Geohelminth infections and Nutritional Status of Mbororo Children 2 - 15 years in the Bafmeng Health Area, North West Cameroon

ABSTRACT

Background

Geohelminth infections are endemic in Cameroon affecting millions of people and have serious nutritional and developmental effects especially among children.

Aims: There is paucity of information on the prevalence, risk factors and nutritional effect of geohelminths on minority nomadicMbororocommunities in Cameroon, which is addressed herein amongst children 2-15 years in the BafmengHealth Area.

Materials andMethods

Across-sectional community basedstudy was conducted between April 2021 and June 2021 in which 263 children, within the age 2-15 years were randomly recruited and a structured questionnaire was administered to them and their caregivers to obtainsocio-demographic data, hygienic practices and knowledge of caregivers regarding geohelminth infections. A single-stool samplewas obtained from each child and analyzed using the Kato-Katz technique and anthropometric measurements were also obtained and usedtocompute nutritional indices using the World Health Organization Anthro software. Bivariate and multivariate logistic regression were used to identify risk factors of geohelminth infections.

Results

The prevalence of geohelminth infections was 14.4% (38);*Ascaris lumbricoides*(11.41%), *Trichuris trichuira* (2.7%), and hook worm (0.4%). A total of 61.2%(161) of the children were malnourished; underweight (28.5%), stunting (19.0%), severe stunting (11.0%), severely underweight (1.9%), and wasting (0.8%).Geohelminth infectionwas not associated with nutritional status (P=0.4) but it was significantly (p=0.004) associatedwith males (21.9%) than females (8.7%). The use of unsafe water (P=0.03, AOR: 2.01, CI: 1.04 - 1.77) and dumping of waste around the compound(P=0.01, AOR=1.35, CI: 0.13 – 0.95) wererisk factors significantly associated with geohelminth infection. Majority of the caregivers (75.3%) had good knowledge on the transmission and prevention of geohelminths.

Conclusion

On a whole, the prevalence of geohelminth infection is low and malnutrition is high amongst Mbororo children. Long-term control strategies should focus on improvements on environmental hygiene, provision of portable water along side nutritional interventions.

Keywords

Geohelminth Infections, Nutritional Status, Mbororo children, Bafmeng Health Area

Abbreviations:

BAZ: Body Mass Index for A

HAZ: Height for Age

PSAC: Pre-School Age Children

SAC: School Aged Children

SD: Standard Deviation

WASH: Water, Hygiene and Sanitation

DALYS: Disability-Adjusted Life Years

BHA**:** Bafmeng Health Area

W.H.O: World Health Organization

WAZ: Weight for Age

WHZ: Weight for Height

COR: Crude odd ratio

AOR: adjusted odd ratio

INTRODUCTION

Geohelminth infections affect billions of people with serious human, social and monetary burden especially in countries of the tropics [1]. Many people are usually infected by multiple pathogens and infections are noticeably attributed to unsafe water, inadequate sanitation and poor housing conditions [2]. Transmission is often by ingestion of ova found in contaminated soil or water for*Ascaris lumbricoides, Trichuris trichiura* while hookworm infection *(Ancylostoma duodenale and Necator americanus)*is by skin penetration, and they constitute the most common causes of geohelminth infection[3]. Globally, over 2 billion people have been affected by geohelminths [4] and a further 4 billion people are estimated to be at risk [5].In 2017, the global burden of the disease was estimated at 1.9 million disability-adjusted life years (DALYs) [6].

The disease is endemic in Cameroon affecting over 10 million people and is common amongstcountryside dwellers especially in children between 5 – 15 years [7]. Geohelminths have been known to cause alteration in the normal human gastrointestinal flora and aggravation of nutritional disturbances either by reducing food intake and/or increasing nutrient wastage through vomiting, diarrhea, or blood loss [8]. These intestinal worms have been shown to play a significant role in childhood malnutrition, leading to growth retardation, cognitive impairment, and poor academic performance, resulting in a poorer quality of life and less ability to contribute to society [9].

