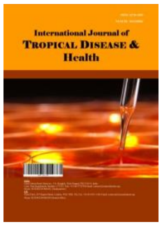

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Prevalence and Risk Factors of Infection with Soil Transmitted Helminths in Children from Bandjoun, the West Region of Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. Authors VRN, PN and MM conceived and designed the study protocol. Authors VRN and ATRJ were major contributors in literature search. Authors VRN, DFDC and NACN participated in data acquisition and analysis. Author VRN drafted the manuscript. Authors PN and MM critically revised the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Background: Soil-transmitted helminths (STHs) continue to be a public health problem in developing countries. In Bandjoun, annual deworming is usually administered to school-age children through the national programme for the control of schistosomiasis and soil-transmitted helminthiasis in Cameroon. However, official data on the level of STH infections are scarce in this locality.

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Methods: We investigated the prevalence and associated risk factors of STHs among children in Bandjoun with the intention to help design future intervention plans. We obtained demographic data and potential risk factors through the interview of children using a structured questionnaire. Stool samples from these children were collected and examined for helminth eggs using Willis' technique.
Results: Three STHs were identified with an overall prevalence of 8.7%. These nematodes were *Ascaris lumbricoides* (8.3%), *Trichuris trichiura* (0.3%) and hookworms (*Ancylostoma duodenale, Necator americanus*) (0.7%). Failure to wash hands before meals (AOR: 2.152 [1.056-4.389]) was the main predictor associated with *Ascaris* infections. Not eating food picked up from the ground (AOR: 0.494 [0.261-0.937]) and not raising pigs at home (AOR: 0.109 [0.045-0.268]) reduced risk of infection.
Conclusion: We recommend that STHs control interventions in Bandjoun focus on the good management of domesticated pigs, the avoidance of contact with soil and handwashing from the earliest ages as a part of daily hygiene practice.

Keywords: Risk factors; prevalence; intensity; soil-transmitted helminths.

1. INTRODUCTION

Soil-transmitted helminths (STH) infections remain a serious public health problem. As pointed out by Hotez et al. [1], the three common STHs are hookworms (*Necator americanus* and *Ancylostoma duodenale*), whipworm (*Trichuris trichiura*) and the common roundworm (*Ascaris lumbricoides*). These parasites are endemic in tropical and sub-tropical regions of the developing world and are associated with poverty, lack of clean water, and poor sanitation [2] which favour their survival and multiplication. Host infection occurs via the faecal-oral route through ingestion of infective embryonated eggs from contaminated soil, vegetables and food products or through direct penetration of the skin by hookworm larvae [3]. Infections are often clinically asymptomatic and contribute to stunted growth and cognitive impairment in children and can cause a fatal disease when high parasitic loads are present [4].

It is estimated that over 2 billion people are globally infected with STHs [5], demanding urgent preventive interventions. In sub-Saharan Africa, STHs infects over 90 million school children [6] and Cameroon is among sub-Saharan African countries where the disease remains an important public health problem. It has been reported that approximately 7.6 million children aged 1 to 15 years are at risk of infection [7] despite deworming campaigns and more than 10 million people continue to be infected with intestinal worms in Cameroon [8]. In addition, the impact of these control efforts remains uncertain or unknown in several localities of the country, such as in Bandjoun, due to financial limitations. We therefore provide current data on the prevalence of STHs among children in Poumougne Sub-division and we investigate associations between specific water, sanitation and hygiene (WASH) related factors and geohelminths to guide the design of appropriate control and prevention measures.

2. MATERIALS AND METHODS

2.1 Study Area and Population

This cross-sectional study was performed in Bandjoun, head of the Nkoung-Nkhi division (5°22'32" Latitude North and 10°24'47" Longitude East), located in the Western part of Cameroon with a total population of 47,405 people in Pètè subdivision. Sixty four per cent (64%) of the population is under 20 years of age and the area is characterized by an equatorial climate of the Cameroonian type, with two main seasons: the raining season (March–October) and a dry season (November–February). Its poor and heterogeneous population is mainly made up of the Bamiléké ethnic group, whose socio-economic status is low. A Health Officer is appointed to each village to coordinate an annual deworming programme with either albendazole or mebendazole, targeted at children.

