The Prevalence of Intestinal Parasites and Water, Hygiene and Sanitation Activities among School Going Children in Artisanal Gold Mining Areas in Kakamega County

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Background and study aim: Intestinal parasitic infections among school aged children are a major public health concern especially in rural areas characterized by poor hygiene and supply of clean water. This study aimed at examining the prevalence of STH and other intestinal parasites in school aged children within gold mining regions of western Kenya after mass drug administration and also investigate the status of water sanitation and hygiene (WASH) activities in the region.

Patients and Methods: The study was conducted in three schools selected randomly from Ikolomani sub-county, Kakamega County according to their proximity to the goldmines. The study was conducted between June and July 2023, where 600 school going children were randomly selected to participate in the study.

Results: The overall prevalence of STH and other intestinal parasites was 16.85%. The common detected STH was Ascaris lumbricoides at 13.3% and very low prevalence of Trichuris Triachuria (0.56%), however no hook worm was reported, Enterobius vermicularis (0.56%) was also detected. Giardia lamblia (1.69%) was the common intestinal protozoan detected followed by Balantidium coli (0.19%) and Entamoeba histolytica (0.56%). Washing hands with water and soap was significantly associated with STH and other intestinal parasite infections.

Conclusion: The MDA program may have reduced the prevalence of STH to some extent, but other factors like sanitation and hygiene practices remain critical in controlling the spread of parasitic infections. Future interventions should adopt a holistic approach that includes education, infrastructure improvements, WASH and community engagement to complement the MDA campaigns.

INTRODUCTION

Intestinal Parasitic infections continue to be an important cause of morbidity and mortality in sub-Saharan Africa. These infections caused by both protozoan and helmithic parasites including Giardia lamblia, entamoeba hystolytica, Balantidium coli, cryprosporidium parvum, Soil transmitted helminths, schistosoma species, Enterobius vermicularis e.t.c. are common among school aged children in developing

Countries [1,2,3]. Although intestinal parasitic infections causes low mortality, they are known to be chronic with recurrent infection in children associated with severe morbidities such as malnutrition, mental deficits, stunted growth and cognitive development, anemia, and school absenteeism [4]. Efforts to control parasitic infections in developing countries mainly focuses on intermittent mass drug administration targeted at specific risk groups mainly school aged children [5]. Nevertheless, reinfection in endemic areas is persistent.

Intestinal parasites are characterized by different morphologies and lifecycles but they are all transmitted through the fecal oral route/skin penetration where the infectious stages are found in the soil. The Parasites' eggs, cysts and trophozoites are passed in the stool of infected individuals in to the soil or water, which develop in to infectious stages under optimal conditions of moisture and temperature [6]. Transmission of intestinal parasites is common in sub-tropical and tropical countries, where climatic condition is suitable for development of the infectious stages, additionally where there is poor personal hygiene sanitation enhancing transmission [7]. Moreover, mining activities often results in to land destruction, soil erosion, water pollution, and ecosystem destruction creating the perfect environment for continuous transmission of intestinal parasitic infections. Most artisanal mining sites have poor sanitation and limited clean water supply which further propagates the transmission of intestinal parasites [3 .[

Current control strategies of STH and other intestinal parasites recommended by WHO is mass drug administration (MDA) to the groups at risk which includes School going children (5-14 years old) and Pre School aged children (2-4yrs) irrespective of their infection status, with the anthelminthic drugs albendazole or mebendazole [8]. World Health Organization aim for 75% STH MDA coverage in endemic countries both in SAC and pre-SAC by 2020 [9]. In the past two decades, global coverage of MDA has increased but has not hit the 75% mark. Studies have also shown that is not enough to target SAC and Pre-SAC but also adults should be targeted to eliminate STH and other intestinal parasitic infections most especially in regions where there is high prevalence of hookworms [9,10 .[

