanization type in low income countries can be also ideal for poor hygiene-related parasitic diseases transmission and persistence in urban areas where overcrowding of neighbourhoods, promiscuity, poor sanitation access and mostly poor hygienic conditions are common. In 2012, the World Health Organization and UNICEF estimated that more than 700 million people worldwide still lacked ready access to improved sources of drinking water; nearly half living in sub-Saharan Africa and that more than one third of the global population did not use an improved sanitation facility, and of these 1 billion people still practicing open defecation [34,35]. Such situation is likely to maintain transmission of intestinal parasitic infections in sub-Saharan Africa.

Most of the available data on the burden of intestinal parasitic infections worldwide are mostly focused on STH in rural areas of tropical and subtropical regions while data on intestinal protozoan infections are scarce. Few studies have been so far carried to assess the endemicity of intestinal parasitic infections in urban settings in Central Africa countries thus leading to an underestimation of the public health importance of these diseases in the sub-Region.

Douala city is the economic capital of Cameroon and also one of the African huge cities with several slums according to UN-Habitat definition [36]. Recent data on the prevalence of intestinal parasitic infections in Douala focused on soil-transmitted helminth infections in a school-based survey [33]. Knowledge on the extent of intestinal parasitic infections through a community-based survey is rare if any in urban milieu of Cameroon.

This prospective cross-sectional research was set with the aim to describe the epidemiological features of intestinal helminthes and protozoan infections in two quarters of the urban area in the Douala city. Important features were to determine the prevalence rates of main intestinal protozoan and helminthes infections, and its relationship with some demographic factors (sex, age, living area), sanitation access, hygiene practices and self preventive deworming practice.

2. Material and Methods

Study type, study period and place. This was a cross sectional descriptive study which took place from March to June 2013 for patients recruitment in Ndogbong and Bali. Laboratory analysis took place at the Faculty of Medicine and Pharmaceutical Sciences of the University of Douala in Cameroon.

Douala itself is the economic capital city of Cameroon. Ndogbong and Bali are two of main biggest quarters

located at the Western and Center zone of the Douala town respectively. These quarters like many others in Douala have a mix-housing with squatter housing close to well constructed settlements. Almost all squatter settlements in the study area occupy marshy sites in lowlands. In these quarters, there are many open drains which are often never cleaned and clogged with all types of debris and garbage. Wherever sewers exist, they are often blocked and overflow into the streets. Most parts of the selected quarters are flooded during and after heavy rains, and such areas are usually marshy with an overcrowding household type. According to UN-Habitat, such household type are considered as slums defined as group of individuals living under the same roof in an urban area who lack one or more of the following: durable housing, sufficient living area, access to improved water, access to sanitation and secure tenure [36]. Most latrines in the study area were located outside of household premises and were usually open-mouth and shared with neighboring households. A latrine was found communicating with a pipe.

Main occupations in the Douala are business, industries and farming. Douala is situated in the Equatorial zone with annual mean temperature about 26°C, heavy rainfall in the rainy seasons. Relative damp is usually 99% in rainy season and 80% in the dry season.

2.1. Procedure

Ethics. The study protocol was approved in Cameroon by the Academic Board of the Faculty of Medicine and Pharmaceutical Sciences of the University of Douala, the Public Health regional office head in Douala and the National Ethics Committee of Cameroon. The study objectives and procedures were discussed with the residents head and the local health care officials who informed the residents. Adult individuals who were interested to participate signed an informed consent. Legal parents or guardians signed the informed consent for under fifteen years old children.

Study participants and sample size. All inhabitants of Ndogbong and Bali were targeted as study population however those with a recent history of antihelminthic treatment or antiamoebic treatment (taken one month before the study) were excluded from the study. The intended sample size at enrolment was not calculated since the available prevalence rate of helminth infection in Douala was obtained from a school-based survey.

