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Research Article

Prevalence and Associated Risk Factors of Hookworm Infection among Primary School Children in Three Selected Schools in Moriba Town, Southern Sierra Leone

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Abstract: Background: In tropical and subtropical developing nations, hookworm is the main cause of maternal and childhood illnesses. In vulnerable children, hookworm causes cognitive and growth retardation, intrauterine growth delay, prematurity, and low birth weight among newborns of infected mothers. The research aims to determine the prevalence and risk factors of hookworm infection among primary school children in three selected schools in the study area. **Methods:** This study utilized a case-control research approach. Stool specimens were collected and analyzed for intestinal parasites from children in classes 1-6. A total of sixty (60) enrolled students between the ages of 5 and 15 were chosen at random from three primary schools in Moriba town, Bo city, southern Sierra Leone. **Results:** The research findings revealed that the prevalence of hookworm infection was 47.4% among 5-7 years in the study area. The findings also demonstrated that there was no connection between the children's sex and hookworm infection. It was discovered that women had a higher risk of contracting an infection than men. The prevalence of hookworm among the children and the accessibility of toilets in the home were significantly correlated. A significant association with hookworm infection was shown in the toilet facility type. **Conclusion:** Hookworm infections are extremely frequent in Sierra Leone among schoolchildren and are a major cause of the disease. Poor personal and environmental hygiene, poverty, and a favourable climate are important variables for the sustainability of transmission, but no policy-driven effort to prevent it has been made.

Keywords: hookworms, toilet facility, children, environmental sanitation, poverty

1. Introduction

Hookworm is the most common cause of maternal and childhood illnesses in developing tropical and subtropical countries. In developed countries, hookworm infection is usually mild, but anaemia in a chronically infected person

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can be severe [1]. Despite tremendous progress in treatment and control, hookworms are the most common intestinal helminth parasites transmitted by soil, affecting a major fraction of the global populace (about 900 million people yearly), primarily in tropical and subtropical regions [2]. In school-aged and adult populations in tropical areas, mature hookworms attach to the small intestine's mucosa, feed on blood, and are a primary cause of anaemia [3]. The two primary types of human hookworms are *Necator americanus* and *Ancylostoma duodenale*, which attach themselves to the intestinal wall and feed on blood, leading to symptoms such as abdominal pain, diarrhoea, and anaemia. People in endemic areas frequently have both types of infection at the same time. For treatment and management techniques, these species are usually regarded as identical, notwithstanding major variations in their life histories [4]. Reports of unsuccessful medication treatment and fast reinfection rates after anthelmintic therapy are probably due to failure to take into account such variations. Reports of the various anthelmintic susceptibilities between species show that the use of just one anthelmintic may not be sufficient to eradicate both species [5].

In most researches, hookworm infections are not distinguished, and past epidemiological data indicating that one species prevails over the other is relied on [6]. This is because the eggs of the two species are identical, and while physical distinctions are found between the adult worms, regular parasitological testing is seldom accessible. The delicate physical traits that distinguish the infectious, third-stage filariform (L3) larvae raised from eggs in copra cultures have historically been used for species identification [7]. The larvae of both hookworms may be microscopically differentiated, but this is not done frequently, normally for research purposes. Although adult worms are rare, if they are founded, they would enable conclusive species identification. The length of the buccal cavity and the distance between the mouth entrance and the oesophagus can both be used to specify [8, 9]. Moreover, the larvae of *A. duodenale* have an unobtrusive head and tail with no gap between the oesophagus and the intestine, and the oesophagus is not shaped like a thistle funnel. Larvae of *N. americanus* also have a blunt head and tail without a gap between the oesophagus and the intestine. However, the oesophagus is shaped like a thistle funnel [10].