2.2 Description of Study Setting

A pre-survey allowed us to observe the state of the premises in Bandjoun and to note that the dominant activities of the population are agriculture and traditional animal husbandry under poor hygienic standards, hence the choice of the locality. Six villages (Kamgo, Ha'a, Tessé, Famleng, Mbieng and Ndjione) in the municipality of Pètè Bandjoun where then selected for the study. Some children were seen moving barefooted, playing with fingers on the ground, eating with hands and wearing dirty dresses. People in this area have limited access to basic services and live under poor hygienic standards. Most of the houses are built with soil (poor quality materials) and have soil floors. The living room also serves as kitchen and some rooms are used as stores and houses do not have dining rooms. The types of latrines most often vary from house to house, the majority being pit latrines without a cemented floor and not covered. Houses are most often surrounded by gardens for agriculture and most of the population have electricity.

2.3 Enrolment of Participants

Prior to stool collection, we asked the administrative authorities to sensitize parents about our work in order to facilitate our reception in the households. Children who were sick or had any intestinal contract medication in the past one or two months before specimen collection were excluded from this study. Six hundred (600) children of 1 to 14 years of age participated and provided stool samples.

2.4 Stool Collection and Parasitological Technique

The study was conducted from May to December 2018 prior to the planned national deworming exercise. Faecal pots were distributed to each participant marked with numerical identification and then collected the following morning between 7.30 and 11 am by a door to door collection. Parents and guardians were urged to supervise the children to ensure that fresh stool specimens were collected into the containers provided. All stool samples were checked, placed in a cooler containing ice and immediately transported to the University of Dschang for further processing the following day. In the laboratory, two grams of faeces were analysed with a saturated sodium chloride solution (flotation fluid) as described by Willis [9]. The type of helminth eggs was recorded for each positive sample.

2.5 Questionnaire

A face-to-face interview was conducted with participants in the evening after school. Interview was directed to the parents/guardians of those under seven years of age and directly to children above that age using a structured questionnaire. The questionnaire was prepared originally in French and English, and then translated into Ghomala language (local language) when needed. From each participant, we obtained information on demographic and socio-economic characteristics (i.e. age, sex, education), clinical features (history of deworming), behavioural status (personal hygiene, use of footwear when outdoors, individual defecation practices), as well as living conditions (use of household latrines, water supply) and data on contact with chickens, pigs, dogs, cat. The identification codes on specimen bottles were matched with the identification codes on each child's questionnaire.

2.6 Statistical Methods

Analyses were conducted using SPSS for Windows version 26.0. Pearson Chi-square test was used to test for differences in prevalence according to demographic parameters. The association between helminthic infection and determinant factors was determined by logistic regression by computing crude and adjusted odds ratios at 95% confidence level. Statistically significant variables in the bivariate analysis were used as predictors in the multivariate logistic regression. $P<0.05$ was considered significant. The analyses were only performed for *A. lumbricoides* due to low prevalence of hookworms and *T. trichiura*.

3. RESULTS

3.1 Study Population Sampled

Samples were obtained from 303 (50.5%) males and 297 (49.5%) females. The mean age of children involved in the study was 7.4 (± 3.8 years). The socio-demographic characteristics of the study participants are given in Table 1.

3.2 Analysis of Questionnaire Responses

Well water was the major source (54.7%) for drinking and domestic chores. 564 (94%) of the children used latrines and the remaining, 6% defecated in the open fields or around the household. Two hundred and seventy-nine (46.5%) of the children regularly practiced hand washing before eating. 40.3% of the participants reported they eat food directly collected from ground. In addition, 65.5% of the children did not regularly wear shoes outside the house. Almost 72.5% of participants take anthelminthic but most of them believe in traditional herbs. 66.7% of participants raise animals in or around the household. Two hundred thirty-five (39.2%) of the children do not regularly trim their fingernails and had always dirt in their fingernails.