The national prevalence of geohelminthiasis in Cameroon stood at 20.6% and the national prevalence of moderate to heavy infection intensity of the disease was 2.8% in 2018 [10]. In Cameroon, there are about 9.02 million pre-school age children (PSAC) and school age children (SAC) in need of preventive chemotherapy [11]. Data regarding geohelminth infections and malnutrition in minority and pastoralist communities like the Mbororos in Cameroon is unavailable. The indigenous Mbororos constitute a significant proportion inhabiting hard to reach rural settings, which makes it difficult to achieve regular prophylactic chemotherapy amongst PSAC and SAC. Their environment usually presents unique challenges, such as lack of portable drinking water and when tap water is available they are usually far away from the homes, which increases the risk of contamination with geohelminth during transportation.Children usually practice poor personal hygiene such as not washing their hands after visiting the toilet or before eating, eating unwashed fruits and vegetables, consume unpasteurized milk, practice geophagy and move about barefooted, which increases their risk of contracting geohelminth infections. Families typically have close and frequent animal contact, a migratory lifestyle, poor infrastructure, and have limited access to health care facilities, which also increases the risk of worm infections.Few studies have been carried out in Mbororo communitiesand current evidence is lacking with regards to the prevalence, risk factors of geohelminthic infections and its effect on Mbororo children. This study aimed at providing data on the prevalence of geohelminth infections and nutritional status of Mbororo children aged 2 - 15 years residing in the Bafmeng health area, North West region of Cameroon.

MATERIALS AND METHODS

Study Area

The study was carried out in Mbororo communities withinBafmeng Health Area (BHA) underWum health district,in the North West region of Cameroon. This health area is a typical rural settlement which is poorly accessible and harborsmanyMbororo settlements.The main health facility providing primary health care services in the area is the Bafmeng Medicalized Health Center.The BHA lies between longitude

10°08'30''E and 10°16'30''E and latitudes 6°20'08'' and 6°26'30''N and has an estimated population of about 18,738 inhabitants [12]. The area has an agrarian-based economy that consists of cattle rearing, maize, plantain and beans cultivation. Mbororo families, which may be polygamous, live in a compound made of a collection of mud-brick buildings roofed with either grass or corrugated aluminum sheets. Each compound consists of a central building where the father,older male children, and guests live and smaller peripheral buildings for each wife and their younger children. Most of the homes have latrine and the inhabitantsobtain water for domestic choresand drinking from nearby springs and streams. The major means of transportation is by the use of motorcycles.

Study Design

It was a community based cross-sectional descriptive study carried out from April to June 2021, which targetedMbororo children aged 2 -15 years and their primary caregivers in Bafmeng health area. This age group represents the pre-school aged and school aged children who are at high risk of infection with geohelminths.A simple random sampling technique was used to select five (Kiy, Imo, Iseh, Ipalim and Hausa Quarter) out of the eight quarters/sub-villages (Kiy, Imo, Iseh, Ipalim, Hausa Quarter,Akain**,** NyosandAloh) that were included in the study. The name of each quarter/sub-village was written in a separate piece of paper. Each piece of paper was then twisted and put in a box; the papers were then thoroughly mixed and six papers were randomly picked. The name of each of the randomly selected quarter/sub-village was recorded in a sheet of paper. In each quarter/sub-village, Mbororo settlements were conveniently selected based on the population density and accessibility or nearness to a motorable road to enable easy transportation of stool samples to the health facility for analysis. Since these settlements were dispersed, all the households in each selected settlement were included in the study to enable the attainment of the targeted sample size. One child was selected in each household and in case there was more than one child that met the inclusion criteria in a household, a simple random technique was used to select the child for the study. In polygamous homes, one child was selected if all the family members shared a common meal and were under the responsibility of the head of the household, otherwise they were considered separate households and a child was selected from each of the households.Anthropometric measurements and stool sample was obtained from the recruited child and a questionnaire was administered to the child and his or her caregiver. Children who were ill or who had lived in the study area for less than a month or who took anti-parasitic medications less than a month before the study were excluded.

Sample size

The sample size was determined using the Fischer's formula. A prevalence of geohelminths among children obtained from a previous study carried out in a rural community within the North West Region of 19% [13] was used in the calculation and a sample size of 240 was obtained. Assuming a non-response rate of 10%, the targeted sample size was 270.

Ethical Consideration

This study was ethically approved by the Institutional Review Board of the Faculty of Health Sciences, University of Buea(Ref. No.2021/138804/UB/SG/IRB/FHS).Administrative clearance was obtained from the Regional Delegation of Public Health for the North West region, (Ref. No. 125/ATT/NWR/RDPH/BRIGAD) and written informed consent was obtained from the caregivers and assent was obtained from all the children recruited in to this study.

Questionnaire administration

A structured questionnaire was used to collect data using a face-to-face method from each primary caregiver/child after assent/consent was obtained. The questionnaire was used to obtain data on socio-demographic and socioeconomic characteristics of primary caregivers/households, hygienic/behavioral practices of children, information on water and environmental conditions, transmission and prevention of geohelminth infection. The questionnaire was adopted and modified from previous survey questionnaires from two studies [14,15].Participants were met at their homesforquestionnaireadministration and anthropometric measurements. Each pair of participant was interviewed separately in a language they best understood(English, Pidgin English and Fulfulde).