In Kenya, approximately five million school age children (SAC) are at risk of soil-transmitted helminthiasis (STH) and other intestinal parasitic infections infections [11]. The Government of Kenya launched a National School Based Deworming (NSBD) program in 2012, which targeted SAC living in STH endemic areas in order to reduce the infections to the negligible levels if not eliminating the infections [11]. Since then, the programme has been implemented successfully in endemic populations, with extensive monitoring and evaluation programmes. Although MDA programmes have been successful in reducing the global STH infections and associated morbidity, there is recurrent infections in the groups at risk driven by lack of clean water supply, sanitation and both environmental and personal hygiene coupled with limited health education. The modes of transmission of STHs are well known and understood, however hot spots of STHs and intestinal parasitic infections in the communities are not known, additionally the status of STH and intestinal parasitic infections in gold mining areas are not known since this areas are characterized by congestion and minimal WASH activities, which consequently hinders both the design and the implementation of water sanitation and hygiene, and health education interventions.

The aim of this study was to examine the prevalence of STH and other intestinal parasites in SAC within gold mining regions of western Kenya and also investigate the status of water sanitation and hygiene (WASH) activities in the region.

PATIENTS AND METHODS

Study Area

The study was conducted in Ikolomani sub-county (E:00.16556, N:034.73194), located in Kakamega county. Ikolomani sub-county is divided in to four administrative wards namely: Idakho South, Idakho East, Idakho North and Idakho Central. It covers an area of approximately 143.6 square Km and a population of 111,743 according to the 2019 census. The area experiences two rainy seasons, long rains (early April to late July) and short rains (October to November). The main economic activity in the study area is small scale farming of food crops such as sugarcane, maize and vegetable. The residents of this area are also involved in artisanal gold mining activities.

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Study design

A cross sectional survey was adopted .

Study Population

School going children aged between 6-14 years whose parents or guardians had given consent to participate in the study and also residing within Ikolomani sub county were included in the study .

Sampling Procedure and sample size

Three Primary schools were conveniently sampled basing on their proximity to the gold mines. The research team visited the schools and explained the aim of the research to the head teachers and also issued the consent forms for the child to take to the parents for signing before the study commenced. A total of 200 pupils aged between 6-14 years (School aged) from each school were randomly selected to participate in the study resulting to a total of 600 participants. The study was conducted between June and July 2023 two weeks after the national deworming program among the School aged children within this region .

Data collection

Before the study commenced the selected schools were visited two days prior to the survey date in order to explain the purpose of the study to the school headteacher, additionally Ethical approval was sought from Masinde Muliro University of Science and Technology Institutional Ethical Review Committee (MMUST-IERC) followed by approvals from National commission for Science, Technology and Innovations (NACOSTI), the ministry of Education at Kakamega county level and also from the local wards administrators .

On the day of collection, every child who was recruited to participate in the study was given a poly-pot container labeled with unique identifier and instructed on how to put his or her stool in the container with the help of the class teachers and trained research assistants. The stool samples were then transported to Masinde Muliro University of Science and Technology (MMUST) medical laboratory, processed within 24 hours and examined in duplicate for the presence of STH eggs, cysts and trophozoites by two technicians. Briefly, for each of the stool samples the following macroscopic parameters were recorded before processing; color, form and consistency. A few drops of normal saline were added to the specimen and emulsified using applicator sticks, then a drop of the emulsified sample was placed on a new clean glass slide, cover slipped and examined under microscope for Ova, Cyst and larvae, trophozoites [12]. As part of the NSBD program during MDA, all participating children who were found to have STH and any other intestinal parasitic infection were treated with albendazole or mebendazole according to MoH and WHO guidelines.

Structured questionnaires were also administered to the children and teachers to collect data on WASH activities .

