Prevalence and infection intensity of geohelminthiases among school children as an environmental health indicator to guide preventive activities in Nandi County, Kenya

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Original Article

Prevalence and infection intensity of geohelminthiases among school children as an environmental health indicator to guide preventive activities in Nandi County, Kenya

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Abstract

Background: Intestinal helminth infections acquired from contaminated environment cause morbidity and mortality worldwide. These infections have persisted in some communities prompting the need to evaluate epidemiological determinants and plan for intervention programs. **Design and Setting:** A 6 months cross-sectional school-based study was undertaken in Nandi County, Kenya to assess the prevalence and intensity of intestinal geohelminthiases in school children. **Materials and Methods:** Fecal samples were analyzed by modified formal-ether concentration technique. Whole sediment formed after centrifugation was transferred onto a slide and examined microscopically. All helminth ova and larvae were isolated and identified based on morphological features and enumerated. Chi-square statistic test was used to analyze and make comparisons of variables. **Results:** Of a total of 2000 stool samples collected, 73.9% (n = 1478) were analyzed while 26.1% (n = 524) were discarded due to contamination. Ascariasis was most prevalent accounting for 42–74% compared to trichuriasis 16–38% and hookworm disease 6–41%. There was no significance difference in prevalence among study sites and between sexes ($P > 0.05$). However, a significant difference in age group-specific prevalence ($P < 0.05$) was established. Analysis of sex-specific prevalence indicated that males had a higher prevalence than females ($P < 0.05$). Infection intensities were light in all sites and sexes. **Conclusions:** Intestinal geohelminthiases prevalence was high and was evidence of a major public health problem. The findings present a basis and good reference demonstrating the distribution pattern of geohelminths in school children. Relevant and appropriate treatment should be undertaken for those infected and plans for community-wide preventive measures should be initiated.

Keywords: Ascariasis, geohelminthiases, hookworm disease, infection intensity, prevalence, trichuriasis

Introduction

Parasitic helminths cause important human infectious diseases that result in mortality and morbidity in developing countries.[1] The most important and prevalent are intestinal helminth nematodes acquired from contaminated soil, water, and vegetation. Usually, the infective stages (viable ova and or larvae) are acquired from contaminated environment. In this regard, associated infections are referred to as intestinal geohelminthiases or soil-transmitted helminthiases. The nematode species involved include *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms *Necator americanus* and *Ancylostoma duodenale*. Each species is responsible for a specific infection in humans. Hookworms cause hookworm disease (HWD); *A. lumbricoides* causes human ascariasis, and *T. trichiura* causes trichuriasis.

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The estimated global prevalence of geohelminthiases is over 1 billion cases of ascariasis, 740 million cases of HWD and 795 million cases of trichuriasis.[2] Ascariasis and trichuriasis are the most prevalent geoheminthiases collectively infecting 2 billion adults and children globally.[3] Approximately, 500 million children are infected with geohelminths worldwide[4] and of these, about 90 million schoolchildren are infected in sub-Saharan Africa including Kenya.[2] In these regions, geohelminthiases are more prevalent in rural, urban-rural, and urban areas where sanitation facilities are poor, inadequate, or nonexistent and with minimal hygiene.[2]

Geohelminths do not replicate within the host but after mating females release thousands of eggs and in some cases larvae which are passed out along with feces. These developmental stages undergo further development in suitable environment such as moist soil and or water before becoming infective in the case of *A. lumbricoides* and *T. trichiura* or hatch into infective third stage larvae in the case of hookworms.[5]

Geohelminthiases are therefore common in communities with poor or nonfunctional latrine system where the soil and water sources become contaminated with parasite eggs deposited in bushes, fields, and playing grounds. In such communities, the persistence of geohelminthiases is closely associated with continuous contamination of environment.[6] Disease(s) severity in these communities is proportional to the intensity of infection and is related to the level of environmental contamination.[7]

Alternative determinants of increasing prevalence of geohelminthiases in resource-poor countries mainly in Africa and Asia are a combination of illiteracy and poverty. Widespread poverty and illiteracy levels in many sub-Saharan countries have been consistently linked to heavy infections in children.[8] Infection in school children is often with no specific symptoms but in severe infections, result in significant morbidity[9] and mortality[10] in school-age children. Specifically, the infections aggravate malnutrition and amplify the emergence of anemia, decreased nutrient uptake, or functionally increase nutrient requirements. The main form of morbidity is the negative effect on nutritional status including mal-absorption of nutrients, loss of appetite, and reduction in food intake in children.[11] The other adverse effects such as intestinal bleeding in HWD, rectal prolapse in trichuriasis, and complications requiring operation, for instance, intestinal and biliary blockage associated with ectopic ascariasis have been reported.[2]

Soil-transmitted intestinal helminth infections among school children are often suggestive of general environmental contamination, poor hygiene, and improper human fecal waste disposal in the community. The study objective was to evaluate the prevalence and intensity of geohelminthiases. The purpose of the study was to provide a basis for formulating relevant community-wide intervention strategies by the Nandi County Government.