Anthropometric Measurements

This was done following the method described by a study in Ethiopia [16]. The procedure for measurement was explained to the child and caregiver. The child's weight (Kg) and height (cm) were then measured using a mechanical weighing balance (P.M HANA HK, LTD) with a precision of 1kg and a measuring tape with a precision of 0.1cm respectively. Children were weighed and measured alone in bare foot and with light clothing while standing. Children who resisted measurements (mostly 2years old) were weighed together with the mother or caregiver, the caregiver was then weighed alone and the difference between the two measurements was recorded as the child's weight.

Age, height and weight were then used to calculate the following indicators: a) Height-for age Z-score (HAZ) to assess stunting; b) Weight-for-age Z-score (WAZ) to assess underweight; c) Height-for-age Z-score (WHZ) to assess wasting; c) Body mass-index-forage Z-score (BAZ) to assess thinness. Calculations were done using the WHO AnthroPlus software version 1.0.4 and WHO Anthro software version 3.2.2 (WHO, Geneva, Switzerland). BAZ was used as a complement to HAZ for children 10 to 15years [17]. Nutritional status was classified based on the WHO 2007 growth reference in to the following; Stunting: HAZ< -2 SD, Severe stunting: HAZ< -3 SD; Wasting: WHZ< -2 SD, Sever wasting: WHZ< -3 SD; Under-weight: WAZ< -2 SD, Severe underweight: WAZ< -3 SD. The weight status of adolescents was evaluated by calculating the body mass index (BMI)-for-age percentile in comparison to a reference population and was classified as follows: Normal (5–85th percentile), underweight (<5th), or overweight (>85th) [18]. A child with at least one of the three (stunting, wasting or underweight) categories of nutritional status was considered malnourished.

Collection and processing of stool samples

After filling the questionnaire, a labeled screw capped plastic stool container and an A4 sheet of paper was provided to the caregiver or child. The procedure for stool collection was explained to the caregiver/child. In case the child was unable to produce the sample at the time of the survey, the household was revisited for the sample.

The stool was processed on a microscope slide following the Kato-Katz technique [Ref].The slides were stained with malachite green and examined within 60 minutes of preparation using the ×10, and ×40 objectives of the microscope. Two laboratory technicians examined slides that were suspected to have geohelminths and the ova were counted and reported. The total number of eggs counted were multiplied by 24 (for a 41.7mg template) to obtain the number of eggs per gram of stool. The intensity of geohelminth infection was classified based on the number of eggs per gram [19].

Assessment of knowledge of geohelminths

The assessment of knowledge of prevention and transmission of geohelminthiasis was done by allocating a score of 1 for a true response and 0 for a false response to each question on knowledge. The total scores were determined by aggregating the scores from all the correct responses to questions on knowledge. The scores of the total number of correct responses were then used to determine whether a participant had good or poor knowledge using the method proposed in a previous study [20].

Statistical Analysis

Data from questionnaires was keyed in to Excel version 2013 and exported to SPSS version 25 for analysis. Data was summarized and presented in frequency tables (categorical variables). The Chi-square test or Fischer's exact test were used to explore associations between variables. Logistic regression was used to explore associations between socio-demographic, socioeconomic factors, hygienic practices, and environmental variables with geohelminth infections. $p<0.05$ was considered significant and odds ratios at 95% confidence interval were used to indicate the precision and strength of association.

RESULTS

Demographic characteristics of study participants

A total of 280 participants were recruited from the five Mbororosettlements selected for the study (Table 1). The settlement of Ise had the highest number of participants 88 (33.5%), followed by Ipalim 63 (23.9%) and the least number of participants came from Hausa Quarter25 (9.5%). After enrolment, 17 participants (children) were dropped from the study due to inability to provide stool samples for analysis (n=14) and recent consumption of worm medications (n = 3). The age of participants ranged from 2 to 15 years (8.17 ±

3.83) and 149 (56.7%) of the children were females. Majority (37.6%) of the children were in the aged range of 10 – 15 years. One hundred and fifty-sevenof the children (59.7%) were out of school.

Table 1. Socio-demographic characteristics of children recruited in the study.