2.2. Field and Laboratory Procedures

Families were informed a week before recruitment through community health workers. Interested family members were invited to the local meeting home for further information and enrolment. No monetary compensation was offered for participation. Participants answered a questionnaire-based interview investigating socio-demographic issues, sanitation access, hygiene practices, drinking water treatment, wearing shoes, water access and preventive chemotherapy. Improvement of water access, sanitation access and hygiene practices were defined as follow according to World Health Organization and UNICEF [35]. Sanitation access referred to ownership and use of latrines, latrine maintenance, and fecal sludge management. Hygiene practices referred to human

behavior patterns related to handwashing practice before eating or after defecation, producing and treating drinking water, walking barefoot or not, and water storage practices. "Treated water" was defined as the use of any chemical or physical treatment of water to change its potability. Improvements in water access referred to quality of drinking water supply, water quantity, and distance to water.

Each participant was given a labeled stool collection container with a unique identifier and their full name. The ability of all study participants to recognize their collection container was determined, and the importance of using the own receptacle emphasized. Each morning, filled containers were collected at spot.

Stool samples were brought to laboratory and processed on the collection day. Each stool sample was visually inspected for adult worms, diagnosed by microscopic examination simultaneously as fresh wet mounts, Kato Katz technique and smears from modified Ritchie formol-ether concentration technique [37,38]. These laboratory techniques were preferred due to their accuracy to concurrently detect different intestinal parasite species in the same stool sample and the common occurrence of polyparasitism in developing countries [18,39,40,41]. Fresh mounts and sediment from formol-ether concentration were examined immediately after processing as saline wet mounts and as iodine wet mounts to detect trophozoites, ova, larva and cysts of parasites. Kato Katz smears were read within 30 to 90 minutes of preparation to prevent over-clearance of hookworm eggs to detect and count helminths ova and larva [38]. Each slide was read by two well trained microscopists and at least 10% of the daily diagnoses were cross-checked by the principal investigator.

Data were analyzed using the SPSS 18 statistical software and Excel. Descriptive statistics was done using Chi square and Fisher tests. Differences were considered significant when p was less than 0.05.

3. Results

Table 1 shows the distribution of participants recruited according to residence, sex and age groups. A total 428 subjects participated in the study. There was no significant difference between sample sizes from the two quarters. Female subjects were predominant (54.9%). Mean age of participants was 24.6 ± 17.8 years (range: 9 months - 78 years). Subjects aged between 10 to 39 years were most represented.

Prevalence rates of helminthes as well as protozoa infections according to sociodemographic factors, behavioral factors and environmental factors are shown in **Table 1**. Overall intestinal parasitic infection prevalence rate was 15.2%. Both helminth and protozoan were found in stool analysis. Protozoan found in stool specimen were as cyst stages. Overall intestinal helminth prevalence rate was lower (5.8%) than protozoan infection prevalence (10.9%).

Mixed infections of two or three parasites occurred in 1.1% of participants. These associations were *E. histolytica*/*E. dispar* + *S. mansoni*, *E. histolytica*/*E. dispar* + *S. stercoralis*, *E. histolytica*/*E. dispar* + *T. trichiura*, *E. histolytica*/*E. dispar* + *H. nana* + *T. trichiura* and *E. histolytica*/*E. dispar* + *E. coli* + *A. lumbricoides*.

Table 1. Prevalence (%) of intestinal parasitic infections according to quarters, sex, age groups and regular deworming practice.