Data analysis

Water, sanitation and hygiene (WASH) activities and demographic characteristics of interest from the questionnaires included reported individual, household and school-level variables that are known factors affecting STH and intestinal parasites prevalence. Individual factors included age, gender, hand washing, defecation, swimming activities and shoe-wearing behaviors at school and home. Household-level factors included availability of toilet, anal cleansing material, hand washing facility equipped with water and soap, type of water source. Information regarding type of household latrine School-level factors included interviewer-verified availability and type of school toilet facility, availability and type of hand washing facility equipped with water and soap, and availability of anal cleansing material at school. Overall, the WASH factors associated with STH and intestinal parasite prevalence were analyzed. Pearson's Chi-Square tests and logistic regression were applied to assess the association between various hygiene behaviors and the prevalence of soil-transmitted helminths and other intestinal parasites.

RESULTS

Demographic Characteristics of the study participants

Out of 600 pupils who were selected to participate in the study, 534 (89%) pupils participated. Majority of the participants were female at 273 (50.9%). Majority were aged between 9-10 years old 207 (38.76%) and the least were those aged 15 years old 5 (0.094%) as shown in (Table 1.(

The Prevalence of STH

A total of 90 pupils out of 534 that were sampled were found to be infected with STH, an overall prevalence of 16.85%.

Age and gender with the prevalence of Soil transmitted helminthes: Children aged between 9-10 years had a high prevalence of STH and other intestinal parasites at 7.14%. Followed by 6-8 years old at 5.36%. 13-14 years old were the least affected at 0.7% (T value= -0.97, P value 0.333). Girls were more affected by intestinal parasites at 8.7% compared to boys at 7.14%, however, there was no significant difference in the prevalence (T value 0.26, P=value 0.793) see Table. 2.

Intestinal parasites present: Ascaris lumbricoides was the most prevalent intestinal worm at 13.3%, followed by T. trichuria, E. Vermicularis at 0.56%. No hookworm was observed. Other interstinal parasites observed were G. lamblia at 1.69%, Entamoeba histolytica at 0.56% and Balantidium coli at 0.19%. (Table 3 (

Correlation between the prevalence of STH and other intestinal parasites with Hygiene activities :

Majority of the participants ate home cooked food at 70%, whereas the rest 30% ate hotel prepared food. 70% of the participants ate raw vegetables and fruits, 12% of this did not wash the vegetables and fruits before eating, 42.9% washed their fruits and vegetables before eating, where as 45% occasionally washed their fruits before eating. 11% consumed raw or undercooked food where 89% reported that they don't eat raw or undercooked meat. Our results indicated that Not washing fruits correlates with a higher prevalence of suggesting that poor hygiene when handling food is a risk factor for helminth infections. However there was no significant relationship between washing fruits and the prevalence of STH (χ^2 Value = 0.1195, P value $\geq$ 0.0.05), see table 4.

43.4%washed their hands with water and soap after contact with soil, 41% washed with water only whereas 15.1% did not wash their hands after contact with soil. Regarding washing hands before eating, 46.8% washed their hands with water and soap before eating, 50.6 washed with water only where as 2.6% do not wash their hands before eating. 37.7% washed their hands with water only after visiting the toilet, 54% washed with water and soap where as 8.3% did not was their hands after visiting the toilet, 37.7% washed their hands with water only after visiting the toilet, 54% washed with water and soap where as 8.3% did not was their hands after visiting the toilet. Children who did not wash their hands with soap showed the highest prevalence (20.47%). There was a significant relationship between washing hand and prevalence of STH (χ^2 Value =4.7822, P value $\leq$ 0.005), see table 4.