Variable	Frequency (%)
Age Category (Years)	
PSAC (2 – 5)	83 (31.6)
SAC (6 – 9)	81 (30.8)
Adolescents (10 – 15)	99 (37.6)
Sex	
Male	114 (43.3)
Female	149 (56.7)
Child Schooling	
Yes	106 (40.3)
No	157 (59.7)
Settlement	
Ise	88(33.5)
Ipalim	63(23.9)
Imo	48(18.2)
Kiy	39(14.8)
Hausa Quarter	25(9.5)
Total	**263(100)**

Socio-demographic characteristics of caregivers

The mean age of caregivers was34.40 ± 9.13. Majority (95.1%) of the caregivers were housewives and81.4% of them had no formal education (Table 2). More than half of caregivers (89.7%) were married and 52.5% of those married were in polygamous homes.

Table 2. Socio-demographic characteristics of caregivers at the Bafmeng health area.

Variable	Frequency (%)
Occupation	
House wife	250 (95.1)
Others	13 (4.9)
Marital Status	
Married	236 (89.7)
Separated	10 (3.8)
Widow	17 (6.5)
Marriage type	
Monogamy	138 (52.5)
Polygamy	125 (47.5)
Can read and write	
Yes	47 (17.9)
No	216 (82.1)
Level of Education	
No formal education	214 (81.4)
Primary	35 (13.3)
Secondary	14 (5.3)

Socio-economic characteristics of caregivers

A high proportion (99.6%) of caregivers lived in mud block houses with earthed floors(Table 3). The pit latrine was the most common toilet type (99.6%). More than 90% of homes had no electricity and averagely, more than six persons lived in a household with majority of caregivers earning less than 11000 FCFAper month.

Table 3. Socio-economic characteristics of caregivers in the Bafmeng health area.

Variable	Frequency (%)

Type of house	
Mud block	262(99.6%)
Cement block	1(0.4%)
Type of floor	
Earth	188(71.5%)
Cement	74(28.1%)
Tiles	1(0.4%)
Type of toilet	
Pit latrine	262(99.6%)
Flushing toilet	1(0.4%)
Presence of electricity	
Yes	5(1.9%)
No	258(98.1%)
Ownership of domestic animals	
Yes	254(96.6%)
No	9(3.4%)
Number of persons in the household	
< 6	112(42.6%)
≥ 6	151(57.4%)
Monthly income	
< 11000FCFA	135(51.3%)
≥ 11000FCFA	128(48.7%)

Behavioral and hygienic practices of Mbororo children

Majority of the children (91.3%) reported that, they had received deworming medications in the past but not within one month from the study date (Table 4). A total of(98.8%) of the children practice hand hygiene and (79.8%) of these children consumed unpasteurized milk. Forty six percent of households utilized water from springs for drinking and other household chores. Walking barefoot was not a common practice (6.8%) among the children in the communities visited.

Table 4. Hygienic and behavioural practices of Mbororo children surveyed in the BHA.

Variable	Frequency (%)

Child dewormed in the past	
Yes	240 (91.3)
No	23 (8.7%)
Hand washing before meals and after defecation	
Yes	260 (98.9%)
No	3 (1.1%)
Use of toilet paper during defecation	
Yes	33 (12.5%)
No	230 (87.5%)
Eating of unwashed fruits and vegetables	
Yes	141 (53.6%)
No	122 (46.4%)
Consumption of uncooked meat	
Yes	74 (28.1%)
No	186 (70.7%)
Consumption of unpasteurized milk	
Yes	210 (79.8%)
No	53 (20.2%)
Walking barefooted	
Yes	18 (6.8%)
No	245 (93.2%)
Untrimmed nails	
Yes	35 (13.3%)
No	228 (86.7%)
Soil eating habits	
Yes	37 (14.1%)
No	226 (85.9%)
Waste disposal site	
Pit hole	54 (20.5%)
Around the house	184 (70.0%)
River	25 (9.5%)

Source of drinking water	
Spring	123 (46.8%)
Stream	102 (38.8%)
Public tap	38 (14.4%)
Water treatment before drinking	
Yes	29 (11.0%)
No	234 (89.0%)

Prevalence and intensity of geohelminth infection

The overall prevalence of infection was 14.4% (95%, CI 4.05 to 4.33) Table 5. The most frequent infection was *A. lumbricoides* (11.4%, 95%, CI: 3.80 to 4.04) followed by *T. trichiura* (2.3%, 95%, CI 3.79 to 3.85) and hookworm (0.4%, 95% CI 2.40 to 2.41). Less than 1% (0.4) of the infected children had polyparasitism and all infected children had light intensity infections with mean egg per gram of stool being 78.3 ±893. The prevalence of geohelminth infection did not vary by age (P=0.910) in this study, although infection occurred mostly in pre-school children (n=15). The prevalence of infection differed significantly by sex (P=0.004) and was highest among male children (21.9%).

Table5. Prevalence and intensity of Geohelminthiasis among Mbororo children by sex and age.