Table 1. Socio-demographic characteristics of participants

Variables	Character	Frequency (%)
Gender	Female	297 (49.5)
	Male	303 (50.5)
Age in years	1 to 5	196 (32.7)
	6 to 10	261 (43.5)
	11 to 14	143 (23.8)
Educational status	No formal education	105 (17.5)
	Nursery school	79 (13.2)
	Primary school	314 (52.3)
	Secondary school	102 (17)
Locality	Famleng	101 (16.8)
	Ha'a	115 (19.2)
	Kamgo	90 (15)
	Mbieng	108 (18)
	Ndjione	86 (14.3)
	Tesse	100 (16.7)

3.3 Prevalence of STHs

Of the 600, 52 (8.7%) were tested positive for at least one STH. The prevalences of *A. lumbricoides*, *T. trichiura* and hookworms were 8.3%, 0.3% and 0.7% respectively. Eight per cent (8%) were infected with a single species and 0.6% had polyparasitism. For single infection, 7.7% of children were infected with *A. lumbricoides* only and 0.4% infected with hookworms only. The double infections identified in the present study were *A. lumbricoides* and *T. Trichiura* (0.3%) and *A. lumbricoides* and hookworm (0.3%). No significant difference was observed for both monoparasitism and biparasitism amongst infected children.

Table 2. Sex-related prevalence of infection with soil-transmitted helminths

Nematodes	Sex		Total N (%)
	Females N (%)	Males N (%)	
A. lumbricoides	27 (9.1)	23 (7.6)	50 (8.3)
T. trichiura	1 (0.3)	1 (0.3)	2 (0.3)
Hookworm	-	4 (1.3)	4 (0.7)
Total	**28 (9.4)**	**28 (9.2)**	**56(9.3)**

Legend: N (%) = number of positive cases and prevalence (%) in bracket

Table 3. Age distributed prevalence of soil-transmitted helminths in Bandjoun

Age groups (years)	*A. lumbricoides* N (%)	*T. trichiura* N (%)	Hookworm N (%)	Total N (%)
1-5	15 (7.7%)	-	2 (1)	17 (8.7)
6-10	26 (10)	1 (0.4)	2 (0.8)	29 (11.1)
11-14	9 (6.3)	1 (0.7)	-	10 (7)

Legend: N (%) = number of positive cases and prevalence (%) in bracket

Table 4. The prevalence of soil-transmitted helminths among localities

Quarters	*A. lumbricoides* N (%)	*T. trichiura* N (%)	Hookworm N (%)	Total N (%)
Famleng	9 (8.9)	0	1 (1.0)	10 (9.9)
Ha'a	12 (10.4)	0	0	12 (10.4)
Kamgo	9 (10)	2 (2.2)	2 (2.2)	13 (14.4)
Mbieng	9 (8.3)	0	1 (0.9)	10 (9.3)
Ndjione	5 (5.8)	0	0	5 (5.8)
Tessé	6 (6)	0	0	6 (6)

Legend: N (%) = number of positive cases and prevalence (%) in bracket

Table 5. Bivariate and multivariate logistic regression analysis for risk factors for *A. lumbricoides* infection

Variables	***Ascaris lumbricoides***		**OR (95 % CI)**	***p*-value**	**AOR (95 % CI)**	***p*-value**
	Negative N = 550 (91.7)	**Positive N = 50 (8.3)**				
Water source						
Tap water						
Yes	134 (94.4)	8 (5.6)	1.69 (0.77 - 3.69)	0.18		
No	416 (90.8)	42 (9.2)				
Well						
Yes	298 (90.9)	30 (9.1)	0.78 (0.43 – 1.42)	0.43		
No	252 (92.6)	20 (7.4)				
River						
Yes	117 (90.7)	12 (9.3)	0.85 (0.43 – 1.69)	0.65		
No	433 (91.9)	38 (8.1)				
Hand washing habit						
Always	267 (94.3)	12 (9.3)				
Sometimes	283 (88.2)	38 (11.8)	2.98 (1.52 – 5.84)	0.00 **	2.15 (1.05 – 4.38)	0.03 **
Nail cleaning						
Regurlarly trimmed	331 (90.7)	34 (9.3)	0.71 (0.38 – 1.32)	0.28		
Irregularly trimmed	219 (93.2)	16 (6.8)				
Wearing shoes						
Yes	192 (92.8)	15 (7.2)	1.25 (0.66 – 2.34)	0.48		
No	358 (91.1)	35 (8.9)				
Eat food fallen on the ground						
Yes	212 (87.6)	30 (12.4)	0.41 (0.23 – 0.75)	0.00 **	0.49 (0.26 – 0.93)	0.03 **
No	338 (94.4)	20 (5.6)				
Regular deworming						
Yes	403 (92.6)	32 (7.4)	1.54 (0.84 – 2.83)	0.16		
No	147 (89.1)	18 (10.9)				
Raising animals						
Yes	352 (88)	48 (12)	0.07 (0.01 – 0.30)	0.00 **	0.43 (0.08 – 2.21)	0.31
No	198 (99)	2 (1)				