Prevalence of STH and Safe Drinking Water: Majority of the participants did not have access to clean water as 66.7% fetched their water from the river, 11.8% used spring water, 16.7% use piped water 1.3% got their water from the well where as 0.6% got their water from the borehole. 62.7% treated their water before drinking whereas 37.3% do not treat their water before drinking. There was no significant relationship between treating water and the prevalence of STH (χ^2 Value 0.3972, P=0.529(

Swimming activities: 34.6% of the participants reported to swim, 85.5% of this indicated that they swim in the river where as 14.5% use swimming pools. There was no significant relationship between swimming activities and the prevalence of STH (χ^2 Value = 0.1785 P Value=0.915.(

Sanitation: 99.3% of the participants have pit latrines at home where as 0.7% did not have latrines at home. High prevalence of STH was significantly associated with lack of latrines (χ^2 Value=1.7878, P Value=0.181(

Cases of diarrhea and deworming: 48.7% of the participants reported to have had diarrhea in the past 3months, out of this 34.2% visited the hospital for treatment where as 65.8% did not seek medical attention. 90.1% of the participants had been dewormed in the school aged children programme conducted by the government. Whereas 9.9% were not dewormed as they were absent from school during the deworming exercise.

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Table 1: Demographic characteristics of participants

Total No. of participants	**N=534**	**Proportion**
Gender	Male	261 (49.1%)
	Female	273 (50.9%)
Age	5-6 yrs	33 (6.18%)
	7-8 yrs	157 (29.4%)
	9-10 yrs	207 (38.76%)
	11-12 yrs	88 (16.48%)
	13-14 yrs	44 (8.24%)
	15 yrs	5 (0.094%)

Table 2: Age and gender with the prevalence of Soil transmitted helminthes

Variable	**Category**	**Present N=534**	**Prevalence (%)**	**Odds Ratio (OR)**	**t-value**	**p-value**	**95% Confidence Interval**
Age Group	6-8 years	28	5.36%	0.784	-0.97	0.333	[0.479, 1.283]
	9-10 years	38	7.14%				
	11-12 years	13	2.5%				
	13-14 years	11	0.7%				
Gender	Female	24	8.7%	1.351	0.26	0.793	[0.144, 12.704]
	Male	20	7.14%				

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Table. 3 Intestinal parasites present

Intestinal parasite present	Numbers present (N=534)	Prevalence %
Ascaris lumbricoides	71	13.3%
Trichuris trichuria	3	0.56%
Enterobius vermicularis	3	0.56%
Giardia lamblia	9	1.69%
Balantidium coli	1	0.19%
Entamoeba Histolytica	3	0.56%

Table 4. Hygiene and Sanitation Behaviors and Soil-Transmitted Helminths (STH) Prevalence among School-Going Children

Behavior	Chi-Square Hygiene Value (χ^2)	Degrees of Freedom (df)	P-Value
Washing Fruits	0.1121	2	0.946
Eating Raw Fruits	0.1195	2	0.942
Eating Undercooked Food	0.3773	1	0.539
Handwashing with Water and Soap	4.7822	2	0.002
Handwashing with Water Only	1.1181	2	0.572
Handwashing after Defecation	2.8247	2	0.244
Treating Drinking Water	0.3972	1	0.529

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Swimming (Yes/No)	0.0288	1	0.865
Swimming Location (Lake/River/Pool)	0.1785	2	0.915
Latrine Access	1.7878	1	0.181

DISCUSSION

This study assessed the prevalence of soil-transmitted helminthes and other intestinal parasitic infections among school going children in Ikolomani subcounty, Kakamega County, an area characterized by artesinal goldmining activities. The overall prevalence of STH and other intestinal parasites was 16.85%. This indicates a remarkable decrease in the prevalence of STH compared to the 12.3% reported in the same region by Werunga et al., & Andereck et al., [13, 14] reported a prevalence of 44% of STH in Nyanza province, Okoyo et al, [11] reported a prevalence of STH to be 20% in Eastern and Northern parts of Kenya, in 2020, the reduction in the prevalence can be linked to the national school base deworming programmes and increased sensitization on WASH activities.