	Sex			**Age group (Years)**		
	Male n=114	**Female n=149**	**Total n= 263**	**(2 – 5) n=83**	**(6 – 9) n=81**	**(10 – 15) n=99**
Prevalence of infection	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Any geohelminth	25 (21.9)	13(8.7)	**38 (14.4)**	14 (16.8)	16 (19.7)	8 (8.1)

P value	0.004				0.910	
Ascaris lumbricoides	19 (16.6)	11(7.3)	**30 (11.4)**	13 (15.6)	11 (13.5)	6 (6.1)
Trichuris trichiura	5(4.3)	2(1.3)	**7(2.7)**	1(1.2)	6 (7.4)	1(1.1)
Hookworm	1(0.8)	0(0)	**1(0.4)**	0(0)	0 (0)	1(1.1)
Polyparasitism						
A. lumbricoides+ T. trichiura	1(0.8)	0(0)	**1(0.4)**	0(0)	1(1.2)	0(0)
Intensity of any geohelminth						
Light (78.3 ±893)	24 (21.0)	13 (8.7)	**37 (14.1)**	14 (16.8)	15 (18.5)	8(8.1)

Prevalence of Malnutrition among study participants

The overall prevalence of malnutrition was 61.2% (95%, CI: 5.28 to 6.50)Table6. The prevalence of stunting, severe stunting, and wasting was 19.0% (95%, CI: 4.55 to 4.93), 11.0% (95%, CI: 0.48 to 0.7), and 0.8% (3.40 to 3.42) respectively. Underweight was observed in 28.5% (95%, CI: 5.18 to 5.76) and 1.9% (95%, CI: 5.33 to 5.37) of the study participants were severely underweight.

Table6. Nutritional status of Mbororo children in the BHA.

Variable	**Frequency (%)**

Malnutrition		
Yes		161 (61.2)
No		102 (36.8)
Stunting (< - 2 SD)		50 (19.0)
Severe stunting (< -3 SD)		29 (11.0)
Wasting (< -2 SD)	2 (0.8)	
Underweight (< -2 SD)		75 (28.5)
Severe underweight (< - 3 SD)		5 (1.9)

Effect of age, sex and Geohelminth infection on nutritional status

The prevalence of stunting did not differ significantly (*P*=0.1) by sex and PSAC were the most stunted (51.8%), compared to SAC (44.4%) and adolescents (0.0%)but this difference was statistically significant (*P*=0.*2*). Underweight was more prevalent among male children(36.8%) than in females(25.5%) and this difference was significant (*P*=0.04). Underweight was also more prevalent among SAC(40.7%) compared to the other age groups, however this difference was not significant (*P*=0.05). The frequency of malnutrition washigher in male children (71.9%) compared to their female counterparts (53.0%) but this difference was not significant (*P*=0.09). The SAC had the highest prevalence of malnutrition (85.1%). The relationship between helminth infection and nutritional status was investigated and chi square analysis showed that there was no significant association between geohelminth infections and malnutrition among the study participants (*P*=0.4). Out of the thirty eight children who were infected with at least one geohelminth, 29 of them were malnourished.

Table 7. Association of age, sex and geohelminth infections with nutritional status of Mbororo children in the BHA.

Parameter	Category	n (%)	Stunting (n=79)	Wasting (n=2)	Underweight (n=80)	Malnourished
	Male	114(43.3%)	40(35.0%)	0(0%)	42(36.8%)	82 (71.9%)

Sex	Female	149(56.6%)	39(26.1%)	2(1.3%)	38(25.5%)	79(53.0%)
	P value	-	0.10	-	0.04	0.09
Age group (years)	2 - 5	83(31.5%)	43(51.8%)	2(2.4%)	21(25.3%)	66(79.5%)
	6 - 9	81(30.7%)	36(44.4%)	-	33(40.7%)	69 (85.1%)
	10 - 15	99(37.6%)	0 (0%)	-	26(29.2%)	26 (26.2%)
	P value	-	0.20	-	0.050	0.08
	Positive	38(14.4%)	14(36.8%)	1(2.6%)	14(36.8%)	29 (76.3%)
Geohelminthiasis	Negative	225(85.5%)	65(28.8%)	1(0.4%)	66(29.3%)	132 (58.6%)
	P value	-	0.09	-	0.330	0.40

n: Frequency, PSAC: 2-5years, SAC: 6-9 years, adolescents: 10-15 years

Behavioural, Environmental and Socio-economic risk factors of geohelminth infections

