A Cross-Sectional Study of Intestinal Parasitic Infections in Children in Ghettoed, Diverse and Affluent Communities in Dschang, West Region, Cameroon

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Abstract

Background: There is a paucity of knowledge on the epidemiology of parasitic diseases which remain rampant in the Dschang municipality. Three communities around Dschang town—Ngui (slummy), Paidground (heterogeneous) and the Administrative Quarter-AQ (wealthy) were investigated to highlight the aetiology of intestinal parasitic infections (IPIs) in children in order to enhance health policy intervention priorities. Methods: Between July and November 2009, 31 stool samples were collected from children aged six months to 18 years (mean 9 years) in 295 households across the three communities. A structured questionnaire was used to obtain information on socio-demographic characteristics, source of water supply, de-worming practice and treatment history. Stool samples were screened for ova/larvae of intestinal parasites using direct wet mount, brine floatation and formol-ether sedimentation methods. Results from stool tests and information obtained from questionnaires were analyzed using SPSS. Results: In total, 223 (26.8%) children had single (19.9%) and multiple (7%) infections from seven parasites: the overall prevalence was 34.7%; helminthes 19.3% and protozoa 15.4% (χ^2 = 4.3, P < 0.0380); corresponding to *Entamoeba histolytica* 8.8%, *Ascaris lumbricoides* 7.5%, *Trichuris trichiura* 6.8%, *Entamoeba coli* (5.8%), hookworm 4.6%, *Giardia lamblia* 0.8% and *Vampirolepis* (Syn: *Hymenolepis*) *nana* 0.4%. Infections were more severe and rates significantly higher in Ngui (45.9%, χ^2 = 86.83, P < 0.0001) than in the AQ (17.7%) and Paidground (16.7%), and in the oldest children above 15 years (55.3%, χ^2 = 111.97, P < 0.0001). Conclusion: Regular sustained synchronized deworming alongside anti-protozoaics, periodic diSagnostics for all children and slummed residents which lend to intestinal protozoa; sanitary inspection of homes and water supplies; adequate drainage and community wastes disposal; and prevention education on hygiene, sanitation, safe water and health were desirable.

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Intestinal Parasites, Prevalence, Risk Factors, Mitigation, Children, Cameroon

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1. Introduction

Parasites have been associated with a tremendous burden of disease the world over [1]-[8]. Studies which have attempted to unravel the epidemiology of parasitic infections in children abound, although these diseases remain pestilential in some developing countries [9]-[24]. Globally, millions of people have suffered from parasitic infections such as *Ascaris lumbricoides* (1.2 billion), *Trichuris trichiura* (795 million), hookworms *i.e*. *Ancylostoma duodenale* and *Necantor americanus* (740 million), *Entamoeba histolytica* (50 million) and *Giardia lamblia* (2.8 million) [25]. However, in the underdeveloped world, the prevalence of intestinal pathogenic parasites varies from study to study depending on the diagnostic techniques used, the study population, the degree of hygiene and sanitation, and the prevailing socio-economic and climatic factors [26]-[29]. In Cameroon, helminthic infections have been documented in inhabitants in the country [26] [30]-[33], as well as in the population of Dschang [34] [35]. Data are also available on intestinal parasitic infections (IPIs) in children in Yaounde and Bafang [36], and in North Cameroon [37]. There are records of gastrointestinal helminthic infections in Dschang school children [38] [39]. Over time, the Ministry of Public Health through the National Program for the control of Schistosomiasis and Intestinal Helminthiasis in Cameroon (PNLSH) has endeavoured to curtail IPIs in children once every three months using anthelminthic drugs such as mebendazole and praziquatel [40].

Parasitic diseases continue to beset mankind despite giant strides to redress them. In Dschang, at the time of this study, unpublished health records indicated that geohelminths remained highly endemic in children, pointing to the fact that little success has been achieved with control measures in place. Thus, this research sought to elucidate the aetiology of IPIs in children in ghettoed, diversified and affluent communities in Dschang, against the perspectives of water, hygiene and sanitation, treatment, prevention and control issues, to advance suggested prime intervening initiatives.

2. Materials and Methods

2.1. Study Area

This research was carried out in Dschang, the Divisional Head Quarters of Menoua Division in the West Region of Cameroon. Dschang is situated between latitude 5˚20'N to 5˚28'N and longitude 10˚3'E to 10˚6'E at an altitude of 1382 - 1500 m in the Western Highlands of Cameroon. The climate is Sudano-Guinean type with two characteristic seasons: a dry season beginning from mid-November to mid-March, and a rainy season from mid-March to mid-November. Data obtained from the meteorological station (IRAD) Dschang showed an average annual rainfall of 3353 mm; an average annual sunshine of 1591 hours; and an average annual temperature of 22.5˚C. The vegetation is grassland savannah, interspersed with few trees especially eucalyptus, cypress, fir and pear trees. It also has some water reservoirs notably the MunicipalLake, and the University ponds. The soils are the ferralitic type [41].

The natives are the Bamileke ethnic group with the main religious groups being Christians and Muslims. The principal occupation is commerce and subsistence farming where, the main cash crop is coffee. There is pipe-borne water, electricity, wells, and protected and unprotected water sources for most of the population. There are pit toilets in most houses and schools as well as indiscriminate urination and defecation in the surroundings of the unfenced playgrounds and bushes.