One of the main risk factors for hookworm infection is living in or travelling to areas with poor sanitation and hygiene. These worms are transmitted through contact with contaminated soil or faeces, and people living in areas without access to clean water or proper sanitation are at a higher risk of infection. Research conducted [11] among school children in Northwest Ethiopia revealed that factors such as the absence of regular wearing of shoes and the absence of proper latrine utilization were significantly associated with hookworm infection. Another risk factor is poverty, as people living in poverty are more likely to live in areas with poor sanitation and may also have limited access to healthcare. Findings from a study by [12] indicated that low socioeconomic status was highly associated with Soil-Transmitted Helminth infections. Another study by [13] also indicated that poverty was associated with hookworm infection. Other potential risk factors include walking barefoot, working in jobs that involve contact with soil, and having a weakened immune system [14].

Research interest in hookworm infection is driven by the high burden of disease in developing countries, where the infection is most prevalent. Although past findings from parts of Sierra Leone revealed that *N. americanus* is the ubiquitous and dominant hookworm species and *A. duodenale* represents an insignificant portion of the local hookworm infections, the epidemiological conditions may differ from those previously reported [7]. The proportional distribution of the two species might also vary between endemic areas. Similar studies in other parts of the country must therefore be carried out to have a better understanding of the problem.

Due to high morbidity associated with hookworm infections in children, it will be very prudent to undertake this research work so as to determine rate of hookworm infections among primary school children and the associated risk factors. Most children who are asymptomatic may serve as a source of infection to other children. This research will help determine children who are asymptomatic but are carriers of hookworm infections so that they can be treated immediately to prevent the spread of the infection. The results which would be obtained from the research work will help the Ministry of Health, the Town Development Council and stakeholders to provide the necessary interventions such as school deworming programmes, health education and other preventive measures to minimize the burden of hookworm infestation within the study area.

Therefore, this research is aimed at determining the prevalence and intensity of hookworm infection among primary school children in three selected schools in the study area.

2. Methods

2.1 *Research design*

This study employed a case-control research design. Stool specimens were collected and examined for intestinal parasites from children in classes 1-6 in three schools. Children identified to be infected with intestinal parasites were compared with the same number of uninfected children in the same class based on age, sex, institution, and nutritional status including, the socio-economic class of the parents.

2.2 *Study area*

The three public primary schools included in this study were United Brethenin Crist (UMC) primary school, Islamic primary school, and District Education Committee (DEC) primary school in Moriba town section, Bo city southern Sierra Leone. UMC primary school had 155, Islamic primary school had 165, and DEC had 145 children aged 5-10 years. Every school listed had upgraded restrooms with slab-covered walls and floors made of cement. Additionally, they have at least one water tank, but it was only used to store water during rainy periods, therefore there was never any water in the classrooms during dry seasons. Bo city (which lies approximately 160 miles southeast of Freetown) has a population of 306,000. It covers an area of 51.71 Km^2 with a population density of 87.29 persons/km^2. The Moriba town section is inhabited by different ethnic groups, mainly the mende, temne, fula, madingo, and loko. The main sources of income in the region include backyard gardening, petty trading, and commercial bike (Okada) riding.

2.3 *Study population*

The population was gathered from three primary schools selected at random among six schools in the Moriba town section of Bo city. The study population included children aged 5-15 years who were able to provide stool samples and whose caregivers gave their full consent to the study. Those who could not meet these criteria were excluded from the study.

2.4 *Data collection methods*

2.4.1 *Structured questionnaire*

A structured interviewer-administered questionnaire was employed in this school-based study to obtain data, which was primarily quantitative. The caregivers of the participating children were questioned using pre-tested structured administered questionnaires in English at school after providing written consent and a fingerprint (for those without reading and writing skills). The questionnaire covered problems in the family history of children aged 5 to 10 years in their respective schools, socio-demographics, economics, hygiene, and environmental sanitation. Each questionnaire was clearly labelled with the participant Identification number.

