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Original Article

Assessment of Soil-Transmitted Helminth Infections among Pregnant Women in Western Kenya: A Cross-Sectional Study

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ABSTRACT

Intestinal geo-helminths are among the common human infections in the developing world. Preschool and school-age children in Kenya have been targeted for deworming strategies through the National School-Based Deworming Program leaving out vulnerable groups including pregnant women. We conducted this study to assess the prevalence and intensity of worm infections and associated risk factors among pregnant women in Western Kenya. A cross-sectional study was carried out among 250 pregnant women seeking antenatal care services from selected health facilities in Vihiga County. Stool samples were collected and examined for soil transmitted helminths (STH) using the Kato-Katz technique and structured questionnaires were administered to determine associated risk factors. Statistical analysis was done using STATA version 14.1. Differences in proportions by age and health facility were assessed using Chi-square ($\chi 2$) test and differences in means using the student t-test. Prevalence of STHs was 12.4% (95%CI: 9.1%-16.9%). Infection caused by hookworm was 2.4% (95%CI: 1.2% - 4.7%), Ascaris lumbricoides 9.6% (95%CI: 6.3% - 14.6%), Trichuris trichiura 2.0% (95%CI: 0.8% - 5.3%). The mean intensity of hookworm infection was 101 (95%CI: 8 -1355), A. lumbricoides 375 (95%CI: 107 - 1308), and T. trichiura 3 (95%CI: 0 - 29). Univariable analysis of factors associated with infection did not reveal any significant associations. Participants with primary level of education had higher odds of T. trichiura infection compared to other participants (OR=2.58, p=0.400). Farming had higher odds of STH and A. lumbricoides infections (OR=3.47, p=0.076) and (OR=3.75, p=0.089) respectively compared to other occupations. Participants in the second trimester of pregnancy had higher odds of hookworm infection (OR=3.36, p=0.272) those with children under

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three years had higher odds of T. trichiura infection (OR=3.60, p=0.165). The study revealed that STH infection is prevalent among pregnant women in Vihiga although there were no significant risk factors associated with the infection. Therefore, health facilities should conduct deworming and testing for STH also they should provide health education on the risks of getting infected.

APA CITATION

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INTRODUCTION

Soil-transmitted helminth (STH) infections, caused by *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms, are among the most common Neglected Tropical Diseases (NTDs) in developing countries (WHO, 2011). There are 800–1000 million *A. lumbricoides* cases reported worldwide, 700–900 million cases of *Necator americanus* and Ancylostoma. *duodenale*, and 500 million cases of *T. trichiura* (Gyorkos et al., 2004). Preschool-age children (PSAC), school-age children(SAC), and women of reproductive age (WRA) are the three population groups identified by the World Health Organization(WHO) as having the highest risk of STH-related morbidity (WHO, 2011). Hookworm infection affects over half of the people in Sub-Sahara Africa, including 40-50 million school-aged children and 7 million pregnant women for whom it is the leading cause of anaemia (Hotez & Kamath, 2009).

Studies conducted in Kenya have shown that STHs are common in parts of Western and Coastal Kenya (McClure et al., 2014; van Eijk et al., 2009). Helminthic infection prevalence of up to 76.2% has been documented in some regions of Nyanza , the Western part of Kenya(van Eijk et al., 2009). The impact and effects of helminths on populations other than schoolchildren, including (PSAC), women of childbearing age, and pregnant women appear to be substantial. However, these populations are understudied, particularly pregnant women(Sousa-Figueiredo et al., 2012; Gyorkos, 2004). Due to the scarcity of resources, targeted control among school-aged children is frequently advocated for and sometimes the main operation in Sub-Sahara Africa. These specific groups, which are thought to be under-exposed to infection and often left untreated, could act as infection reservoirs, bringing the disease distribution to pre-control levels over time (Salawu & Odaibo, 2014).

The National School Based Deworming Programme which was initiated in Kenya to lower STH infection among SAC and PSAC has enabled widespread medicine distribution of deworming drugs. During the initiative, school children in

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Western Kenya were tested for STH infection and treated. After a five-year period (2012-2017) of the Mass Drug Administration, four counties(Kericho, Kisii, Narok, and Vihiga) still had a STH prevalence ranging from 20% to 50%, indicating that STH infections are still being transmitted among school children (Mwandawiro et al., 2019a). This evidence shows that school children serve as an active reservoir for STH infections and thus putting pregnant women at risk of getting infected.