	Quarters				Sex			Age groups (years)					Regular deworming			
	Global	Ndogbong	Bali	p	Male	Female	P	0-4	5-9	10-19	20-39	≥40	p	Yes	No	p
Sample size	428	198	230		193	235		47	52	75	173	81		234	194	
Protozoa+helminthes	15,2	9,6	20	0,00	15	15,3	0,93	14,9	19,2	14,7	11,6	20,9	0,01			
Protozoa infections																
<i>E. histolytica/E.dispar</i>	8,9	4,5	12,6	0,00	8,8	8,9	0,96	6,4	1,5	6,7	7,5	13,6	0,02	NA	NA	
<i>E. coli</i>	1,6	0	3	0,13	0,5	2,6	0,09	2,1	3,8	0	1,2	2,5	0,06	NA	NA	
<i>G. intestinalis</i>	0,7	0,5	0,9	0,65	0,5	0,9	0,68	2,1	3,8	0	0	0	0,08	NA	NA	
Helminth infections																
<i>A. lumbricoides</i>	2,1	2	2,2	0,91	2,6	1,7	0,52	4,3	5,8	4	0	1,2	0,09	2,1	2,1	0,73
<i>S. stercoralis</i>	0,9	0	4	0,06	0	1,7	0,06	0	0	1,3	0	3,7	0,03	1,3	0,5	0,68
<i>T. trichiura</i>	1,9	3	0,9	0,10	1,6	2,1	0,66	2,1	0	4	1,7	1,2	0,38	2,1	1,5	0,54
<i>S. mansoni</i>	0,7	1,5	0	0,06	1,6	0	0,05	0	0	0	1,7	0	0,34	0	1,5	0,10
<i>H. nana</i>	0,9	0,5	1,3	0,39	0	1,7	0,06	0	0	0	0,6	3,7	0,18	0,4	1,5	

NA = Non applicable.

Helminth intensities of infection. Intensities of infection were light in all helminth parasites. Parasites loads ranged between 24 and 48 e ggs/g of stool for *A. lumbricoides* (mean 30.8±10.8/g of stool), 24 and 408 eggs/g of stool for *T. trichiura* (141±124eggs/g of stool), 48 to 192 eggs/g of stool for *H. nana* (mean 104±62.99 eggs/g of stool), 24 to 48 rhabditoid larvae/g of stool for *S. stercoralis* (mean 30±10 larvae/g of stool).

Influence of the study neighbourhoods. There was a significant relationship between residence area and prevalence rates overall intestinal infection as well as some specific parasitic infections (Table 1). According to area, overall intestinal parasite prevalence rate was significantly higher at Bali (20%) than Ndogbong (9.6%); ($\chi^2 = 8.94$, $p = 0.003$). Also, prevalence of protozoa infection was significantly higher in Bali (16.5%) than Ndogbong (5%) whereas helminth infection prevalence rates were almost similar between the two quarters (6.5% at Bali and 7% at Ndogbong).

Main protozoa found were *E. histolytica*, *E. coli* and *G. intestinalis*. *E. histolytica* had the highest prevalence rate (8.9%) and *G. intestinalis* had the lowest (0.7%) (Table 1). Prevalence were significantly different in either quarter for the pathogenic *E. histolytica* ($\chi^2 = 8.551$, $p = 0.003$) and non pathogenic *E. coli* ($\chi^2 = 6.126$, $p = 0.013$). Prevalence rate of *E. histolytica* infections were 4.5% and 12.6% at Ndogbong and Bali respectively. *E. coli* cysts were found only among subjects from Bali. *G. intestinalis* cysts were recorded in the two areas at low prevalence rates (0.5% and 0.9% at Ndogbong and Bali respectively. Mix infection between *E. histolytica* and *E. coli* was the only association recorded among intestinal protozoan in 0.4% of the participants.

Unlike protozoan infections, helminthes were either monospecific or coinfection. Main helminth parasites recorded were *A. lumbricoides*, *T. trichiura*, *S. stercoralis*, *H. nana* and *S. mansoni*. Helminthes infection prevalence rates were usually low (ranges: 0% to 3% at Ndogbong, and 0% to 2.2% at Bali). Prevalence rates of *T. trichiura* and *A. lumbricoides* were the highest in Ndogbong and Bali respectively (Table 1). The only coinfection by helminth recorded was *A. lumbricoides* - *T. trichiura* found in 0.4% of participants.

Influence of sex (Table 1). The three protozoa species namely *E. Histolytica/dispar*, *E. coli* and *G. intestinalis*

were recorded in either sex. There was no statistical difference in protozoa infection between both sexes ($p > 0.05$). Prevalence rates of the pathogenic *E. histolytica* were almost similar between males and females whereas a difference but not statistically significant was recorded between sexes for infection by the non pathogenic *E. coli* ($p = 0.09$). Infection rates by *G. intestinalis* were the lowest recorded between the sexes.