Materials and Methods

Ethical consideration

The study was approved by the Institutional Review and Ethics Committee of Moi University and consent obtained from guardians or parents of all pupils before undertaking the study. Personal details relating to participants and diagnostic results were kept confidential. Positive cases for parasitic infection(s) were referred to a clinician for appropriate treatment and management.

Study area

The study was carried out at the Nandi-Hills, Kaptumo locations, Nandi County, Kenya. It is located at latitudes 35°15’ E and 0°08’ N-0°5’ N. It is topographically hilly with an average altitude of 1998 m above sea level and receives mean annual rainfall of 1600 mm and has a mean annual temperature of 18°C.

There are numerous large-scale tea estates run by various companies where latrines are communally shared and are not well maintained. There are primary schools within tea estates, urban centers/towns, and in villages. Modern sanitary facilities including piped water, flush toilets, and sewerage systems have been installed in some urban centers. These facilities are either privately owned or communally shared with numerous households. Most households in villages share communal pit latrines and lack piped water.

Study design and sampling procedure

6 months cross-sectional school-based study was undertaken from January to June 2014. The study area was divided into three study sites comprising of estates, villages, and one town. All the schools within each study site were identified, and two schools were randomly selected except town study site which had one representative school thus making an overall total of 9 schools. A total of 200 children were randomly selected from each school in each of the study sites except town study site to participate in the study.

From the estates study site, Kipkoimet, Septon, Kipsitoi, and Chemoni primary schools were targeted for 800 sample specimens. From the villages study site, Sinendet, Kosoiwo, Kaboi, and Tendwet primary schools were targeted for 800 sample specimens. The only school in urban/town was selected as sampling point with a target of 400 sample specimens. In total, the expected specimen was 2000 from the three study sites.

Specimen collection, processing, and data analysis

Each pupil was provided with a labeled sterile polypot, stool specimen container, wooden spatula, black polythene bag, data form for recording details on age, sex, and residence. They were instructed to deposit approximately 2 g of fresh morning stool on polypot. The samples were collected and transported to the Moi University Teaching laboratories for preservation and/or analysis.

Helminth parasite ova and or larva were isolated by a modified formal-ether concentration technique.[12] Whole sediment formed after centrifugation was transferred onto a slide using a Pasteur pipette and covered by 22 mm × 22 mm coverslips before microscopic examination. The entire sediment was examined at ×10 objective with the condenser sufficiently closed for good contrast. All the ova and larva were identified based on morphological features and enumerated. Chi-square statistic test was used to analyze and make comparisons on variables.

Quality control

Each fecal specimen was examined microscopically by three trained and experienced laboratory technicians. In cases where the results were different, the slide preparation was examined by a 4th technician. Some slide preparations were randomly selected and sent the Department of Medical Microbiology and Parasitology, School of Medicine, Moi University, Eldoret, Kenya, to confirm the reproducibility of the study results.

Results

Participants and family socioeconomic characteristics

A total of 2000 pupils of age range 5–19 years (mean age 12.5 years) were enrolled in the study. Stool samples were received from 1478 pupils for analysis representing 73.9% while 26.1% (524) stool samples were discarded due to contamination. Sex distribution of the participants was males 707 (47.8%) and females 771 (52.2%) with an almost 1:1 sex ratio.

Participants from estates lived in labor camps where parents worked as farm laborers in the extensive tea plantations. Housing made of bricks and communal latrines was provided, but not well-maintained. Families in the urban center were regarded as well-off economically. Most of them had access to modern sanitary facilities, piped water, and sewerage system. However, those on the outskirts of town lacked similar facilities and had to share privately owned or communally latrines. In villages, families were economically disadvantaged, lived in mud-built and thatch-roofed houses. There was no piped water; the main water sources were contaminated streams and rivers. Majority shared few poorly maintained latrines.

Infection prevalence

Intestinal geohelminthiases prevalence rates in the three study sites are presented in Table 1. Ascariasis was the most prevalent accounting for 41.5–74.3% compared to trichuriasis (15.5–37.7%) and HWD (6–41.2%). In all study sites, the lowest intestinal helminth infestations were recorded in pupils from the villages and the highest in those from the tea estates. The difference in prevalence of geohelminth infestations among the three sites and between sexes was not statistically significant ($P > 0.05$).