Variables	*Ascaris lumbricoides*		OR (95 % CI)	*p*-value	AOR (95 % CI)	*p*-value
	Negative N = 550 (91.7)	**Positive N = 50 (8.3)**				
Pigs farming						
Yes	166 (79.8)	42 (20.2)	0.08 (0.03 – 0.17)	0.00 **	0.10 (0.04 – 0.26)	0.00 **
No	384 (98)	8 (2)				
Dogs farming						
Yes	110 (85.9)	18 (14.1)	0.44 (0.24 – 0.82)	0.01 **	0.52 (0.26 – 1.05)	0.06
No	440 (93.2)	32 (6.8)				
Place of defaecation						
Latrines						
Yes	515 (91.3)	49 (8.7)	0.30 (0.04 – 2.23)	0.24		
No	35 (97.2)	1 (2.8)				
Open air defecation						
Yes	33 (97.1)	1 (2.9)	3.12 (0.41 – 23.36)	0.26		
No	517 (91.3)	49 (8.7)				

Legend: OR= odds ratio, AOR= adjusted odds ratio, CI=confidence interval

3.4 Prevalence According to Sex

We did not observe any difference in prevalence between males and females although the prevalence of *A. lumbricoides* infections was slightly higher in females than in males, 9.1% and 7.6% respectively (Table 2). Hookworms were found only in males (1.3%), whereas *T. trichiura* was found in both sexes (0.3%).

3.5 Age Related Prevalence

The highest prevalence was recorded in children aged between 6-10 years (11.1%) and the lowest in those 11-14 years (7%) but differences were not significant (Table 3). Generally, *A. lumbricoides* were present in all age groups while *T. trichiura* and hookworms were rare findings. In the 6-10 years aged group, *A. lumbricoides* had prevalence of 10%. Next come children aged 1-5 years where *A. lumbricoides* had the rate of 7.7%.

3.6 Sampling Site Related Prevalence of STHs

All STHs were present in Kamgo where as Famleng and Mbieng had both *A. lumbricoides* and hookworm. In the other localities, only *A. lumbricoides* was detected (Table 4). Prevalences did not differ according to quarters.

3.7 Risk Factors Associated with *A. lumbricoides* Infection

The assessment of risk factors in the bivariate logistic regression identified five factors as independently associated with *A. lumbricoides* infections. After adjusting for potentially confounding variables, we found in the multivariate logistic regression model that not eating food collected from the soil (AOR: 0.494 [0.261-0.937]) and not raising pigs (AOR: 0.109 [0.045-0.268]) were associated with reduced *Ascaris* ($p<0.05$). Irregular washing of hands before meals (AOR: 2.152 [1.056-4.389]) was not only significantly associated with infection ($p<0.05$) but was also the best predictor associated with *Ascaris* infections (Table 5).

4. DISCUSSION

The overall prevalence of STH was 8.7%, with *A. lumbricoides*, *T. trichiura*, and hookworms recorded. This result agrees with the observations of Tchuem Tchuente´ et al. [8] who noted a low prevalence of STHs in the Western region (10.49%) of Cameroon compared to other regions of the country. Khan Payne et al. [10] found a prevalence of 8.5% in Babadjou, a locality close to our study area. In contrast, Njunda et al. [11] in Yaounde, the political capital of Cameroon and Tabi et al. [12] in Tiko town, South West Region of Cameroon, found lower prevalences (2.5% and 1% respectively) than we did. A much higher prevalence of 19.3% has been reported among children in three communities of Dschang town by Fusi-Ngwa et al. [13] and in other regions of Africa [14,15]. Differences in prevalence between studies vary in relation to geographical areas, and climatic conditions as earlier observed by Ratard et al. [16]. The degree of collective and individual hygiene in a community will also influence the prevalence. Also, in this study 72.5% of the participants had a positive attitude toward deworming as reported in the questionnaire responses. Indeed, children were started sampling two months after the school deworming program that may also explain the low prevalence recorded.