The common detected STH was Ascaris lumbricoides and very low prevalence of Trichuris Triachuria, however no Hook worm was reported, Enterobius vermicularis was also detected. Giardia lamblia was the common intestinal protozoan detected followed by Balantidium coli and Entamoeba histolytica. Our findings are similar to other studies that have observed high prevalence of A. lambricoides in school aged children even after deworming [15, 16,17]. This suggests that there is a high reinfection rates of Ascaris lambricoides and Trichuris trichuria and therefore a need for additional control approaches with an emphasis on public health education and WASH for prophylactic approaches to be effective. Notably, no Schistosoma eggs were detected in the samples, despite reported swimming activities among participants. This finding may be explained by the mass drug administration (MDA) carried out in the community prior to the survey, which likely contributed to a reduced prevalence of schistosomiasis.

Female pupils had a higher prevalence of STH compared to the male pupils. This agrees with Tongiura et al., [2] who also reported a higher intestinal parasite infection rate infection rate in females than in males. This can be attributed the type of house chore responsibilities that female children engage in like fetching water, cleaning latrines and preparing food compared to their male counterparts .

Generally, the prevalence of soil-transmitted helminths (STHs), principally Ascaris lumbricoides and Trichuris trichiura, was observed to decrease with increasing age among children. Those aged 6–10 years were more affected compared to older children. This trend may be attributed to greater awareness and uptake of STH control interventions such as improved water, sanitation, and hygiene (WASH) practices among older age groups. Furthermore, the majority of study participants fell within the older age bracket, which may have contributed to the observed pattern. Our findings align with several other studies that have reported similar age-related trends in STH prevalence [1, 18, 19.[

Findings from this study also showed that hygiene and sanitation behaviors such as fruit washing, eating raw fruits, under cooked food consumption, and swimming do not exhibit a statistically significant relationship with the presence of soil-transmitted helminths. However, behaviors like handwashing with soap showed a near-significant trend, highlighting the potential for improved hygiene practices to reduce STH

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and other intestinal parasites transmission. In this study, we explored the association between various hygiene and sanitation behaviors and the prevalence of soil-transmitted helminths (STH) among school aged children in Kakamega County, specifically within the artisanal gold mining areas. The hygiene practice for removing contaminants, including soil-borne helminth eggs. However, there are several plausible explanations for the lack of significance. First, the primary route of transmission for soil-transmitted helminths and most intestinal parasites is via the fecal-oral route, with contamination typically occurring through soil, water, and food sources that come into contact with infected human feces. While washing fruits could theoretically reduce the risk, it is possible that other environmental factors such as contaminated water or poor sanitation are more significant in this context .

Additionally, if children were using contaminated water for washing fruits, this could render the practice ineffective. In regions like Kakamega, where artisanal mining activities may contribute to widespread environmental contamination, water sources may not be clean, reducing the efficacy of fruit washing as a preventive measure.

This results are similar to other previous studies that reported source of drinking water, toilet facilities, washing of hands after using the toilets, washing of hands before meals, the pattern of waste disposal, and washing of hands after waste disposal were associated with intestinal parasitic infections to be the the risk factors associated with the distribution and spread of intestinal parasites infection among school-age children [19; 21]. This confirms that the WHO recommendation of safe and sufficient water, sanitation, and hygiene (WASH) is pivotal in preventing most neglected tropical diseases NTDs including intestinal parasitic infections, soil-transmitted helminths, and schistosomiasis [21 .[

Results from our study showed that hand washing play a role in reducing STH transmission, particularly hand-washing with soap is generally recognized as a key preventive behavior against fecal-oral transmission, the effect might be moderated by the quality of soap, the availability of clean water, or inconsistent hand washing practices. This results agrees with other studies that observed higher infection rates were among those who didn't wash their hands before meals compared to those who did; and among those who didn't wash their hands after waste/garbage disposal compared to those who did [18, 19, 20, 1]. It is important that communities get access to improved water, sanitation, and hygiene (WASH) infrastructure and services to reduce STH and other intestinal parasitic infections disease burden by reducing exposure to Soil-Transmitted Helminths STH and other intestinal parasites infective stages in the environment.