Infection intensity

The infection intensity and distribution of average eggs per gram (avEPG) of feces output in the pupils is presented in Table 2. The difference in intensity of ascariasis in the estate, village, and town localities was not statistically significant. Similarly, the age-specific intensity was not significant ($P > 0.05$).

Based on the WHO recommended classification of helminth infection intensity,[13] the infection intensities were found to be light in all study sites and sexes. The

Table 1: Prevalence of specific geohelminthiases in study sites

Study site	Sex	Number examined	Ascariasis prevalence +ve (%)	Trichuriasis prevalence +ve (%)	Hookworm disease prevalence +ve (%)	*P*
Villages	Males	306	130 (45.5)	46 (15.5)	46 (15.3)	>0.05
	Females	367	152 (41.5)	62 (16.9)	22 (6.0)	
Town	Males	59	36 (63.2)	108 (16.0)	21 (36.8)	
	Females	109	57 (52.3)	40 (36.7)	26 (33.9)	
Estates	Males	342	254 (74.3)	124 (36.3)	141 (41.2)	
	Females	295	191 (64.7)	112 (37.6)	103 (34.3)	
Total		1478	820	492	359	

+ve=Positive cases, %=Percentage prevalence avEPG for ascariasis was within the range of 1–4999 while that of HWD and trichuriasis was within 1–999 in all study sites and sexes.

Infection prevalence and intensity in relation to age groups

Age group-specific prevalence was highly variable as presented in Table 3. The prevalence was lowest (0–20.8%) in the lower age group, highest in middle age group (20.4–38.0%), and declined in the higher age group (8.7–17.5%). Overall, there was a tendency toward an upward trend from the 5 to 9 years age group to peak in the 10–14 years age group then declined in the 15–19 years age group. There was a significant difference among the age group-specific prevalence in the study sites ($P < 0.05$). Analysis of sex-specific prevalence indicated that male pupils had a higher prevalence than the females ($P < 0.05$).

Discussion

The overall intestinal geohelminthiases prevalence in the study area was high (30–70%). This is due to the fact that intestinal helminthic infections are chronic, and the signs and symptoms are usually nonspecific. There is, therefore, a high possibility that many people could harbor parasites without knowing until when they visit a medical facility for a medical examination or routine medical check-up. Similar high prevalence findings have been reported in related cross-sectional studies conducted in neighboring counties in Western Kenya.[14,15]

The high prevalence of ascariasis and trichuriasis were observed in the present study findings. These intestinal infections are faeco-orally transmitted, and their epidemiology is largely determined by the local hygienic habits and conditions, which affect the level of environmental contamination by the helminth ova.[16] Furthermore, the helminth species associated with these infections are known to share the same environment and locations inside and outside the host and same mode of transmission. Therefore, conditions that influence the presence of *A. lumbricoides* in the host and outside environment similarly influence the presence of *T. trichiuria*.[17,18] This partly explains why the two species are often reported in association in communities resident in endemic areas.

Furthermore, ova of *A. lumbricoides* and *T. trichura* have tough outer coat that enables them to resist adverse environmental conditions. This enhances their survival; hence, a high probability of the two helminth species being transmitted together. The high prevalence of the two infections is often an indication of fecal contamination of the environment (soil, water, and vegetation) in a community. This is often through poor sanitary habits of indiscriminate defecation.[19]

Ascariasis was the most prevalent of the three intestinal geohelminthiases in the study. Comparable findings have been reported elsewhere.[20-22] In Kenya, ascariasis has been reported in school going children in Kisumu[23] Nairobi[24] as the most prevalent intestinal helminth

Table 2: Infection intensity in study sites

Study site	Sex	Number examined	Ascariasis intensity +ve (avEPG)	Trichuriasis intensity +ve (avEPG)	Hookworm disease intensity+ve (avEPG)	*P*
Villages	Males	306	130 (425)	46 (31)	46 (8)	>0.05
	Females	367	152 (600)	62 (41)	22 (15)	
Town	Males	59	36 (573)	108 (92)	21 (19)	
	Females	109	57 (612)	40 (39)	26 (33)	
Estates	Males	342	254 (756)	124 (53)	141 (25)	
	Females	295	191 (1014)	112 (42)	103 (24)	