2.2. Ethical Clearance

The Chief Medical Officer of Dschang, Menoua Division, granted the authorization to execute this study, as there was no ethics and research committee to do so then. The results of laboratory analysis of specimens were submitted to the study subjects, who were advised on how to get appropriate therapy from accredited health centres, and control interventions to adopt at home based on observed risks.

2.3. Description of Study Setting

This study involved three different communities-Ngui (a poor neighborhood), Paidground (mixed) and the Administrative Quarter-AQ (well off), all located around the Dschang town centre and proximate to the University of Dschang where specimens collected were processed.

2.4. The Ngui Locality

The Ngui community was understandably one of the most populous in Dschang with poor housing, usually very swampy and muddy in the wet season, and dusty in the dry season with so many potholes. Houses were mostly built of sun dried bricks and unfenced, leading to very close interaction among children. Most Nguiresidents lived in squalid conditions, with goats, sheep, dogs, chickens or geese being tethered or reared on yards, verandas or in kitchens at night. Poor drainage and disposal of garbage attracted rodents, chickens, cockroaches, flies, stray domestic/farm animals and other pests to homes.

2.5. Paidground

This was a mixed community, as well as a student residential area due to proximity to the university. Most houses were clean, and garbage piles were seldom seen. Also, on rare occasions could children be seen wearing dirty dresses, moving barefooted, playing with fingers on the ground, or interacting with each other.

2.6. The Administrative Quarter

This was a community made up of many fenced houses with much control over children's behavior, leading to very limited interaction among children. Many houses were surrounded by administrative offices, and good road infrastructure (all streets were tarred). Like Paidground, garbage piles were hardly sighted.

2.7. Study Design/Sampling

This was a community-based cross-sectional study, employing multistage sampling technique. From July to November 2009, households in the three localities were counted and informed consent for the study obtained from family heads. Next, the population of children was established, and then questionnaires and specimen bottles were distributed thereafter.

2.8. Administration of Questionnaires

The parents/guardians and children who consented to engage in the study were initially given questionnaires to complete. In most instances, the parents or guardians, the children and the researchers discharged the questionnaire together.

The questionnaires focused on risk factors and the practice of preventive measures for gastrointestinal infections (GITs) by household respondents including demographics of children, occupation of parents or guardians, the number of individuals per household, keeping animals, taking of parasitic prophylaxis, the intervals and where medication was purchased and their sources of potable water. Types of lavatories in use were documented indicating whether they were cemented, covered and possessed a roof or a door, and their frequency of cleaning.

2.9. Specimen Collection

Consenting parents, guardians and children who accepted to also provide specimens for the study were handed clean, dry and wide mouth containers (30 ml capacity with tight fitting lids, carrying numerical codes) in which to collect and retain early morning faeces. The numerical codes were to help identify the children during the microscopic examination of the stools. The sample containers were collected the following morning and transported in a dark leak proof plastic bag to the Laboratory of Biology and Applied Ecology (LABEA) for processing. Parents and guardians were urged to supervise the children to ensure that fresh stool specimens were collected into the containers provided; avoiding contamination with water or urine, since water may contain free-living organisms that could be mistaken for human parasites, and urine may destroy motile organisms. Children who neither completed the questionnaires nor donated specimens for analysis were considered non-respondents. Due to cultural mythology, misapprehension and trepidation about giving specimens to strangers, only one fresh morning stool was processed per child by the direct wet mount, brine floatation and formol-ether sedimentation methods.

3. Parasitological Examination

3.1. Direct Wet Mount

A small amount (2 mg) of faeces was emulsified in a drop of physiological saline on a microscope slide using a wooden applicator stick, and then covered with a coverslip. This preparation was systematically examined, first under low power (10× objective of the light microscope) and then using the 40× objective to determine parasites and motile protozoa. After checking for trophic amoebae, a drop of lugol's iodine was added at the edge of the cover slip to enhance the visibility of nuclei and glycogen vacuoles in any cysts present. Usually iodine kills trophozoites leading to loss of motility [42].

3.2. Formol-Ether Sedimentation

Using a wooden applicator stick, an estimated 1 - 1.5 g of faeces was emulsified in 5 ml of 10% formalin in a beaker. Another 5 ml of formalin was then added and the suspension was strained through a 150 µm mesh sieve directly into another beaker. This suspension was poured into a 15 ml centrifuge tube. Also, 3 ml of ether was added to the suspension in the tube and mixed by putting a rubber stopper on the tube and shaking vigorously for 10 seconds. The stopper was removed and the tubes placed in the centrifuge. These tubes were balanced and centrifuged at 400 - 500 g for 2 - 3 minutes. After removing the tubes from the centrifuge, the contents consisted of 4 layers: a top layer of ether, a plug of fatty debris that was adherent to the wall of the tube, a layer of formalin, and a layer of sediments [42]. The plug of debris was gently loosened with the applicator stick and the top layers poured off, allowing the tube to drain inverted for at least 5 seconds, with a small amount of residual fluid from the walls of the tube flowing back into the sediment. The fluid and the sediments were mixed and a drop of this mixture transferred onto a slide, covered with a coverslip, and then observed as described under the direct wet mount technique, including an iodine-stained preparation [43].