Concerning helminth infections, *A. lumbricoides* and *T. trichiura* were recorded in both sexes while *S. stercoralis* larva occurred only among female subjects (1.7%). The cases of *S. mansoni* infections were recorded only in male subjects inhabiting the same house.

Influence of age (Table 1). An age-related infection was found for protozoan infection. *E. histolytica* / *E. dispar* infected all age groups whereas *E. coli* cysts were found only among younger and older subjects. *G. intestinalis* infected only under ten years subjects. *E. histolytica* infection was statistically different among age groups ($\chi^2 = 14.197$, $p = 0.028$).

Helminth infection did not exhibit a significant age-related trend. *A. lumbricoides* and *T. trichiura* eggs were recorded in all age groups ($p = 0.095$), whereas *S. stercoralis* larvae and *H. nana* eggs were mostly diagnosed among over 40 years old participants. *S. stercoralis* infections showed a significant age-related distribution of prevalence rates ($\chi^2 = 13.9$, $p = 0.031$).

Influence of living habits. There was no significant influence of walking barefoot or not on prevalence rates of *S. stercoralis* infections. Prevalence rates of infection were almost similar between those who used to walk barefoot and those who did not ($p = 0.94$).

Influence of drinking water source (Table 2). Participants reported collecting drinking water either from piped water on premises (32.7%), boreholes (33.4%), both boreholes and piped water on premises (30.1%), dug wells (1.4%) or water in sachet (28%). All three protozoan species were found among participants who reported drinking exclusively piped water and water from boreholes with a significant greater prevalence for *E. histolytica/E. dispar* infection than *E. coli* or *G. intestinalis*. *E. histolytica* was the only protozoan found among those who drank only water from dug wells. Participants who drank water in sachet had *E. histolytica* cysts (10%) or *E. coli* cysts (0.8%). There was a

significant higher prevalence rates between those who drank piped water than those who did not for *E. histolytica*/*E. dispar* infections ($\chi^2 = 6.26$, $p = 0.012$) and *E.*

coli ($\chi^2 = 4.21$, $p = 0.040$). Consuming water from boreholes, dug wells or sachet did not influence significantly any of intestinal protozoa infections in Douala ($p > 0.05$).

Table 2. prevalence (%) of intestinal parasites according to drinking water type and treatment

	Drinking water type																	
	Piped water			Borehole			Wells			Mineral water			Sachets			Drinking water treatment		
	Yes	No	p	Yes	No	P	Yes	No	P	Yes	No	P	Yes	No	p	Yes	No	p
Sample size	269	159		272	156		6	422		370	58		120	308		160	268	
Protozoa+helminth	17,8	10,7	0,04	14,7	16	0,71	16,7	15,2	0,92	10,3	15,9	0,27	13,3	15,9	0,5	15,0	15,3	0,93
<i>E. histolytica</i>	11,5	4,4	0,01	8,1	10,3	0,45	16,7	8,8	0,49	8,6	8,9	0,94	10	8,4	0,61	11,3	7,5	0,18
<i>E. coli</i>	2,6	0	0,04	1,1	2,6	0,25	0	1,7	0,75	0	1,9	0,29	0,8	1,9	0,41	1,3	1,9	0,62
<i>G. intestinalis</i>	0,7	0,6	0,89	1,1	0	0,18	0	0,7	0,84	0	0,8	0,49	0	1	0,28	0	1,1	0,18
<i>A. lumbricoides</i>	1,9	2,5	0,64	2,6	1,3	0,37	0	2,1	0,72	0	2,4	0,23	0	2,9	0,05	1,3	2,6	0,34
<i>T. trichiura</i>	1,1	3,1	0,13	2,2	1,3	0,49	0	1,9	0,73	1,7	1,9	0,93	0	2,6	0,07	1,3	2,2	0,46
<i>H. nana</i>	0,7	1,3	0,59	0,4	1,9	0,11	0	0,9	0,81	3,4	0,5	0,03	0	1,3	0,21	1,3	0,7	0,6

There appeared an influence though not too significant of drinking water sources on prevalence rates of helminth infection. Helminth infection was recorded among all participants irrespective of the quality of drinking water source. Use of piped water, protected dug wells and water from sachet was associated with reduced likelihood of helminth infection. However, participants who used water from boreholes had higher prevalence rates of infection by *Ascaris* and *Trichuris*.