The prevalence of *T. trichiura* (0.3%) and hookworms (0.7%) reported in this study are low when compared to 31% and 1.4% respectively reported by Nkengazong et al. [17] among school age children in South-West Cameroon and children in West Cameroon (6.8% and 4.6%) obtained by Fusi-Ngwa et al. [13]. *A. lumbricoides* was found to be the most prevalent parasite as also recorded by Mbuh et al. [18] and Dankoni and Tchuem Tchuente´ [19] in rural communities of Cameroon but with higher prevalence (19.3% and 17.2% respectively) compared to the present study (8.5%). It remains unknown why the prevalence of hookworms and *T. trichiura* were lower in the present study as the studied localities share the same climate. However, as we used the Willis technique which has lower sensitivity than Kato-Katz quantitative technique [20], which was used by Nkengazong et al. [17], Fusi-Ngwa et al. [13] and by Loukouri et al. [15], this may partly explain the observed differences. The higher prevalence of *Ascaris* may be related to their thick shell, which seems to improve their preservation through time compared to other STHs [21] and renders them remarkably resistant to harsh environmental conditions. The very high egg output most likely also plays a role as it is estimated that a single worm may release up to 27 million eggs during the course of an infection and up to two million eggs per day which enter the environment with faeces as reported by Olsen et al. [22].

Lack of hand wash before meals is a predictor for *A. lumbricoides* among children and doubles the risk of being infected. Similar findings have been described previously by Ako et al. [23] in Buea town, among Douala residents [24], the economic capital of Cameroon and among schoolchildren in Ethiopia [14,25]. Indeed, handwashing after contact with excreta is poorly practiced globally as reviewed by Freeman et al. [26]. We observed that there was no water and soap around toilets (most of which were pit toilets and rarely cleaned) for hand washing, reflecting poor standards of hygiene by the households. Children of households that kept domesticated pigs had higher prevalence of *A. lumbricoides* infection than those without pigs. Olsen et al. [27] indicated that pigs are likely to act as transport hosts for human-derived *Ascaris* and Traub et al. [28] found that pig ownership was a significant predictor of *Ascaris* infection in some communities in India. Pigs may therefore act as a disseminator of *A. lumbricoides* eggs but as humans also can become infected by *A. suum* this may also explain pigs being a risk factor for *Ascaris* infections in humans [29,30]. Indeed, we observed that pigsties were poorly maintained with poor disposal of their waste used as fertilizer in the gardens around the houses where children usually play. Some kitchens and latrines were situated about two meters from the pig styles where management systems were sometimes semi-intensive, which may reflect a contamination of the environment with *A. suum.* Children who did not eat food picked up from the ground were about two times at lower risk of being infected with *Ascaris* as compared to those who had such habits. This corroborates with the findings of Galgamuwa et al. [31], highlighting again the importance of hygiene in preventing infection.

5. CONCLUSION

In this study, common STHs were present in children and occurred at various prevalences. *A. lumbricoides* was the most common parasite and infected both sexes and different age categories. This study did not show any significant difference in prevalence by sex, age and sampling site. *Ascaris* infection was associated with hand washing habit, indicating that children must be taught how to keep their hands clean, in particular to wash with soap before eating. We recommend a greater emphasis on the good management of domesticated pigs since keeping pigs around the households was associated with *Ascaris* infection in children. Questions on *Ascaris*'s persistence in order to achieve elimination targets need to be investigated further.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT AND ETHICAL APPROVAL