3.3. Preparation of a Saturated Sodium Chloride Solution for the Brine Floatation and McMaster Methods

This was achieved by thoroughly mixing 400 g of Sodium Chloride (NaCl) (kitchen salt) and 1000 ml of distilled water in a clean measuring cylinder of 1500 ml capacity to obtain a saturated solution that was allowed to stand for 48 hours before use [44].

3.4. Brine Flotation

Using a clean spatula, 2 g of fresh faeces was thoroughly stirred in a beaker containing 60 ml of saturated NaCl solution to obtain a homogeneous solution, which was then strained through a metallic sieve of 150 µm mesh into another beaker. Some of this sieved solution was used to fill two test tubes which were left to stand for a few minutes to eliminate air bubbles, after which coverslips were gently placed on top of the test tubes. The coverslips were carefully removed after 30 minutes, placed on clean microscope slides and then examined using the 10× objective [45]. Protozoan cysts, coccidian oocysts, and helminthes eggs and larvae were supposed to float and adhere to the cover slips since the NaCl solution is denser than parasites.

3.5. McMaster Technique

Part of the homogenized mixture for the brine floatation procedure was used to fill in a two-celled McMaster with the aid of a Pasteur pipette. This slide was left to stand for five minutes to allow eggs of helminthes to float, and then viewed under the 10× objective [45].

The cysts and eggs of various parasite species were identified using number of nuclei, glycogen vacuoles, nature of cell wall, shape, diameter and colour. Parasite eggs or cysts present in the stool samples were counted and densities of each species expressed as: "many" (>three cysts per high-power field; >20 eggs per mount); "moderate" (two cysts per high-power field; 10 - 19 eggs per mount); "few" (one cyst per high-power field; 3 - 9 eggs); "rare" (two-to-five cysts and <2 eggs). For simplification, numerical values were assigned to each density: many, 4; moderate, 3; few, 2; rare, 1; and none, 0 [25] [46].

3.6. Statistical Analysis

Data collected was entered into SPSS 16.0 for windows. Chi square was used to compare prevalence with respect to communities, age and gender. Significance level was tested at 5% probability.

3.7. Problems Encountered

Working with families in the three communities was challenging. Superstitions, misconceptions and fear linked to sorcery or "black magic" about giving clinical specimens to unknown persons (the researchers) prevented some households from partaking in the study and limited the study to only one faecal sample collection per respondent. Generally, parents of low social status responded well and were happy with the exercise especially parents who got results to treat positive cases. On the contrary, some wealthy parents closed their doors and gates, and were not concerned with the study. Some of these parents claimed to take their children to the hospital when they were ill and did not entertain any intrusion. Some parents found it boring and time consuming to fill in the questionnaires, and considered the act of assisting their children to collect stool nasty. A few suspicious parents were aggressive, threatening to beat up the researchers if they did not leave their premises with immediate effect. Some of the houses in Ngui were virtually inaccessible as the leading foot paths were very narrow, coupled with the fact that these parents who were mostly farmers and "petty" traders left home very early in the morning and returned late in the evening such that these households could not be sampled. Persuading the children to give specimens was a nightmare for some parents. As a matter of fact, there were confrontations between parents and particularly the older teenagers above fourteen who were not willing to submit specimens for the study. The researchers had to visit some homes twice, trice or more (up to five times for some) to collect stool or to deliver laboratory results. The researchers also faced the task of convincing parents of children who harboured parasites to treat the children and to get medication from authentic chemists.

4. Results

A total of 521 households were identified in the study communities (Ngui 286, Paidground 123 and the Administrative Quarter-AQ 112). Two hundred and ninety-five (295) of the 521 homes answered questionnaires and submitted stool for analysis, giving a response rate of 56.6%. The Ngui locality had a high absolute compliance rate of 69.6% (199 out of a total of 286 households counted completed the questionnaires and provided stool samples for analysis); whereas 39 (13.6%) households only responded to the questionnaires. Only 54 (43.9%) of 123 homes in Paidground complied with this study; 11.4% (14/123 households) only answered questionnaires. The AQ also had an absolute low compliance rate of 37.5% (42/112 homes) and 12.5% partial compliance (14/123 households completed questionnaires. One hundred and fifty-three (153, 29.4%) did not partake in the study at all (Ngui 48, Paidground 55 and the AQ 50).

Tables 1-3 show data on general information, and personal and environmental hygiene in the study areas. Pets rearing was recorded in <20% of households in the study population.

At Ngui, parents were predominantly unskilled workers *i.e*. traders and farmer. Some kitchens were situated just about one to three meters from the latrines and pig styles; and pig sewerage streamed in front of some kitchens. Overflown septic tanks; washed up water from kitchens, toilets and bathrooms; promiscuous defaecation and urination, and the presence of garbage piles and stagnant water were noted health disasters in some living facilities, as children were noticed to play around them. Children were witnessed to play in dirty surroundings of some houses, barefooted. Worthy of note was no water around toilets for hand washing. Some children were seen scavenging bins and wastes disposal sites reportedly searching for pigs' food and other "useful" objects like metals, plastics, used tins and shoes to sell. Spring and tap water constituted the principal sources of potable water in the majority (89.4%) of households in Ngui. A few households (<7.5%) also drank well water. A staggering 88.4% of Ngui natives bought drugs from markets and hawkers, sources discouraged by the government since for the most part, cheap, fake, or substandard medication could be purchased. Additionally, the regular three monthly deworming modal intervals were not respected by more than half of the households which responded to this work. About half of the household respondents had infected children.