Bivariate analysis revealed that geohelminth infections were significantly (*P*=0.006) associated with male children (21.9%) than female children (8.7%) Table 8. Children who consume unpasteurized milk were 2.28 times more at risk of geohelminth infection than those who do not. Likewise, participants who had the habit of walking barefooted were 2.5 times more likely to be infected with geohelminths, than their counterparts who put on shoes.Base on age group, adolescents (8%) had a significantly (*P*=0.02) lower prevalence of geohelminth infection than SAC (18.55%). However, gender and age group were considered as potential confounders in the model and as such were not included in the multivariate analysis. Other variables which showed *P values* $\leq$ 0.25 in the bivariate analysis were used in the multivariate analysis and they were; sex, age group, child schooling or not, use of tissue paper when visiting the toilet, consumption of unpasteurized milk, walking barefoot, and water source.

Table8. Bivariate analyses of risk factors of geohelminth infections among Mbororo children at the BHA.

Variable	Category	Geohelminth infection status		Bivariate Analysis, COR (95% CI)	*P- value*
		Yes n=38	No n=225		
	Male	25(21.9%)	90(78.9%)	0.35 (0.17 – 0.74)	**0.006**
Child sex	Female	13(8.7%)	135(90.6%)	1	

Children age group	2 - 5	14(16.8%)	69(83.1%)	0.89 (0.40 – 1.20)	0.420
	6 - 9	15(18.5%)	66(81.4%)	0.38 (0.15 – 0.96)	**0.020**
	10 - 15	8(8.0%)	91(91.9%)	1	
Child schooling	No	27(17.1%)	130(82.8%)	1.99 (0.92 - 4.31)	**0.080**
	Yes	10(9.4%)	96(90.5%)	1	
Has received deworming medicine in past.	No	5(21.7%)	18(78.2%)	1.80 (0.62 – 5.20)	**0.250**
	Yes	32(13.3%)	208(86.6%)	1	
Hand washing before eating and after defecation.	No	0(0%)	3(100%)	0.86 (0.66–1.13)	0.990
	Yes	37(14.2%)	223(85.7%)	1	
Use of toilet paper when visiting the toilet.	No	36(15.6%)	194(84.3%)	5.93 (0.78 – 4.84)	**0.080**
	Yes	1(3.0%)	32(96.9%)	1	
Consumption of unwashed fruits and vegetables.	Yes	19(13.4%)	122(86.5%)	0.90 (0.44 – 1.80)	0.760
	No	18(14.7%)	104(85.2%)	1	
Consumption of uncooked meat.	Yes	12(16.2%)	62(83.7%)	1.24 (0.59 – 2.63)	0.560
	No	25(13.3%)	162(86.6%)	1	
Consumption of unpasteurized milk	Yes	33(15.7%)	177(84.2%)	2.28 (0.14 – 1.29)	**0.130**
	No	4(7.5%)	49(92.4%)	1	
Walking barefoot	No	32(13.0%)	213(86.9%)	1	
	Yes	5(27.7%)	13(72.2%)	2.5 (0.13 – 1.16)	**0.090**
	Yes	5(14.2%)	30(85.7%)	0.98 (0.35 – 2.71)	0.960
Untrimmed nails	No	32(14.0%)	196(85.9%)	1	
Child's soil eating habit	Yes	7(18.9%)	30(81.0%)	0.65 (0.26 – 1.62)	0.360
	No	30(13.2%)	196(86.7%)	1	
Family type	Polygamous	18(14.4%)	107(85.6%)	0.94 (0.47 – 1.90)	0.880
	Monogamous	19(13.7%)	119(86.2%)	1	
Caregiver's educational level	No formal education	30(14.0%)	184(85.9%)	1.00 (0.17 – 5.87)	1.000
	Primary	5(14.2%)	30(85.7%)	0.97 (0.20 – 4.50)	0.970
	Secondary	2(14.2%)	12(85.7%)	1	
Number of persons in the household	≥ 6	23(15.2%)	128(84.7%)	1.25 (0.61 – 2.57)	0.520
	< 6	14(12.5%)	98(87.5%)	1	
Caregiver's knowledge on STH transmission and prevention	Poor	8(12.3%)	57(87.6%)	1.22 (0.52 – 2.82)	0.630
	Good	29(14.6%)	169(85.3%)	1	

After adjusting for confounders in the multivariate analysis, it was observed that participants who drank water from unsafe sources such as springs and wells were significantly (P=0.03) associated with geohelminth infection (15.1%) than those who drank water from safe source such as tap and bottled water (7.8%) Table 9. Likewise, children who dump dirt around their compound were significantly (*P*=0.01) associated with a higher prevalence of geohelminth infection (13.0%), than those who through dirt in pit holes (11.1%). However, the highest odds of infection (AOR=5.63, 95 CI: 0.78 – 4.04) was observed among children who reported of not using a tissue paper when visiting the toilet,than their counterparts, but this difference was not statistically significant (*P*=0.08).