Influence of drinking treatment processing (Table 2).

The main specific forms of treatment identified included filtering water at home, bleaching and decantation. 34.2% of participants reported treating water before drinking and 65.8% did not treat drinking water. Of those who treated water before drinking, 85.6% proceeded by filtration, 11.2% by bleaching and 0.3% by decantation.

There was a positive impact of treating drinking water only on infection by *G. intestinalis*. *G. intestinalis* infections were recorded only among participants who did not treat water before drinking. Treating drinking water had paradoxical effect on *Entamoeba* infections since prevalence of infection by *E. histolytica*/*E. dispar* appeared higher among those who treated drinking water than those who did not. *E. coli* prevalence was similar in the two groups. Protozoan infections were recorded despite the treatment process used by the participants.

Treating water before drinking showed a positive impact on food-borne helminthiasis. Globally, prevalence rates of *Ascaris* and *Trichuris* infections were lower among those who treated drinking water but not statistically significant.

Influence of dwelling area (Table 3). Study participants lived either in swampy areas (48.6%) or non swampy areas (51.4%). *E. histolytica*/*E. dispar* and *E. coli* infections were diagnosed in either area at barely similar prevalence rates while *G. intestinalis* cysts occurred only in residents from swampy areas. There was a significant difference in the pattern of prevalence rates for *E. coli* ($\chi^2 = 3.9$, $p < 0.05$) and *G. intestinalis* ($p < 0.05$).

Soil-transmitted helminth infections trend was influenced by the swampy or non swampy area type. *A. lumbricoides* as well as *T. trichiura* were more prevalent in swampy areas than non swampy areas whereas *S. stercoralis* and *H. nana* infections had similar but significant different infection prevalence rates.

Handwashing practice after defecating (Table 3). 86.7% participants systematically washed their hands after defecation and 13.3% did not. Systematic handwashing practice after defecation significantly lowered *E. Histolytica*/*E. dispar* and *E. coli* prevalence rates as well as helminth infection prevalence rates. However, *Giardia* cysts were found only among participants who declare to systematically wash hand after defecation.

Table 3. Prevalence rates of intestinal parasitic infections according to sanitation type and hygiene practices

	Occupation area			Sanitation type			Handwashing before eating			Handwashing after defecating		
	Marshy	Non marshy	P	Pit latrines	Improved	P	Yes	No	P	Yes	No	p
Sample size	208	220		191	237		229	199		371	57	
Protozoa+helminth	16.8	13.6	0.35	15.2	15	0.90	12.7	18.1	0.11	13.7	24.6	0.03
Protozoa infections												
<i>E. histolytica</i> / <i>E. dispar</i>	7.7	10	0.40	7.9	9.6	0.05	8.7	9	0.91	8.4	12.3	0.33
<i>E. coli</i>	2.9	0.5	0.04	2.1	1.3	0.05	1.3	2	0.56	1.3	3.5	0.23
<i>G. intestinalis</i>	1.4	0	0.07	1	0.4	0.05	0.4	1	0.48	0.8	0	0.49
Helminth infections												
<i>A. lumbricoides</i>	2.9	1.4	0.27	3.7	0.8	0.03	0.9	3.5	0.05	1.3	7	0.00
<i>S. stercoralis</i>	1	0	0.95	NA	NA	NA	NA	NA	NA	NA	NA	NA
<i>T. trichiura</i>	2.9	0.9	0.13	2.1	1.7	0.07	1.3	2.5	0.36	0.8	8.8	0.00
<i>S. mansoni</i>	0	1.4	0.09	NA	NA	NA	NA	NA	NA	NA	NA	NA
<i>H. nana</i>	1	0.9	0.95	0	1.7	0.07	1.3	0.5	0.38	1.1	0	0.43

NA = Non applicable.