Paidground comprised about 50% civil servants. The sources of potable water were the spring and tap. About 65% of parents bought drugs from certified pharmacies or hospitals, the three monthly deworming interval was not respected by most of them (48.1% compliance). Children from 38.9% of households were infected.

Table 1. Baseline variables in the study communities in Dschang.

Characteristic	Variable	Communities			
		Ngui (%) N = 199	Paidground (%) N = 54	Administrative Quarter (%) N = 42	Total (%) N = 295
Occupation: family heads	Civil servants	32 (16.1%)	27 (50%)	39 (92.9%)	98 (33.2%)
	Skilled workers	37 (18.6%)	13 (24.1%)	-	50 (16.9%)
	Unskilled worker	130 (65.3%)	13 (24.1%)	4 (9.5%)	147 (49.8%)
	Student	-	1 (1.9%)	-	1 (0.3%)
Keep pets/domestic animals	Yes	48 (24.1%)	5 (9.3%)	4 (9.5%)	57 (19.3%)
Reported GIT problems	Yes	14 (7%)	7 (13%)	6 (14.3%)	27 (9.1%)
Source of GIT drugs	Hawkers	25 (12.6%)	2 (3.7%)	-	27 (9.1%)
	Market	151 (75.9%)	17 (31.5%)	2 (4.8%)	170 (57.6%)
	Pharmacy	23 (11.6%)	35 (64.8%)	41 (97.6%)	99 (33.6%)
Sources of drinking water	Well	10 (5%)	-	-	10 (3.4%)
	Tap	3 (1.5%)	13 (24.1%)	40 (95.2%)	56 (19%)
	Spring	3 (1.5%)	19 (35.2%)	-	22 (7.5%)
	Well/tap	5 (2.5%)	-	-	5 (1.7%)
	Spring/tap	178 (89.4%)	22 (40.7%)	3 (7.1%)	203 (68.8%)
Deworming intervals	3 months	71 (35.7%)	26 (48.1%)	28 (66.7%)	125 (42.4%)
Houses fenced	Yes	1 (0.5%)	3 (5.6%)	17 (40.5%)	21 (7.1%)
Houseswith infected children	Yes	102 (51.36)	21 (38.9%)	13 (31%)	136 (46.1%)

N = number of households surveyed.

The majority of parents (90.7%) at the AQ were civil servants, and many more (95.3%) bought medication from authentic sources (pharmacies and hospitals). Many families (48.8%) had pit toilets. Most families (93%) consumed tap water. Like PG, garbage piles were hardly sighted. Most of this more informed elite and cosmopolitan population (65.1%) respected the regular three monthly deworming intervals.

The frequency (96%) of pit toilets (most of which were never cleaned) in Ngui was about six times that in the other study areas and the difference was highly statistically significant ($\chi^2 = 78.7$, $P < 0.0001$). About 98% of toilets were roofed, cemented and had doors, but for the Gendarme Camp in the AQ (19 households) which had toilets without doors. All the pit toilets seen were not covered, and all the households did not have cleaning schedules for toilets. Common GIT symptoms were recounted by 39 symptomatic respondents (**Table 4**).

Household size in the three studied communities averaged 7 individuals (**Table 5**). A total of 831 children from the three communities participated in the study. The prevalence of IPIs was significantly higher in the children from the Ngui community (45.7%, $\chi^2 = 86.83$, $P < 0.0001$) than in children from the other two quarters-AQ (17.7%) and Paidground (16.7%) (**Table 6**). Intestinal helminthes identified rated 19.3% significantly different from protozoa with a frequency of 15.4% ($\chi^2 = 4.3$, $P = 0.0380$) (**Table 7**). *Entamoeba histolytica*, *Entamoeba coli*, *Ascaris lumbricoides* and *Trichuris trichiura* were common with rates between 5% and 10%. Increasing age had a significant impact on infection rates ($\chi^2 = 111.97$, $P < 0.0001$) but not sex-131 (33.7%) of 389 males and 157 (35.4%) of 442 females were infected ($\chi^2 = 0.31$, $P = 0.5772$) (**Table 8** and **Table 9**). *E. histolytica* was most prevalent in the 3-to-6 years' age group. *Ascaris lumbricoides* and *T. trichiura* predominated in those above six up to nine years old, while hookworm peaked in those between 12 and 18 years of age. Three children in the 6-to-12 years' category were infected with *Vampirolepis* (Syn. *Hymenolepis*) *nana*. Single parasitic infections were recorded in 288 cases (19.8%), double infections in 51 children (6.1%), and triple infections in 7 infants (0.8%). *E. histolytica* and *A. lumbricoides* ranked highest in single species; common paired associa-

Table 2. Data collected on the personal hygiene of the children in households sampled.