2.4.2 *Stool examination*

As previously reported, Katz's modified thick-smear technique was used to collect and analyse stools [15]. A small amount of stool is collected in a container and mixed with a fixative, such as formalin, to preserve the parasites before being placed on a microscope slide. The slide is then stained with a special dye, such as Lugol's iodine, to make the parasites visible under a microscope. To calculate the intensity, the species and quantity of eggs/worms were identified and counted. Children who tested positive for eggs and worms were chosen as study subjects. Selecting those only infected by hookworm infection came first. Only those with mild concurrent infections with Ascaris or Trichuris were included in the hookworm-positive group in situations of mixed infection with hookworm and other parasites. Children who had solely hookworm infections were divided into groups based on the WHO's standards for heavy, moderate, and light infections [16]. Following a stool analysis, helminth-free kids were chosen to represent the control group.

2.4.3 *Deworming*

Children with hookworm infections alone or hookworm and Ascaris infections received a single dosage of 400 mg of albendazole (2 × 200 mg tablets). Children with combined infections (hookworm/trichuris) were given mebendazole, 100 mg twice daily for three (3) consecutive days. Each child receiving treatment was observed to ensure that the medication was taken properly.

2.4.4 *Data analysis*

Data was entered and analyzed using SPSS version 25 statistical software. Using descriptive statistics, the overall magnitude of hookworm was determined. Bivariate analysis was used to determine the strength of the association between hookworm infection and several determining variables. Multivariate analysis was performed on independent variables with a Crude Odds Ratio (COR) < 0.02. To eliminate the confounding effect, multivariate logistic regression was used to calculate Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI). If the p-value was less than 0.05, the differences were considered statistically significant.

2.4.5 *Ethical approval*

The study was approved by the Sierra Leone Ethics and Scientific Review Committee of the Ministry of Health and Sanitation and authorities in the Southern Region. Written, informed consent was obtained from Head Masters, community leaders, household heads and mothers for the questionnaire survey and sampling at the clinical field unit and from head teachers in the primary schools on behalf of the school pupils who participated. Focus Group Discussions (FGD) was held with the parents, children, and community leaders in each school to explain the aim of the study, the procedures involved, and the benefit and risks of being involved in the study. The benefits were that school children received free laboratory investigation and free treatment for Hookworm infection.

3. Results

3.1 *Sociodemographic information of pupils and prevalence of hookworm infection*

From Table 1, a total of 60 pupils from three different schools took part in the study, with an average age of 11-15 years (41.7%), 5-7 years (31.7%) and 8-10 years (26.7%). Male participants accounted for over half of the population that participated in the study (51.6%). Most of the participants practised Christianity (50.0%) followed by Islam (43.3%). An equal number of participants (20) was obtained from each school represented (UMC, DEC, and IPS, respectively). The prevalence of hookworm was 47.4% among 5-7 years old followed by 44.0% among 11-15 years old and 31.3% among 8-10 years old. The prevalence of hookworm infection among male and female pupils was 16 (51.6%) and 9 (31.0%), respectively (Table 1).

3.2 *Socio-demographic information of caregivers*

Results from the socio-demographic information of caregivers revealed that most of the caregivers attended tertiary institutions (38.3%), 18.3% attended primary and secondary schools, respectively, and 25.0% of the caregivers attended neither primary, secondary, nor tertiary institutions. The majority (51.7%) of the caregivers were males, while females accounted for 48.3%. The marital status of the caregivers revealed that 43.3% were married, 31.7% were single, 13.3% were divorced, and 11.7% were widowed. Most of the caregivers were unemployed (56.7%), while 43.3% were employed. The Table also revealed that 40% had a family size of 5 to 6, 31.7% had a family size of 7 and above and 28.3% of the caregivers had a family size of less than 4. 61.7% of the caregivers earned a salary of less than Le 500,000 and 38.3% earned more than Le 500,000. The majority of caregivers (68.3%) live in cities, while 31.7% live in rural areas (Table 2).