Ethical clearance for this study was received from the National Committee of Research Ethics for Human Health in Cameroon (N^0 2019/11/54/CE/CNERSH/SP). Children's participation was voluntary after parental or legal guardian consent in writing on their behalf.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hotez PJ, Brindley PJ, Bethony JM, King CH, Pearce EJ, Jacobson J. Helminth infections: The great neglected tropical diseases. Journal of Clinical Investigation. 2008;118:1311-1321.
2. Ogbe MG, Edet E, Isichel NN. Intestinal helminths infections in primary school children in areas of operation of shell petroleum development company of Nigeria. Journal of Parasitology. 2012;23(1):3-10.
3. Brooker S, Archie C, Don AC, Bundy AP. Global epidemiology, ecology and control of soil transmitted helminth infections. Advances in Parasitology; 2006.
4. Blouin B, Casapia M, Joseph L, Kaufman JS, Larson C, Gyorkos TW. The effect of cumulative soil-transmitted helminth

infections over time on child development: A 4-year longitudinal cohort study in preschool children using Bayesian methods to adjust for exposure misclassification. International Journal of Epidemiology. 2018;47(4):1180–1194.
5. Pullan RL, Smith JL, Jasrasaria R, Brooker SJ. Global numbers of infection and disease burden of soil transmitted helminth infections in 2010. Parasite Vectors. 2014;7:37.
6. WHO/Department of control of neglected tropical diseases. Eliminating soil-transmitted helminthiasis as a public health problem in children. Progress Report 2001-2010 and Strategic Plan 2011-2020. Geneva, Switzerland. 2012;78.
7. Ministère de la Santé Publique. Programme National de Lutte contre la Schistosomiase et les helminthiases Intestinales: Plan stratégique 2010-2015. Ministère de la Santé Publique, Cameroun. 2015;29. French
8. Tchuem Tchuente´ LA, Kamwa Ngassam RI, Sumo L, Ngassam P, Dongmo Noumedem C, Luogbou Nzu DD, Dankoni E, Kenfack CM, Feussom Gipwe N, Akame J, Tarini A, Zhang Y, Fobuzski Angwafo III F. Mapping of schistosomiasis and soil-transmitted helminthiasis in the Regions of Centre, East and West Cameroon. PLoS Neglected Tropical Diseases. 2012;6(3):1-12.
9. Thienpont D, Rochette F, Vanparijs OFJ. Le diagnostic des verminoses par examen coprologique. Janssen Research Foundation, Beerse. Belgium. 1979;187.
10. Khan Payne V, Lontuo Fongang R, Ngangnang GR, Megwi L, Mbong E, Yamssi C, Bamou R, Mpoame Mbida. Prevalence and intensity of infection of gastro-intestinal parasites in Babadjou, West Region of Cameroon. International Journal of Clinical and Experimental Medical Sciences. 2017;3(2):14-22.
11. Njunda LA, Assob NJC, Nsagha SD, Nde FP, Kamga FHL, Asangbeng TE, Kwenti TE. Low prevalence of helminth infection among HIV patients in Cameroon. Research and Reviews: Journal of Microbiology and Biotechnology. 2012;1(1):1-11.
12. Tabi ESB, Eyong EM, Akum EA, Löve J, Cumber SC. Soil-transmitted helminth infection in the Tiko Health District, South West Region of Cameroon: A post-intervention survey on prevalence and intensity of infection among primary school children. Pan African Medical Journal. 2018;1-9.
13. Fusi-Ngwa C, Besong E, Wabo Pone J, Mpoame Mbida. A cross-sectional study of intestinal parasitic infections in children in Ghettoed, Diverse and Affluent Communities in Dschang, West Region, Cameroon. Open Access Library Journal. 2014;1:1-14.
14. Teshale T, Belay S, Tadesse D, Awala A, Teklay G. Prevalence of intestinal helminths and associated factors among school children of Medebay Zana wereda; North Western Tigray, Ethiopia 2017. BMC Research Notes. 2018;11(444):1-6.
15. Loukouri A, Méité A, Kouadio OK, Djè NN, Trayé-Bi G, Koudou BG, N'Goran EK. Prevalence, intensity of soil-transmitted helminths and factors associated with infection: importance in control program with Ivermectin and Albendazole in Eastern Côte d'Ivoire. Journal of Tropical Medicine. 2019;1-10.
16. Ratard RC, Kouemeni LE, Ekani Bessala MM, Ndamkou CN, Sama MT, Cline BL. Ascariasis and trichuriasis in Cameroon. Transactions of the Royal Society of Tropical Medicine and Hygiene. 1991;85: 84-88.
17. Nkengazong L, Njiokou F, Wanji S, Teukeng F, Enyong P, Asonganyi T. Prevalence of soil transmitted helminths and impact of Albendazole on parasitic indices in Kotto Barombi and Marumba II villages (South-West Cameroon). African Journal of Environmental Science and Technology. 2010;4(3):115-121.
18. Mbuh JV, Ntonifor NH, Ojong J. The epidemiology of soil-transmitted helminth and protozoan infections in South-West Cameroon. Journal of Helminthology. 2011;86:30-37.
19. Dankoni EN, Tchuem Tchuenté LA. Epidémiologie de la schistosomiase et des géohelminthiases dans l'Arrondissement de Kékem (Ouest- Cameroun). International Journal of Innovation and Applied Studies. 2014;8:1782-1790.
20. Santos FLN, Cerqueira EJL, Soares NM. Comparison of the thick smear and Kato-Katz techniques for diagnosis of intestinal helminth infections. Rev Soc Brasil Med Trop. 2005;38:196-198.
21. O'Lorcain P, Holland CV. The public health importance of *Ascaris lumbricoides*. Parasitology. 2000;121:S51-S71.