Nonetheless, high infection rates of infection among pregnant women are mostly due to faecal pollution of soil and domestic water supply in the vicinity of residential areas as a result of inadequate sanitation and incorrect poor sewage disposal (Brooker et al., 2008). Helminth infections have been linked to unfavourable maternal-foetal outcomes such as premature birth, low birth weight, and decreased breast milk production in women of reproductive age (Brooker et al., 2004).

In STH endemic countries, drug donations are currently accessible for regular preventive treatment among PSAC and SAC (Mupfasoni et al., 2018). Due to the increased risk of comorbidities associated with STH infections, the WHO created specific guidelines for pregnant women. In endemic areas, current WHO guidelines propose treating all adolescent females and pregnant women with a single dose of albendazole 400 mg or mebendazole 500 mg during the second or third trimester, with a second dose during the third trimester in highly endemic areas (World Health Organization, 2019). To reduce STHs infections among pregnant women living in geographic locations where they are frequent, international guidelines propose routine prevention and treatments that are both safe and effective throughout pregnancy (McClure et al., 2014). STH screening and treatment for pregnant women is essential, as it has been established in other countries to improve the health of mothers and children. It is much better to enter a pregnancy free of STH infection and nutritionally replete than the various alternatives (Steketee, 2003).

Prevention of STHs is achievable through health education on proper sanitation and hygiene since the benefits of deworming during pregnancy have not been extensively evaluated(Hailu et al., 2020). In Kenya, it has been shown that infection with STHs is common among PSAC and SAC in Vihiga County, Western Kenya, although the prevalence and risk factors associated with STH infection among pregnant women are still unknown. The current study sought to determine the prevalence and risk factors of STH infections among pregnant women with a view of providing epidemiological data for the introduction of interventions within the antenatal health care system to reduce the STH burden during and after pregnancy.

METHODS

Study Site

Vihiga County is one of the four counties located in the Western region of Kenya. It borders Nandi to the East, Kisumu County to the South, Siaya County to the West, and Kakamega County to the North. The county covers a total area of 531 Km^2 with equator cutting across the southern part of the county. Its climate is classified as tropical with an annual average rainfall of between 1,800 mm and 2,000 mm and an average temperature of 24 ^{0}C. Vihiga's population is 590, 013, as per the 2019 census document(Kenya National Bureau of Statistics, 2019). The major economic activities include; cottage industries, subsistence farming, tea farming, horticulture, livestock farming, wholesale and retail trade, quarrying and mining (State Department Of Devolution, 2020).

Study Design

This was a cross-sectional study which involved quantitative methods of data collection. Stool samples were collected to determine the prevalence and intensity of STH infection among pregnant women. A structured questionnaire was administered at household level to collect data to determine the associated risk factors of STH infection.

The study was carried out in August 2019 in Vihiga County, Western Kenya. Vihiga County was purposively sampled owing to previous studies that had shown a high prevalence of worm infections (Mwandawiro et al., 2019b). The target population recruited in the study was 300 pregnant women, adults above 18 years, and mature minors between ages 13-17 years in the second or third trimester

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seeking antenatal care services in the selected health care facilities in the study area.

Four health facilities were purposively sampled in Luanda and Vihiga Sub-counties based on closeness to the schools targeted by the NSBDP (Mwandawiro et al., 2019a). For comparison purposes, two health facilities were from an urban setting (Mbale Rural Health Training Center and Emuhaya Sub -county Referral hospital) and the other two health facilities from a rural setting (Lyana Ginga Health Center and Ekwanda health centre).

Sample Size Determination and Sampling Procedure

Based on a study conducted in Western Kenya among pregnant women which showed a 76% prevalence of STH (van Eijk et al., 2009), the sample size was determined using Fisher's formula, with a margin of error of 5% with 4% adjustment for nonresponse rates. A sample size of 300 pregnant women in their second or third trimester seeking antenatal care services was purposively sampled at the selected health centres of Vihiga and Luanda Sub-counties. The participants were enrolled in the study on a rolling basis until the sample size was achieved.

Stool Sample Collection and Processing

Research teams explained information about the study during the recruitment exercise and thereafter informed consent was sought from 250 pregnant women and mature minors with the help of trained nurses from the selected health facilities. Each participant was requested to provide a single morning stool sample. The fresh stool samples were taken to the laboratory in the same health facility for processing by qualified laboratory technologists using the Kato-Katz technique (Katz et al., 1972).