Washing after defecation showed a significant reduction in prevalence rates of infection for *A.*

lumbricoides ($\chi^2 = 7.72$; $p = 0.005$) and *T. trichiura* ($\chi^2 = 17.08$, $p = 0.000$).

Handwashing practice before eating (Table 3). 53.5% of participants reported washing their hands before eating. However, they did not systematically washed hands with soap. Handwashing before eating did not significantly influence infection trends by any of the protozoa ($p>0.05$). However, this hygiene practice showed a significant influence on helminth infections. Prevalence rates of *E. histolytica/E. dispar* infections were the highest protozoa infection in both groups.

A. lumbricoides, *T. trichiura* and *H. nana* eggs were recorded among those who washed hands before eating and those who did not systematically do so. Infection prevalence rates were significantly low among those who systematically washed hands before eating.

Influence of sanitation type access (Table 3). Participants reported using latrines located either inside (55.4%) or outside (44.6%) of their household premises. Using private latrines and sharing latrines with neighboring households was not associated with reduced likelihood of protozoa or helminth infection ($p=0.9$). However, participants who used exclusively private latrines had lower helminth infection prevalence rates compared to those who used latrines located outside of households. Prevalence of *E. histolytica/E. dispar* infection was also not significantly different between the two groups ($p=0.05$).

Influence of regular deworming practice (Table 1). 60.3% of participants reported that they systematically swallow an anthelmintic drug at least once a year. The others who did not practiced periodic deworming swallowed anthelmintic drugs only after a medical prescription or when they have abdominal pains. Anthelmintic medicines used for periodic deworming were mebendazole (66.7%), albendazole (31%) or flubendazole (0.4%). Helminth infections were recorded in both groups. However, systematic anthelmintic deworming was associated with reduced but not statistically different likelihood of *A. lumbricoides*, *T. trichiura*, and *H. nana* infection ($p>0.05$). Nevertheless, prevalence rate of *Strongyloides stercoralis* infection was higher among study subjects who dewormed periodically.

4. Discussion

This study aimed to describe the epidemiological profile of intestinal helminthes and protozoa infections in Douala city which is one of huge urban area in the sub-Saharan Africa through determination of the prevalence rates of main intestinal protozoa and helminthes infections, and its relationship with some demographic factors (sex, age, residence area), sanitation access, hygiene practices and self preventive deworming. These risk factors were selected from the fact that transmission intestinal parasites are primarily related to absence of safe drinking water, lack of hygienic behavior, improper sanitary habits, poor fecal disposal systems, poor socioeconomic status, and wide dispersion of parasites within human communities.

Results of this study indicated that of the most common gastrointestinal worm infestations in humans in both tropical and subtropical countries, the most prevalent soil-transmitted helminth *i.e.* *A. lumbricoides*, and *T. trichiura* as well the most prevalent protozoa *i.e.*

E. histolytica/E. dispar, *E. coli* and *G. intestinalis* were present in the Douala city.

Few data are available on intestinal parasitic infections in the Douala city. Data gathered in this study also indicated that dwellers of the two quarters investigated harbored one or more species of soil-transmitted helminth as well as protozoa at low prevalence rates. Helminth intensities of infection were light in the study quarters. The prevalence rate of soil-transmitted helminths recorded from this community-based study was less than half the overall prevalence rate of soil-transmitted helminthiasis recorded in 2011 in a school-based survey in the littoral region [33]. Despite the low prevalence rates of intestinal worms and protozoa, the results obtained so far indicated that some dwellers of the Douala urban areas were at risk for soil-transmitted parasitic diseases as indicated by some relationship found with some socio-demographical factors. The results were of considerable importance since they indicated the extent of poor hygiene and poor compliance to annual systematic deworming in a huge urban area of sub-Saharan Africa. Also, as suggested by a number of authors, even a moderate intensity of infection may result in significant morbidity such as anemia [23,24,25], abdominal pains and absenteeism to work [42]. Moderate intensities of infection can also result in health impact like delayed physical growth and impaired cognitive development, particularly among children of school-going age [43,44]. The low prevalence of infections with helminth and protozoa made difficult to draw conclusive evidence about the direction and strength of association between the parasites species and risk factors. Another limitation relied on the sensitivity of the techniques used for diagnosis in stool samples.