Table 1. Sociodemographic information of pupils and prevalence of hookworm infection

Variables	N	%	Hookworm infection	
			Cases	Controls
Age				
5-7 years	19	31.7	9 (47.4)	10 (52.6)
8-10 years	16	26.7	5 (31.3)	11 (68.8)
11-15 years	25	41.7	11 (44.0)	14 (56.0)
Gender				
Male	31	51.7	16 (51.6)	15 (48.4)
Female	29	48.3	9 (31.0)	20 (68.9)
Religion				
Islam	26	43.3	9 (34.6)	17 (65.4)
Christianity	30	50.0	13 (43.3)	17 (56.7)
None	4	6.7	3 (75.0)	1 (25.0)
Schools				
UMC	20	33.3	6 (30.0)	14 (70.0)
DEC	20	33.3	10 (50.0)	10 (50.0)
IPS	20	33.3	9 (45.0)	11 (55.0)
Total	60		25 (41.7)	35 (58.3)

3.3 *Bivariate analysis of hookworm infection*

Determinant factors including walking barefoot, the habit of not wearing shoes, the absence of toilet facilities, and the absence of deworming in the last 6 months were associated with hookworm infection (Table 3).

3.4 *Multivariate analysis of hookworm infection*

Table 4 shows the characteristics of the cases and controls. At epidemiological analysis, the Odds Ratio (OR) of wearing shoes (OR = 1.56, 95% CI 0.41-5.87); frequency of not wearing shoes (OR = 2.03, 95% CI 0.64-6.5), availability of toilet facility (OR = 1.72, 95% CI 0.29-10.22) and deworming in the last 6 months (OR = 2.1, 95% CI 0.57-7.68) were considerably predictable factors associated with hookworm infection. According to the findings, school children who did not wear shoes had a 1.56 (COR) higher chance of contracting hookworms. Children who do not wear shoes regularly have a 2.03 (COR) higher risk of contracting hookworm than those who do. The odds of hookworm infection were 1.72 (COR) more likely in children who do not have latrines than in those who had. Children who received a deworming treatment had a 2.1 (COR) higher chance of being protected than those who did not.

Table 2. Socio-demographic information of caregivers

Variables	N	%
Education status		
None	15	25.0
Primary	11	18.3
Secondary	11	18.3
Tertiary	23	38.3
Gender		
Male	31	51.7
Female	29	48.3
Marital status		
Single	19	31.7
Married	26	43.3
Divorced	8	13.3
Widowed	7	11.7
Occupational status		
Employed	26	43.3
Unemployed	34	56.7
Family size		
Less than or = 4	17	28.3
5-6	24	40.0
Greater than 7	19	31.7
Family income		
Less than or = Le 500,000	37	61.7
Above Le 500,00	23	38.3
Residence		
Urban	41	68.3
Rural	19	31.7