Characteristic	Variable	Ngui N = 199	Paiground N = 54	Administrative Quarter N = 42	Total N = 295
Wash hands before eating	Always	0 (0)	3 (5.6%)	0 (0)	3 (1%)
	Sometimes	199 (100%)	51 (94.4%)	42 (100%)	292 (99%)
	Never	0 (0)	0 (0)	0 (0)	0 (0)
Wash hands after playing with pets	Always	0 (0)	0 (0)	0 (0)	0 (0)
	Sometimes	199 (100%)	54 (100%)	42 (100%)	295 (100%)
	Never	0 (0)	0 (0)	0 (0)	0 (0)
Wash hands after using the toilet	Always	0 (0)	1 (1.9%)	0 (0)	1 (0.3%)
	Sometimes	199 (100%)	53 (98.1%)	42 (100%)	294 (99.7%)
	Never	0 (0)	0 (0)	0 (0)	0 (0)
Parents trim children's nails	Always	0 (0)	1 (1.9%)	0 (0)	1 (0.3%)
	Sometimes	199 (100%)	51 (94.4%)	42 (100%)	292 (99%)
		0 (0)	0 (0)	0 (0)	0 (0)
Moving barefooted	Always	0 (0)	2 (3.7%)	0 (0)	2 (0.7%)
	Sometimes	199 (100%)	52 (96.3%)	42 (100%)	293 (99.3%)
	Never	0 (0)	0 (0)	0 (0)	0 (0)
Visit to bins/garbage Piles	Always	2 (1%)	1 (1.9%)	0 (0)	3 (1%)
	Sometimes	172 (86.4%)	11 (20.4%)	1 (2.4%)	184 (62.45%)
	Never	25 (12.6%)	42 (77.8%)	41 (97.6%)	108 (36.6%)
Play in dust/dirt	Always	5 (2.5%)	0 (0)	0 (0)	5 (1.7%)
	Sometimes	194 (97.5%)	14 (25.9%)	5 (11.9%)	213 (72.2%)
	Never	0 (0)	40 (74.1%)	37 (88.1%)	77 (26.1%)
Put dirty fingers and objects into mouth	Always	0 (0)	0 (0)	0 (0)	0 (0)
	Sometimes	199 (100%)	8 (14.8%)	4 (7.4%)	211 (71.5%)
	Never	0 (0)	46 (85.2%)	38 (90.5%)	84 (28.5%)
Share cups, food, oys with each other/friends	Always	0 (0)	0 (0)	0 (0)	0 (0)
	Sometimes	199 (100%)	12 (22.2%)	2 (4.8%)	213 (72.2%)
	Never	0 (0)	42 (77.8%)	40 (95.2%)	82 (27.8%)
Wash fruits before eating	Always	0 (0)	11 (20.4%)	18 (42.9%)	29 (9.8%)
	Sometimes	199 (100%)	43 (79.6%)	24 (57.1%)	266 (90.2%)
	Never	0 (0)	0 (0)	0 (0)	0 (0)
Pick up and eat food from the ground	Always	0 (0)	0 (0)	0 (0)	0 (0)
	Sometimes	199 (100%)	10 (18.5%)	9 (21.4%)	218 (73.9%)
	Never	0 (0)	44 (81.5%)	33 (78.6%)	77 (26.1%)

Table 3. Data collected on environmental sanitation of households screened.

Characteristic	Variable	Ngui N = 199	Paidground N = 54	Administrative Quarter N = 42	Total N = 295
Promiscuous urination or defaecation	Yes	8 (4%)	0 (0)	0 (0)	8 (2.7%)
Garbage piles around premises	Yes	19 (9.5%)	0 (0)	0 (0)	19 (6.4%)
Stagnant water in premises	Yes	8 (4%)	1 (1.9%)	0 (0)	9 (3.1%)
Toilet and pig styles close to kitchen (≤3 metres)	Yes	7 (3.5%)	0 (0)	0 (0)	7 (2.4%)
Pig sewerage streaming in front of kitchen	Yes	7 (3.5%)	0 (0)	0 (0)	7 (2.4%)
Toilet has a roof	Yes	198 (99.5%)	53 (98.1%)	42 (100%)	293 (99.3%)
Toilet has a door	Yes	198 (99.5%)	53 (98.1%)	24 (57.1%)	275 (93.2%)
Toilet is cemented	Yes	198 (99.5%)	53 (98.1%)	42 (100%)	293 (99.3%)

Table 4. Frequency of types of toilets in study sites.

Communities	Water System	Pit Toilet	Both Types of Toilets (Water and Pit)
Ngui (n = 199)	1 (0.5)	191 (96.0)	7 (3.5)
Paidground (n = 54)	13 (24.1)	39 (72.2)	2 (3.7)
Administrative Quarter (n = 42)	16 (39.5)	21 (48.8)	5 (11.6)
Total (n = 296)	31 (10.5)	251 (84.8)	14 (4.7)

Significantly more pit toilets were present in Ngui ($\chi^2 = 78.7$, $P < 0.0001$).

Table 5. Sizes of households sampled in the three study sites.

Description	Ngui (n = 199)	Paidground (n = 54)	Administrative Quarter (n = 43)
Minimum	3	3	4
Maximum	12	9	11
Mean	6.9146	6.4259	7.3023
SD	1.946	1.487	1.505

Number of individuals per household did not affect infection rate ($P > 0.05$).

Table 6. Overall prevalence of intestinal parasitic infections in the study communities.

Communities	Total Nb. of Children Screened	Total Nb. of Positives (Infected Cases)	Prevalence (%)
Ngui	505	231	45.7
Paidground	168	28	16.7
Administrative Quarter	158	28	17.7
Total	**831**	**287**	**34.5**

Prevalence was significantly higher in Ngui ($\chi^2 = 86.83$, $P < 0.0001$).

Table 7. Prevalence of specific intestinal parasites in the study communities.