Reliability of the findings was of concern since the laboratory techniques used for this study namely the fresh wet mounts, Kato-Katz and formaline ether-concentration techniques used in this study for diagnosis are of foremost recommended for accurate diagnosis of STHs and intestinal protozoa infections [40,41]. However, the prevalence and intensities of parasites infections may have been underestimated, due to the low sensitivity of the single slide Kato-Katz technique and mostly day-to-day variation in egg and cysts excretions especially in light infections. Using Kato-Katz and formaline-ether concentration technique simultaneously would have overcome these sensitivity limitations. Despite to these limitations, the results were of great significance since it was an advocacy for implementation of sustainable tracking systems for intestinal helminth as well as intestinal protozoa infections.

There was heterogeneity in helminthes infections between the quarters of Douala city as indicated by differences of helminth prevalence rates. Such heterogeneity may evoke differences in socio-economical status like household clustering as well as sanitation and hygiene practices in the sampled areas. Household clustering are known to be indicative of socio-economical level of residents. In Douala city like many other towns in sub-Saharan Africa, quarters in urban areas often bear squatter housing where poor people live in unhealthy environments. According to the results from this study, prevalence rates of *T. trichiura* and *A. lumbricoides* infections varied significantly between the two quarters with occurrence of mixed infections. An explanation could

not be given to such variation since the two quarters bear the same profile concerning sanitation access it may be related to storage conditions of drinking-water and also hygiene practices before eating or after defecation.

Sanitation types did not show significant differences in intestinal parasite infection trends between dwellers whose latrines were located outside of households and those with private latrines despite of the lower helminths infection prevalence recorded in the later group. Despite the low prevalence rates recorded for the intestinal parasitic infections, most of the sanitation facilities located outside of household were poorly constructed and often mouth-opened, uncovered and located in frequently flooded areas. These sanitation facilities were shared in most households with other households in the study quarters of Douala city and the entire country. In 2012, an estimated 74% of the population in Cameroon used improved water-drinking sources and 45% used improved sanitation [34]. This lack of improved sanitation facilities and occurrence of fecal-related parasitic diseases thus incites for more improvement of the sanitary facilities in the study areas and the whole Douala city in order to achieve a major goal of WHO in collaboration with UNICEF which recommend by 2030 to eliminate open defecation, achieve universal access to basic drinking water, sanitation and hygiene for households, schools and healthcare facilities, halve the proportion of the population without access at home to safely managed drinking water and sanitation services; and progressively eliminate inequalities in access [35]. The adherence of Douala city dwellers to this later goal will certainly bring the prevalence of these fecal-derived transmitted intestinal parasitic infections to lower values and therefore meet the corresponding Millenium Goal for Development. However, although significant progress in combating open defecation has been achieved in Asia and Americas, the number of people practicing open defecation is still increasing in most countries in sub-Saharan Africa where 82% of those practicing open defecation in the world live in just 10 countries [35]. Improvement of sanitation access together with hygiene practices remain an urgent requirement in sub-Saharan urban settlements since they are expected to grow rapidly in the coming years during which the United Nations Population Fund's State of World Population 2007 report extrapolates that over half of the population of Africa is expected to live in urban areas by 2040 [36]. The later report indicated that Africa had an urbanization level of 38% in 2005, and 72% of sub-Saharan Africa's urban population lived in slum conditions [36].