Table9. Multivariate analysis of risk factors of geohelminth infections among Mbororo children in the BHA.

Variable	Category	Geohelminth infection status		Multivariate Analysis, AOR (95% CI)	*P-value*
		Yes	No		
Child schooling	No	27(17.1%)	130(82.8%)	1.74 (0.75 – 4.05)	0.190
	Yes	10(9.4%)	96(90.5%)	1	
Has ever received deworming medications in the past	No	5(21.7%)	18(78.2%)	1.75 (0.53 – 5.79)	0.350
	Yes	32(13.3%)	208(86.6%)	1	
Use of toilet paper when visiting the toilet	No	36(15.6%)	194(84.3%)	5.63 (0.78 – 4.04)	0.080
	Yes	1(3.0%)	32(97%)	1	
Consumption of unpasteurized milk	Yes	33(15.7%)	177(84.2%)	1.43 (0.13 – 1.36)	0.150
	No	4(7.5%)	49(92.4%)	1	
Walking barefoot	Yes	5(27.7%)	13(72.2%)	1.38 (0.12 – 1.18)	0.090
	No	32(13.0%)	213(86.9%)	1	
Water source	Unsafe	34(15.1%)	191(84.8%)	2.01 (1.04 – 1.77)	0.030
	Safe	3(7.8%)	35(92.1%)	1	
Waste disposal	Around the compound	24(13.0%)	160(86.9%)	1.35 (0.13 – 0.95)	0.010
	River	7(30.4%)	16(69.5%)	0.32 (0.09 – 1.13)	0.070
	Pit hole	6(11.1%)	48(88.9%)	1	

AOR: Adjusted odds ratio

CI: Confidence Interval

COR: CRUDE odds ratio

1: Comparison group

Caregiver's knowledge regarding the transmission and prevention of geohelminth infections

Out of the 263 caregiver's interviewed, majority 198 (75.3%) of them had good knowledge regarding the transmission and prevention of intestinal worm infection and 250 (95.1%) of them could identify a sign/symptom of worm infection Table 10. However, only 8 (3%) of them knew the different species of worms that cause geohelminthiasis and more than half of the caregivers (53.2%) did not know that soil eating habits and walking barefoot can lead to geohelminthiasis. Majority of caregivers (82.9%) reported that they use concoctions to treat worm infections.

Table 10. Caregiver's knowledge of the transmission and prevention of geohelminth infections.

Parameter	Frequency (%)
Knowledge category	
Good (≥70%)	198(75.3)
Poor (<70%)	65(24.7)
Causes of worm infection	
Known	8(3.0)
Unknown	255(97.0)
Knows a sign/symptom of worm infection	
Yes	250(95.1)
No	13(4.9)
Knows eating soil and walking barefoot can lead to worm infection	
Yes	123(46.7)
No	140(53.2)
Use of concoctions to treat geohelminthiasis	
Yes	218(82.9)
No	45(17.1)

DISCUSSION

The overall prevalence of geohelminth infection among Mbororo children in Bafmeng Health Area was 14.4%, and all infected children experienced light-intensity infections. The low prevalence of geohelminth infection in this study, can be attributed to the deworming program occasionally implemented by the ministry of public health in this locality. This finding is the same as the 14.44% obtained from a similar study carried out in 2018 inTiko, located in the South West Region of Cameroon[21].The results of this study are also in line with previous studiesin the North West and West regions of Cameroon where a prevalence of 18.3% and 11.6% respectively were reported [13] and [22]. However, the overall prevalence of geohelminth infection was lower, when compared to values reported by two other studies [23, 24] carried out in some rural localities in the South West Region of Cameroon, where a higher prevalence of 46.2% and 31.0% respectively was observedamong children. This difference in prevalence can be explained by variations in socio-economic status, behavioral practices, seasonal differences and frequency of deworming campaigns.

Ascaris lumbricoides was the most prevalent parasitic worm (11.4%) followed by *Trichuris trichiura* (2.7%) and hookworm (0.4%). The observation that *Ascaris lumbricoides* was the most dominant geohelminth, followed by *Trichuris trichiura* and hookworm is in agreement with previous studies conducted inLoum, located in the Littoral Region of Cameroon[25]. Ascariasis is most common probably because it is easily transmitted through ingestion of contaminated food or water. The ova of *A. lumbricoides* is also more resistant to desiccation compared to the ova of other geohelminths. This increases the chances of contamination and transmission to humans, hence leading to predominance of the disease. The hookworms (*A. duodenale and N. americanus*) had the lowest prevalence (0.4%), this might be due to the fact that walking barefoot was not a common practice among the children involve in this study.