Parasites	Nb. (%) infected			Total (%) N = 831	Total (%) with Single
	Ngui N = 505	Paidground N = 168	Administrative Quarter N = 158		Infections N = 831
E. histolytica	64 (12.7)	5 (3)	4 (2.5)	73 (8.8)	46 (5.5)
E. coli	39 (7.7)	5 (3)	4 (2.5)	48 (5.8)	27 (3.3)
G. lamblia	7 (1.4)	0 (0.0)	0 (0.0)	7 (0.8)	6 (0.7)
Total	**110 (21.8)**	**10 (6)**	**8 (5.1)**	**128 (15.4)**	**79 (9.5)**
A. lumbricoides	45 (8.9)	7 (4.2)	10 (6.3)	62 (7.5)	42 (5.1)
T. trichiura	47 (9.3)	5 (3)	4 (2.5)	56 (6.7)	20 (2.4)
Hookworm	26 (5.1)	6 (3.6)	6 (3.8)	38 (4.6)	22 (2.6)
V. nana	3 (0.6)	0 (0.0)	0 (0.0)	3 (0.4)	2 (0.2)
Total	**121 (24.0)**	**18 (1.7)**	**20 (12.7)**	**159 (19.1)**	**86 (10.3)**
Grand Total	**231 (27.8)**	**28 (3.4)**	**28 (3.4)**	**287 (34.5)**	**165 (19.9)**

N = number of children examined; *E* = *Entamoeba*; *G* = *Giardia*; *A* = *Ascaris*; *T* = *Trichuris* and *V* = *Vampirolepis* = *Hymenolepis*. Intestinal helminths rated 19.3% significantly different from protozoa with a frequency of 15.4% ($\chi^2 = 4.3$, $P = 0.0380$).

tions were *E. histolytica* and *E. coli* (1.7%), *A. lumbricoides* and *T. trichiura* (1.3%), and *T. trichiura* and hookworm (1.2%). *A. lumbricoides*, *T. trichiura* and hookworm infected four cases (0.5%). The average intensities of the helminths (**Table 10**, **Figure 1**) differed significantly in the three study communities (F_{cal} = 0.09, F_{Theo} =

Table 8. Age-specific prevalence of intestinal parasites in the study communities.

Age groups (years)	Total Nb. examined	Nb. (%) infected			Total (%)
		Ngui N = 505	Paidground N = 168	Administrative N = 158	
0 - 3	200	23 (11.5)	8 (4)	5 (2.5)	36 (18)
>3 - 6	170	48 (28.2)	6 (3.5)	5 (2.9)	59 (34.7)
>6 - 9	158	56 (35.4)	6 (3.8)	2 (1.3)	64 (42.7)
>9 - 12	122	42 (34.4)	1 (0.8)	3 (2.5)	46 (37.7)
>12 - 15	105	30 (28.6)	3 (2.9)	7 (6.7)	40 (38.1)
>15 - 18	76	32 (42.1)	4 (5.3)	6 (7.9)	42 (55.3)
Total	**831**	**231 (45.7)**	**28 (16.7)**	**28 (17.7)**	**287 (34.5)**

N = number of children examined. Increasing age had a significant impact on infection rates (χ^2 = 111.97, P < 0.0001).

Table 9. Sex-related prevalence of intestinal parasites in communities sampled.

Communities	Nb. of Females Examined	Nb. (%) of Females Infected	Nb. of Males Examined	Nb. (%) of Males Infected
Ngui	268	90 (33.6)	237	78 (32.1)
Paidground	90	13 (14.4)	78	12 (15.4)
Administrative Quarter	85	15 (17.6)	73	10 (13.7)
Total	**442**	**118 (65.6)**	**389**	**100 (61.2)**

Sex did not impact on infection rate (χ^2 = 0.31, P = 0.5772).

Table 10. Intensity of Helminthic infections in the study population.

Description	*Ascaris lumbricoides*	*Trichuris trichiura*	*Hookworm*	*Vampirolepis nana*
Number analysed	62	57	38	3
Minimum	50.00	5.00	50.00	50.00
Maximum	8000.00	2000.00	3000.00	600.00
Mean	747.5806	348.2143	307.8947	233.3333
Standard deviation	1493.001	353.2916	510.369	317.5426
Coefficient of variation (%)	199.711	101.4581	165.7609	136.0897

The average intensities of these helminthes differed significantly in the study communities (F_{cal} = 0.09, F_{Theo} = 3.86, P < 0.05).

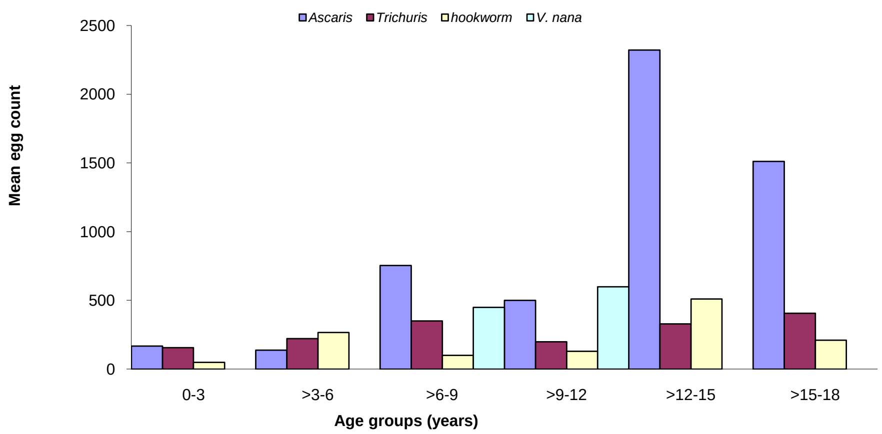

Figure 1. Influence of age on the mean intensities of Intestinal Helminths expressed as mean egg count. Mean egg counts were significantly higher in older children (F_{cal} = 1.3, F_{Theo} = 2.57, P < 0.05).