Table 3. Bivariate analysis of hookworm infection

Variables	N	%	Hookworm infection		Crude OR (95% CI)	p-value
			Cases	Control		
Hand washing before meals						
Yes	44	73.3	18 (22.7)	26 (77.3)	0.69 (0.13-3.83)	
Sometimes	10	16.7	4 (40.0)	6 (60.0)	-	0.01
No	6	10.0	3 (50.0)	3 (50.0)	1	
Do you eat raw vegetables?						
Yes	34	56.7	10 (29.4)	24 (70.6)	0.31 (0.1-0.89)	0.04
No	26	43.3	15 (57.7)	11 (42.3)	1	
How often do you eat raw vegetables?						
Some times	28	46.7	8 (28.6)	20 (71.4)	1.25 (0.19-8.23)	0.00
Regularly	6	10.0	2 (33.3)	4 (66.7)	1	
Do you wear shoes?						
Yes	48	80.0	21 (43.8)	27 (56.3)	1.56 (0.41-5.87)	0.01
No	12	20.0	4 (33.3)	8 (66.7)	1	
How often do you not wear shoes?						
Sometimes	4	33.3	8 (34.8)	15 (65.2)	2.03 (0.64-6.5)	0.03
Regularly	8	66.7	13 (52.0)	12 (48.0)	1	
Hand washing after defecation						
Sometimes	20	33.3	9 (45.0)	11 (55.0)	-	
Yes	31	51.7	9 (29.0)	22 (70.9)	0.12 (0.02-0.67)	0.01
No	9	15.0	7 (77.8)	2 (22.2)	1	
How hands are washed						
Soap and water	25	41.7	8 (32.0)	17 (68.0)	0.5 (0.17-1.45)	0.00
Just water	35	58.3	17 (48.6)	18 (51.4)	1	
Do you have a toilet facility?						
Yes	54	90.0	25 (46.3)	29 (53.7)	1.72 (0.29-10.22)	0.02
No	6	10.0	2 (33.3)	4 (66.6)	1	
Deworming in the last 6 months						
Yes	46	76.7	21 (45.7)	25 (54.3)	2.1 (0.57-7.68)	0.04
No	14	23.3	4 (28.6)	10 (71.4)	1	

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No	14	23.3	4 (28.6)	10 (71.4)	1	

4. Discussion

In underdeveloped nations like Sierra Leone, where school-going children are at the highest risk, hookworm infection during childhood continues to be a significant public health concern. Deworming initiatives are the main strategy being used to reduce the burden of hookworm infection in Sierra Leone. Although this approach lessens Soil-Transmitted Helminths (STH) related sickness, other trials have demonstrated that it does not stop rapid reinfection [17]. Integrated control strategies that incorporate access to sanitation and other complementary primary prevention-focused interventions are required to stop the spread of the disease and achieve local helminthiasis eradication [18]. Therefore, the purpose of this study was to determine the frequency and risk factors for hookworm infections among kids aged 5 to 15 from particular schools in Moriba town sector, Bo city, southern Sierra Leone.

The study findings revealed that the prevalence of hookworm infection was 41.7% in the study area. The findings are similar to a reported prevalence of 40.1% in a study carried out on soil-transmitted helminths infections in school children (aged 3-10 years) in remote Southwest Sierra Leone [19]. On the contrary, the attested prevalence was lower than that of 52.3% reported in a study done in Dessie Referral Hospital on intestinal protozoa among children under five years old [20]. Another study carried out on schoolchildren in underprivileged urban and peri-urban areas of Ethiopia revealed a high incidence (71%) of hookworm [18]. The observed rate in the current study as compared to the high rates in the studies stated above may be explained by changes in the climate, the environment, or the location of the study regions.

The growth and survival of eggs and larvae are known to be influenced by soil moisture and relative air humidity, according to epidemiological research. At low humidity (50%), the ova of hookworm does not embryonate, whereas higher humidity is linked to faster ova development [6]. The rural environment with hookworm infection may also be responsible for the study's low rate of hookworm infection compared to the high rate seen in Freetown's peri-urban and urban neighbourhoods. According to studies that looked at comparable age groups and socioeconomic strata, hookworm prevalence varies across urban and rural locations. It is still unclear why hookworm dichotomies exist between urban and rural areas. In addition to sanitation or population density, socioeconomic disparities may also have a significant impact on the prevalence of hookworm in urban and rural settings [21]. Drug use by the children in the study could have an impact on the prevalence rate. Anti-parasitic medications, in particular, prevent the identification of intestinal parasites through stool testing [22].

Although the sex of the children and hookworm infection were not significantly correlated in this study, it was shown that boys had a higher risk of hookworm infection than girls did. Due to the cultural norms of the Moriba town community, where there are no gender-specific requirements for household chores and everyone participates in routine tasks like farming and cooking regardless of gender, both men and women may be equally exposed to hookworm infection as a result of this insignificance. Contrary to numerous studies that have claimed that hookworm infection in children increases with age, the child's age had no discernible relationship with hookworm infection. For instance, a study of kids between the ages of 5 and 15 in Makeni, northern Sierra Leone, revealed that kids between the ages of 5-7 were more likely than kids in higher age groups to have hookworm [23].