22. Olsen LS, Kelley GW, Sen H. Longevity and egg-production of *Ascaris suum*. Transactions of the American Microscopical Society. 1958;77:380-383.
23. Ako SE, Edith A, Vicky TN, Abiabia AN, Kimbi HK. Persistent soil-transmitted helminth infections and associated risk factors among children aged between 4 and 12 in Mile 16 Bolifamba, Buea, Cameroon: 6 Months Post-Deworming Campaign. International Journal of TROPICAL DISEASE and Health. 2018;32(4):1-9.
24. Kuete T, Yemeli FLS, Essono Mvoa E, Nkoa T, Moyou Somo R, Ekobo AS. Prevalence and risk factors of intestinal helminth and protozoa infections in an urban setting of Cameroon: The case of Douala. American Journal of Epidemiology and Infectious Disease. 2015;3(2):36-44.
25. Feleke BE, Beyene MB, Feleke TE, Jember TH, Abera B. Intestinal parasitic infection among household contacts of primary cases, a comparative cross-sectional study. PLoS ONE. 2019;14(10): 1-11.
26. Freeman MC, Stocks ME, Cumming O, Jeandron A, Higgins JPT, Wolf J, Pruss-Ustun A, Bonjour S, Hunter PR, Fewtrell L, Curtis V. Hygiene and health: Systematic review of handwashing practices worldwide and update of health effects. Tropical Medicine and International Health. 2014;19(8):906-916.
27. Olsen A, Permin A, Roepstorff A. Chicken and pigs as transport hosts for Ascaris, Trichuris and Oesophagostomum eggs. Parasitology. 2001;123:325-330.
28. Traub RJ, Robertson ID, Irwin P, Mencke N, Andrew Thompson RC. The prevalence, intensities and risk factors associated with geohelminth infection in tea-growing communities of Assam, India. Tropical Medicine and International Health. 2004;9: 688-701.
29. Nejsum P, Parker ED, Frydenberg J, Roepstorff A, Boes J, Haque R, Astrup I, Prag J, Sorensen UBS. Ascariasis is a zoonosis in Denmark. Journal of Clinical Microbiology. 2005;43:1142-1148.
30. Zhou C, Li M, Yuan K, Deng S, Peng W. Pig Ascaris: An important source of human ascariasis in China. Infection, Genetics and Evolution. 2012;12(6):1172-1177.
31. Galgamuwa L, Iddawela D, Dharmaratne SD. Factors associated with the prevalence of *Ascaris lumbricoides* infection among preschool children in a plantation community, Kandy District, Sri Lanka. Southeast Asian Journal Tropical Medicine Public Health. 2016;47(6):1143-1152.

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