Male children were significantly more infected when compared to their female counterparts (21.9% vs 8.7%). This can be explained by the fact that, male children are more exposed to outdoor environments which may be contaminated with helminths ova, due to improper disposal of human wastes. Children within the age group 6 – 9 years were the most infected (n=16) and they represent the school aged group which were at a higher risk of contracting the geohelminthiasis. Usually school age children are usually separated from their parents while in school, but they have a very low knowledge of hygienic practices which may expose them to infection during their interactions with one another.

There was a significantly high levels of malnutrition (61.2%) and underweight (28.5%) was the most common nutritional disorder. Stunting and wasting had prevalence of 19.0% and 0.8% respectively and severe stunting and severe underweight among participants was 11.0% and 1.9% respectively. The high level of malnutrition is similar to what is reported in Cameroon Demographic Health Survey,wherethe prevalence of stunted children was 29.0%,wasted 4.0% and underweight 11.0% [26]. Based on gender, males were more malnourished compared to their female counterparts (71.9% vs. 53.0%). These data is consistent with the results of similar studies carried out among Fulani children in Cameroon [27] and Nigeria[28, 29]. The high prevalence may be because these communities are among the underserved group in terms of access to health services and are characterized by poor feeding habits. However, females were more malnourished, compared to males in a study carried out in Foumban[26].

A total of 18.0% of all geohelminth infected children were malnourished but there was no significant association ($p>0.05$) between geohelminthiasis and nutritional status among the study participants. This is consistent with the findings of Garba *et al.* [30] in Ngoundere, Cameroon and Merem*et al.* [31] in Ethiopia. However, contrary to the findings of this study,Moncayo*et al.*, 2018[32] in rural Honduras and Mbuh*et al.*, 2013[33] in Douala, reported that geohelminth infections among children were associated with reduced anthropometric indices. Helminth-induced malnutrition is usually chronic and associated with moderate to heavy infection intensities of intestinal worms, but the current study found light infections among all infected participants and this could be the reason for the absence of significant association of nutritional status with helminthic infection.

This study identified drinking of unsafe water sources and disposal of waste around the compound as risk factors significantly associated with STH infections among the study participants. This is in agreement with the fact that improvements of water hygiene and sanitationfacilities and appropriate health-seeking behavior are essential for achieving sustained control and elimination of STH and many other NTDs at large [34]. In line with the result of this study, a systematic review and meta-analysis also stated that "access to piped water was associated with lower odds of *A. lumbricoides* and *T. trichiura* infection" [14]. Children who did not use a tissue paper after defecation were 5.63 times more at risk of being infected by geohelminths compared to those who use tissue paper, though this was not statistically significant. These results are similar to that obtained by Dzune*et al*., 2020[35] in a study carried out in Banjoun.

Over 70% of caregivers had an overall good knowledge on the risks factors and preventive measures of geohelminthic infection; 95.1% of the caregivers knew at least one sign and symptom of intestinal worm infection. This was consistent with findings from other studiesin Cameroon [36] and Thailand [37]in 2011 and 2015 respectively. However, these findings were contrary to those of a study carried outin Nigeria [38], in 2011 which reported that less than half of the participants had appropriate knowledge. These findings are also contraryto the results of a study carried out in Bangladesh [39] where a high proportion of caregivers had inadequate knowledge. The difference in these findings could be explained by increase awareness and sensitization campaign efforts made by health authorities through the creation national control programmes, health information from media and awareness by health staff and community health workers.

CONCLUSION

A low prevalence of geohelminth infection (14.4%) was observed amongMbororo children in the Bafmeng Health Area, and risk factors for the disease were; drinking of water from unsafe water sources and discarding waste around the compound.However, a high level of malnutrition (61.2%) was observed among the children, which comprised of underweight (28.5%), stunting (19.0%), severe stunting (11%), and wasting (0.8%)but there was no significant association between geohelminth infection and nutritional status.

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COMPETING INTERESTS

The authors declare that they no competing interest over this work.

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AUTHORS' CONTRIBUTIONS

IK: Conceived the topic, Collected the data, participated in writing the proposal, data analysis and interpretation and contributed in the write-up of the final manuscript. RBN: Conceived the topic, participated in writing the proposal, data analysis and interpretation and wrote the first draft of the manuscript. TN: Assisted in data analysis and interpretation and contributed in the write-up of the final manuscript.. All the authors read and approved the final manuscript."

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