The caregivers' educational background did not significantly affect the children's hookworm infection. The findings supported those of an earlier study conducted in Cambodia among preschool and school-aged children, which found no significant relationship between hookworm infections and caregivers' educational levels [24]. The majority of the caregivers in the current study were highly educated and it is therefore logically expected of these caregivers (particularly mothers) to be knowledgeable about the dangers of hookworm infections and the necessary health behaviours to incorporate to prevent them. However, regardless of the literacy level of caregivers, children were still affected.

Children's hookworm infection was strongly correlated with the family income of the head of the household. The results are consistent with a study conducted in Côte d'Ivoire among school-age children, which revealed that the occupation of the parents was substantially related to the child's hookworm infection [25]. The low financial standing of family heads is most likely to blame for the tendency in the current study. The majority of infected children work as temporary labourers or are subsistence farmers, which makes it difficult for them to afford to buy their children shoes, soap, and other hookworm prevention tools.

Analysis of hygiene practices of school-going children concerning hookworm infection showed a significant correlation between hand washing before meals and hookworm infection. Children who did not occasionally wash their

hands before meals were more likely to get an infection. A substantial correlation between the way hands are washed before eating and after urinating and hookworm infection was found (with high infection among those children who used water without soap to clean their hands).

Those who ate raw vegetables were more likely to be infected than those who did not. Wearing shoes while on soil, availability of toilet facilities, and deworming in the last 6 months all had a significant association with hookworm infection. Many studies support the importance of hygiene practices in hookworm infection, revealing a link between hookworm infection and, among other things, washing hands before meals, the mode of handwashing, or eating raw vegetables [26].

5. Conclusion

Risk factors associated with the infection included poor sanitation practices, sociodemographic characteristics and lack of personal hygiene and higher prevalence among children between 5-7 years. These findings highlight the need for interventions to improve sanitation and hygiene in the area, as well as regular deworming programs for children to reduce the burden of hookworm infection among children. Additionally, further research is needed to determine the extent of hookworm infection in other communities in the region.

6. Recommendation

Regular deworming programmes should be implemented in schools to reduce morbidity from STH infection. To avoid transmission and eliminate helminthiasis and other intestinal parasites locally, the study recommends a combination of preventive measures and chemotherapy. Soil-transmitted parasites such as helminths and other interested parties should be controlled by the appropriate government entities such as the health sector and other interested parties by ensuring there is access to improved sanitary facilities and clean water in the neighbourhood. Campaigns to educate children and parents about STH transmission should be expanded throughout the neighbourhood and beyond to raise knowledge about STH transmission and prevention, such as high-standard hygiene practices. The goal of reducing morbidity associated with soil-transmitted intestinal parasitic infections in children in Sierra Leone will be achieved by the above-mentioned efforts. Mass-treatment initiatives must be implemented on a more regular basis. A regular treatment program should also be implemented in all elementary schools, both in rural and urban areas, by the Ministries of Education and Public Health. The school's curriculum should highlight public health education programs.

Declarations

Ethics approval and consent to participate: The study was approved by the Sierra Leone Ethics and Scientific Review Committee of the Ministry of Health and Sanitation and authorities in the Southern Region. Written, informed consent was obtained from headmasters, community leaders, household heads and mothers for the questionnaire survey and sampling at the clinical field unit and from head teachers in the primary schools on behalf of the school pupils who participated. Focus Group Discussions (FGD) was held with the parents, children, and community leaders in each school to explain the aim of the study, the procedures involved, and the benefit and risks of being involved in the study. The benefits were that school children received free laboratory investigation and free treatment for Hookworm infection.

Conflict of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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