3.86, $P < 0.05$); highest in Ngui, and were significantly higher in older children ($F_{cal} = 1.3$, $F_{Theo} = 2.57$, $P < 0.05$). Parasites in 16 children were identifiable by all three techniques used. However, most eggs were observed by the floatation method and the protozoans by sedimentation.

5. Discussion

Intestinal parasitic infections (IPIs) still constitute a major cause of illness in children, and are among the most common infections of humans especially in developing countries [2] [3]. IPIs have always been an important public health problem in the tropics, where the humid climate, insanitary environment and poor socioeconomic conditions contribute to the problem. Moreover, chronic infections impair the physical and mental growth and development of children in general and may increase susceptibility to infections with other pathogens [14].

The main mode of transmission of IPIs is the faecal-oral route via poor personal hygiene, environmental conditions like contamination of soil and water sources with human feces, poor sewage disposal, overcrowding and promiscuous defecation [4] [25] [47]. There can as well be mechanical transfer of eggs and cysts from human faeces or sewage to food and/or water by reservoir hosts such as flies, cockroaches and rats which could be the reservoir hosts of the dwarf tape worm *V. nana* [4]. Additionally, parasites of these infections have been found to adhere to vegetables, fruits, fingers, utensils, door handles and even money [25]. Thus, intestinal parasites are ubiquitous and it is not difficult to become infected [48].

Garbage piles could serve as fertile environment for transmission of intestinal parasites [25]. Pit toilets with poor sanitary conditions were common in Ngui than in the other communities, with a lack of adequate water supplies and bathing/washing up facilities. Lack of pipe borne water was a crisis in most households, with most families consuming spring water. Water was considered a probable source of GITs in the study region as spring or well sources werelocated very close to latrines and had been proven not potable if consumed without adequate treatment [49]. Another probable cause of more infections being recorded in Ngui natives could be inadequate deworming of GITs asmost natives bought drugs from uncertified sources, whereas in PG and the AQ, 64.8% and 95% respectively, of families bought medication from validated drug stores. Moreover, 48.1% and 65.1% of the well informed and cosmopolitan elites in PG and the AQ respectively did respect the regular preventive three monthly deworming modal intervals, contrary to 35.7% in Ngui. Thus, it was not surprising thatabout half of the households (51.3%) in Ngui had infected children; whereas <40% of homes in the other areas were infected. Children of food handlers were diagnosed with asymptomatic double infections, and thus, posed high risk to the public. All food handlers were implored to go for regular checks to be medically fit, since infection can occur by eating food prepared by infected handlers. Infected children had to be treated by medics alongside parents and other members of the households to eliminate risk from asymptomatic carriers. Intestinal parasites can live inside the human body undetected for years causing a variety of chronic diseases and conditions such as bloating, anorexia, vomiting, heart burn or chest pain, nausea, flatulence, abdominal pain, weight loss, constipation and diarrhea [48] [50] [51]. Intestinal protozoa like *E. histolytica*, often accompanies diarrhea with blood and mucus, while *G. lamblia* produces diarrhea with the absence of blood and mucus [48] [50] [51]. Furthermore, children who scavenged bins and garbage piles had very high intensities of soil transmitted helminths. This attitude was discouraged in the strongest possible terms, with a view to sanction defaulters.

The intestinal parasites diagnosed in this study included both protozoa—*E. histolytica* 8.8%, *E. coli* 5.8% and *G. lamblia* 0.8% and helminthes—*A. lumbricoides* 7.5%, *T. trichiura* 6.8%, hookworm 4.6% and *V. nana* 0.4%. These results were in consonance with those of a similar study in Kenya by Nyarango and colleagues in 2008 where *E. histolytica* 11.9% and *A. lumbricoides* 13.1% were most associated with IPIs [25]. The present findings were also in conformity with data obtained in Cuba [16] with*A. lumbricoides* 40.5%, *T. trichiura* 35.5% and hookworm 5.5% inprominence. In Dschang in 2007, Dzemo [39] recorded*T. trichiura* 19.7% taking precedence over *A. lumbricoides* 17.2% from stool specimens in school children.

Entamoeba histolytica 8.8%, *A. lumbricoides* 7.5%, *T. trichiura* 6.8%, *E. coli* 5.8% and hookworm 4.6% affected both sexes and all age groups but older children more. The observation of older children aged 6-to-15 years having higher infection rates in this work was congruous with the 1989 study of Celia and colleagues [52].

The least prevalence of *V. nana* (0.4%) was at variance with the findings of Omar *et al*. [11] in Saudi Arabia, but buttressed observations by Onwulin *et al.* [53] in Plateau State, Nigeria where this dwarf tapeworm had the least prevalence (1.6%). Dschang having a cold climate is unfavourable for the survival of *V. nana*; since, hymenolepiasis prevails more in warm countries [54]. Also, infection with *V. nana* could have been through children eating food contaminated with rats' faeces; as rats are the reservoir host of the dwarf tapeworm [4].