+ve=Positive cases, avEPG=Average number of eggs per gram of faeces

Table 3: Prevalence rate and infection intensity in age groups

Study site	Sex	Number examined	Intestinal geohelminthiases prevalence and infection intensity in different age groups (avEPG)			*P*
			5-9 years %	10-14 years %	15-19 years %	
Villages	Males	306	9.2 (487)	23.2 (377)	10.5 (1398)	<0.05
	Females	367	12.0 (16)	20.4 (441)	8.7 (643)	
Town	Males	59	0.0 (0)	42.1 (574)	17.5 (1144)	
	Females	109	6.4 (228)	33.0 (1046)	12.8 (511)	
Estates	Males	342	20.8 (815)	34.5 (798)	18.7 (655)	
	Females	295	17.3 (1434)	38.0 (1044)	9.8 (564)	

+ve=Positive cases, avEPG=Average number of eggs per gram of faeces parasite. These may be explained by the fact that, in addition to the presence of tough outer coat, the ova of *A. lumbricoides* are known to adhere and stick on hands, fruits, vegetables, utensils, and many other shared articles.[25] In this regard, the ova are much more likely to be spread and be ingested by children through contact, sharing of food, contaminated utensils, pens, and books.[26] This is a likely explanation for the high prevalence of the infection in school pupils reported in this study. Therefore, provision and availability of appropriate of sanitary facilities, clean water, and basic public health education are pivotal in reducing cases of ascariasis in school environment.

The prevalence of HWD caused by skin penetrating helminths, the hookworms was low compared to ascariasis and trichuriasis. This is comparable to findings from studies undertaken in highland areas of Ecuador,[27] Malaysia,[28] and Sudan[29] Highland areas generally experience low temperatures most the year round. Such low temperatures may be prohibitive to successful hatching of hookworm ova and subsequently the growth and survival of infective larval stages in the soil. Furthermore, the study area being predominantly an agricultural area, the heavy use of chemical fertilizers is likely to adversely affect the soil chemical composition which may have deleterious effect on hookworm larval survival. There is need for further studies to determine why HWD prevalence is low in the study area where the main economic activity is agriculture.

Infection intensity was considered as light in all study sites and sexes as per the WHO categorization.[13] Low intensities of intestinal helminthiases have been reported elsewhere even in areas with high infection prevalence.[5,30,31] These studies suggest that levels of infection intensity are generally low in many communities which are comparable to the findings of this study. In other related studies, minor variations have been reported based on gender, age, and daily activities one is involved in.[32,33] These differences are possibly due to variations in study sites and methodology applied. However, infection intensity of any level once established is a reflection of the suitability of the conditions for helminth survival and development. It is, therefore, serves as a suitable indicator of the possibility of repeated exposure and multiparasitism. The biological importance of multiparasitism as regards its effect on individual species infection intensity is not clearly known. There is need for further research on this aspect.

Sex has an effect on prevalence infection, and this is attributed to the traditional roles of males and females in the African society. In related study, sex-related significant prevalence has been reported where males had a higher infection than the females.[32] This has been attributed to involvement in domestic and behavioral activities that exposes male gender to infection more than females. The high prevalence in males in this study is due to exposure to infection while walking barefoot when herding animals in contaminated fields or working in contaminated plantations considering that the area is inhabited by an agricultural community. In an African set-up, farm activities and herding animals are undertaken by boys while girls take care of most of the household core.

The high infection prevalence for the middle age group (10–14 years) in comparison to the low prevalence for the low (5–9 years) and high (15–19 years) age groups is attributed to age-related changes in diet, hygiene, and daily activities with regard to the exposure to helminth infective stages. Comparable findings have been reported elsewhere.[33,34] In Africa, this is the age when both genders are actively involved in outdoor games in damp, muddy contaminated fields, collect water from unprotected wells and participate in herding animals in open fields often contaminated with human waste and agricultural activities. These expose the age group to higher risk of infection than the other age groups.

Conclusions

The intestinal geohelminthiasis prevalence is high in school pupils and by extension in Nandi County. Ascariasis and trichuriasis were the most prevalent infections and HWD the least prevalent. The presence of these infections is indicative of general environmental contamination and poor hygiene. This is evidence of a major public health problem in the Nandi County that needs to be addressed by the relevant office in-charge of public health.

The study findings also present a basis and good reference demonstrating the distribution pattern of intestinal nematode geohelminths in school children so that appropriate treatments could be undertaken for the infected school children and plan for community preventive measures.

Recommendations

There is need for public health education on the importance of environmental sanitation, construction, and proper use and maintenance of latrines in schools and homes.

The general public (community and children) need to be enlightened on the link of parasitic infections to hygiene and environmental sanitation.

Intervention strategies in the county should focus more on children and include studies to monitor and evaluate the possible re-infection patterns. This will help determine the effectiveness of the control/prevention program(s).

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Conflicts of interest

There are no conflicts of interest.

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