According to drinking water type, most households in the study areas lack piped water and rely for drinking-water on water vendors in shops or along the streets, wells and public piped water from boreholes. In Douala city, water vendors are frequently found along streets, markets and other public places where they provide water in sachets or recycled plastic bottles. Water sell in plastic recycled bottles is usually from boreholes. Consuming water from boreholes, dug wells or sachet did not so far influence significantly intestinal protozoa infection in Douala. However, an unusual observation was made for *E.histolytica/E.dispar*, *E. coli* and helminth infections since significant higher prevalence rates were recorded among dwellers who reported drinking piped water than the others. Such observation may be explain by unsafe

storage conditions either through unclean containers used to collect drinking water or improper treatment before redirecting to collection spots. Also, reusing the same water several times from storage containers may also increase the risk of contamination.

Treating drinking water before use was recorded only in third of the sampled participants. The main specific forms of treatment identified included filtering water at home, bleaching and decantation. These forms are of mains recommended for a proper potability of water. Protozoa as well helminthes infections occurred among those who treated drinking water and those who did not, however there was no significant influence of the treatment process. Presence of foodborne parasites in treated water may indicate that there would be frequent contamination in storage containers therefore requiring more attention of the storage conditions in households.

Handwashing practices showed a significant intestinal parasite infection reduction compared to those who did not wash. The difference was more significant when it occurred before eating than after defecating. The handwashing practices prevalence rates recorded were higher than the mean estimation in Africa which indicated in 2014 a mean 14% handwashing with soap prevalence rate [45]. Data collected so far in this study were reports from participants, therefore false declarations could be given by some participants. A reliable assessment could be undergone to highlight whether participants systematically washed hands with soap or no.

According to periodic deworming practices, helminth infections occurred among those who practice preventive chemotherapy as well as those who do practice however it systematic deworming was associated with reduced likelihood infection by *A. lumbricoides*, *T. trichiura* and *H. nana*. This observation is indicative that either the drugs used were not effective or persistence of reinfection. Occurrence of reinfection was the most proper interpretation since hygiene conditions like quality of drinking water and practicing handwashing before eating as well as after defecation is not a rule in the study area. This is also the case though paradoxical with the occurrence of a higher prevalence rate of *Strongyloides stercoralis* infection among those who dewormed periodically than the others. Although preventive chemotherapy eliminates morbidity from helminth infections, reinfection rapidly occurs after treatment as a result of poor sanitation, access to clean water and hygiene practices [46,47,48].

As all *S. mansoni* cases occurred in members of the same family, these infected were thought to be imported cases. Also, there was no transmission site in the area, and specific snail intermediate hosts were not found in waterbodies.

Although the intestinal parasitic infections prevalence were low, specific diversity found indicated that control measures if applied needed to be improved. Such task requires joint efforts between public health institutions, local administrative authorities and community leaders through health education and improvement of access to potable drinking water, improved sanitation. Improving access to sanitation, potable drinking water as well as sensitizing dwellers towards improvement of hygiene practices including handwashing both before eating and after defecating, wearing shoes have been demonstrated to

significantly reduce STH infections [49,50,51]. Implementing these strategies will likely reduce significantly intestinal protozoa infections since they share similar risk factors with soil-transmitted helminthes infections. A successful integration of access to improved sanitation, drinking water together with handwashing practices intestinal into the STH control program alongside with regular deworming is feasible in urban area since the urbanization idea implies improvement of living conditions including improved sanitation access, personal hygiene and sufficient access to clean water in order therefore limiting incidence of poor sanitation and hygiene-related parasitic diseases.

5. Conclusion

Intestinal helminthes and protozoan infection were present among dwellers of Douala city. Although these poor hygiene and sanitation related parasitic infections had low prevalence rates, it occurred in all age groups, sex irrespective of sanitation-type, water provision sources, water treatment types or deworming status. The results were relevant since it emphasized the hygiene practices of Douala city dwellers as well as their specific behaviors in preventing transmission. The risk of acquiring any of the helminthes or protozoan infection at any prevalence rate could be attributed to the coexistence and amalgamation of various biological, social, behavioral and environmental factors like poverty, substandard living conditions and lack of personal hygiene, both at the individual and the community level and chemotherapy.

Conflict of Interest

The authors of this manuscript declare that they have no competing interests concerning this research. There was no private funding for this research.

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