The age group distribution of *Ascaris* and *Trichuris* infections followed the trend reported by Ndiforchu [38] and Dzemo [39] in Dschang; early acquisition in life (children from 0-to-6 years old), peaking in early childhood (those greater than 6-to-9 years old) and then stabilizing in later years. However, the significantly higher peaks noticed in *Ascaris* and *Trichuris* with older children, could be as a result of re-infection through food or water contaminated with the eggs of the above parasites; and lack of adequate treatment. Anderson [55] likewise reported that on the basis of population dynamic considerations alone, *Ascaris* and *Trichuris* were more prevalent than hookworm because with their shorter life expectancies, they would have high transmission efficiency relative to that of hookworms. In Cameroon, the geographical distribution of infection by *Ascaris* and *Trichuris* is similar; since environmental conditions play a major role in their transmission and because the eggs of both parasites mature inside the shell before they become infective [30]. The prevalence of *Ascaris* in this study was higher than that of *Trichuris*. *Ascaris* eggs are better resistant to adverse conditions as they are dormant under dry conditions, while *Trichuris* are much less resistant to desiccation. Again, this survey was carried out during the rainy season, and results obtained from a comprehensive review of the geographical distribution of ascariasis in parts of West Africa indicated high rates of *Ascaris* in areas receiving more than 1400 mm of rainfall annually [30].

In this work, 6.1% of the children harboured paired parasitic co-occurrences and 0.8% triple infections. These low rates recorded for multiple parasitism agreed with the findings of Anderson [55], Deuyo [34] and Ndiforchu [38]. Elsewhere, polyparasitism has been reported to affect a considerable proportion of the population [56].

The identification of protozoa and helminthes in this analysis necessitates both antihelminthic and antiprotozoic prophylaxis by the government, and to carry out acomprehensive routine analysis of stool samples incorporating both brine floatation and formol-ether sedimentation in addition to the direct smear in routine faecal laboratory diagnostics. Laboratory testing plays a key role in the effective management of infectious diseases, both in hospital and community settings, as well as providing invaluable epidemiological data. Accurate, rapid identification of pathogens guides optimal therapy and improves patient outcome. Appropriate collection, transportation, storage and processing of specimens rest in the hands of healthcare personnel, and technical proficiency is crucial.

Sensitization and prevention education particular on health, hand washing, sanitation, and clean water for domestic purposes and consumption were desirable in the study communities to minimize parasitic infections. This could be achieved through social groups, leaflets, posters, and radio and television programs in local and official languages. Squalor, reeked refuse dumps and stagnant water, indiscriminate urination and defaecation, pig sewerage and overflown septic tanks streaming around premises, attracting rodents, pests and stray domestic and farm animals; illiteracy, substandard drugs and ignorance or negligence on precautionary measures are possible risk factors for parasitic infections. Children were advised not to play in dust and dirt because they could inhale cysts and eggs of these parasites; and not to put dirty fingers and other objects into the mouth, and were prohibited picking up and eating fruits and food from the ground since parasites could adhere to fingers and fomites. Moving barefooted was also forbidden because hookworm infection is acquired through skin penetration of the filariform (L_3) larvae. Thorough washing of fruits and vegetables before consumption and hand washing before eating and after using the toilet were emphasized to prevent faeco-oral transmission. Parents were entreated to:

- Have routine cleaning and disinfection schedules for toilets, and to ensure pit toilets were always covered to prevent parasitic transmission through flies, rats, cockroaches and other household pests.
- Stop children foraging for food or things from wastes; not to keep animals on verandas, in kitchens or very proximal to living quarters where they urinate and defaecate resulting in malodour.
- Maintain clean premises avoiding refuse piles, stagnant water and indiscriminate urination or defaecation which could act as fertile ground for parasites.
- Always treat water (e.g. sedimentation/decanting, boiling or filtering) before drinking.
- Ensure nails of children are always trimmed so that the children don't cut them with their teeth.

Sustained synchronized deworming, for all children, for all persons living in poor communities and for all food handlers including free periodic laboratory screening will lend to early detection and referral for treatment of the infected especially asymptomatic carriers. Satisfactory road infrastructure or pathways, latrines and housing; and re-introduction of regular sanitary inspections of homes and water supplies as of old are urgent measures for consideration in the study areas. Health education to ameliorate hygiene and sanitation includingensuring sanitary disposal of faeces, adequate hand washing especially after urination or defaecation, appropriate drainage systems and community wastes disposal, and protection of water supplies should be the responsibility of the Ministry of Health. Discouraging faeco-oral sexual practices and use of untreated human faeces as fertilizer to crops to avoid food and water contamination with faeces are also crucial preventive initiatives for parasitic infections. Appropriate care of pets, other domestic and farm animals avoiding contact with children as much as possible; educating traditional rulers, community leaders and family heads, women and children in various forums on infection control highlighting the need for biomedical research to boost prevention and control efforts, should transform, empower and ultimately eradicate the causes and consequences of IPIs in the study environment. It was of the essence for traditional leaders and community heads to be involved in sensitizing their kinsmen to partake in research deemed beneficial to society. Dschang being highly endemic for GITs necessitated periodic updates of traditional rulers, community leaders and family heads via seminars, workshops or conferences.

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