Treating drinking water is a commonly recommended intervention to reduce waterborne diseases, including helminths. However, the lack of a significant association here may indicate that the water treatment methods employed by the population (e.g., boiling, filtration) are either inconsistent or ineffective in eliminating the types of helminths present in the environment. However this finding does not agree with Gbonhinbor & Awi-Waadu, [19] in their recent studies who reported that a greater percentage of children that never treated their water at home were more infected with STH .

Swimming behavior had no significant relationship with helminth occurrence ($p = 0.865$), indicating that swimming in lakes, rivers, or swimming pools does not contribute significantly to the transmission of intestinal parasites in this study area. While swimming in contaminated water can be a potential route for parasitic transmission in some settings, the results of this study suggest that swimming is not a major factor for STH transmission in Kakamega County. It is likely that other factors, such as the widespread contamination of water sources and soil, overshadow the role of swimming [22]. Moreover, swimming in pools is relatively uncommon in rural settings, and swimming in natural bodies of water, such as rivers and lakes, may not always lead to helminth infection unless the water is heavily contaminated with fecal matter. Therefore, the low significance here may reflect the limited exposure to contaminated water during swimming, relative to other forms of exposure.

The association between latrine access and STH infection was not significant ($p = 0.181$), suggesting that access to latrines did not have a substantial effect on reducing helminth

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prevalence in this study. This result may seem surprising, given that latrine access is often considered a key factor in reducing the transmission of soil-transmitted helminths. However, the effectiveness of latrines in this context could be compromised by several factors: Improper use or maintenance: In some cases, even when latrines are available, they may not be used properly or maintained well, leading to contamination of the surrounding environment. Open defecation: Despite the availability of latrines, open defecation might still be practiced, particularly in remote areas or among children, exacerbating contamination. Latrine design: The design and location of latrines might also affect their efficacy. If they are poorly constructed or located in areas prone to flooding, their impact on reducing STH may be limited .

It is important to note that 90% of the participants had been dewormed in the MDA programmes two weeks before the survey. Therefore results from this study provides evidence on the importance of backing up the MDA programmes with WASH activities for successful control of soil transmitted helmiths and other intestinal parasitic infections

CONCLUSION

The overall prevalence of STH and other intestinal parasites was 16.85%. The common detected STH and intestinal protozoan were Ascaris lumbricoides and Giardia lamblia respectively. The factor analysis provides valuable insights into the multifaceted nature of the factors influencing STH prevalence among school-going children in Kakamega County. The findings underscore the critical importance of hygiene practices, water treatment behaviors, and footwear use in preventing soil-transmitted helminths in artisanal gold mining areas .

Recommendation

Future interventions should adopt a holistic approach that includes education, infrastructure improvements, WASH and community engagement to complement the MDA campaigns.

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Ethical Approval

Ethical approval for the study protocol was obtained from MMUST institutional review committee and permission to conduct the study was obtained from NACOSTI. At the county-level, approval was provided by the respective county health and education authorities. At school, parental consent was obtained. Additionally, individual assent was obtained from each child before participation in the study. All data used was coded with unique identifiers.

Conflict of Interest

Authors declare no conflict of interest

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Authors' contribution

CLW, PN, PB, JO, PC, UA, PWB and EO, conceptualized and designed the study, CLW and EO Analyzed data, drafted and wrote the article, CLW, PB, PC and PN Revised the article.

HIGHLIGHTS

- *Ascaris lumbricoides* remains the most commonly detected soil-transmitted helminth, indicating ongoing transmission despite intervention efforts.
- Hand-washing with soap and water was significantly associated with reduced rates of intestinal parasitic infections, underscoring the importance of personal hygiene.

- Poor sanitation and hygiene practices continue to be major contributors to the spread of parasitic infections in the region.

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