Each stool sample was pressed through a sieve to remove fibrous material. A spatula was used to transfer the stool sample to a labelled slide through a template. A piece of cellophane strip soaked in malachite green stain and glycerol was placed on the stool, the slide was then turned upside down and pressed to spread the sample evenly on the slide. After 30 minutes the slide was examined under a microscope. The number of eggs observed per slide was multiplied by twenty- four to obtain the number of eggs per gram faces. Intensity of infection expressed as eggs per gram (EPG) of faeces was classified according to the WHO recommended cut-off for low, moderate, and high intensities of infection (Montresor et al., 1998).

For assuring diagnostic quality, 10% of all Kato-Katz slides were randomly selected, re-examined by the study investigator for *A. lumbricoides* and *T. trichiura* eggs. In case of discordant results, the slides were read a third time and discussed until consensus was reached (Speich et al., 2015)

Questionnaire Survey

A structured questionnaire developed in English and then translated to Kiswahili and the local language (Abaluhya) was administered to the study participants by trained research assistants to determine the risk factors associated with STHS infection. The questionnaire was pretested before the actual data collection and assessed socio-demographic and socio-economic factors as well as environmental and water and sanitation factors.

Statistical Analysis.

Data was collected and captured electronically using ODK (Open Data Kit) mobile-based data collection system from 250 pregnant women. The data was downloaded to Microsoft Excel Spreadsheet, cleaned, and exported for analysis. Prevalence and average intensity of STH infections were calculated and the 95% confidence intervals (CIs) were determined using binomial and negative binomial regression models respectively. Infection intensities were classified in to light, moderate, and heavy infections according to WHO guidelines (*Guideline: Preventive Chemotherapy To Control Soil-Transmitted Helminth Infections In At-Risk Population Groups*, 2017) and the prevalence of each infection class together with 95% Cis were obtained using binomial regression adjusting for health facility clusters. Analysis of factors associated with any STH and separately for *A. lumbricoides* infection was initially conducted using univariable analysis and described as odds ratio (OR) using the univariable logistic regression model while accounting for clustering at the health facility level. For multivariable analysis, minimum

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adequate variables were selected using a forward stepwise variable selection method, specifying an inclusion criterion of p-value < 0.2. Univariable or multivariable logistic regression models were not conducted for hookworm or *T. trichiura* due to the low number of observations necessary to run this model. All statistical analyses were carried out using STATA version 14.1 (STATA Corporation, College Station, TX, USA).

Ethical Approval

This study was reviewed and ethically approved by the Kenya Medical Research Institute Scientific and Ethics Review Unit (SERU No.3706). Permission to conduct the study was also obtained from Vihiga County Government health centres, pregnant women, and mature minors.

Consent

Verbal consent was obtained from County administrators and the health centre's administration. Written informed consent and verbal assent were sought from each study participant above 13 years of age by explaining the study purpose, the procedures to be followed, and the risks and benefits of taking part in the study before data collection. Data collection and stool samples were collected after obtaining individual written consent from the pregnant women. Individuals positive for STHs were treated with a suitable dose of albendazole by a certified nurse or midwife as per the WHO guidelines(WHO, 2017).

RESULTS

Demographics

Overall, the data analysed were from 250 participants from Luanda and Vihiga Sub-counties. The mean age of the study participants was 27 years (standard deviation ± 6 years) with an age range of 16-42 years. Slightly more than half, 127 (50.8%) of the participants were aged between 21 to 30 years, followed by those above 31 years; 74 (29.6%), and those below 20 years; 49 (19.6%). A majority, 142 (56.8%) were in the second trimester and 93 (37.2%) were in the third trimester. Slightly more than half of the participants were housewives; 132 (52.8%) and had primary school level of education; 131 (52.4%). *Table 1* summarizes the demographic characteristics of the study participants.

Table 1: Demographic, individual and household WASH factors, and the associated STH prevalence in Vihiga County, Kenya

Demographic Factor	N (%)	STH Prevalence			
		STH combined	Hookworm	*A. lumbricoides*	*T. trichiura*
Age group					
≤20	49(19.6%)	6(12.2%)	1(2.0%)	4(8.2%)	1(2.0%)
21-30	127(50.8%)	18(14.2%)	3(2.4%)	15(11.8%)	3(2.4%)
≥31	74(29.6%)	7(9.5%)	2(2.7%)	5(6.8%)	1(1.4%)
Marital status					
Married	205(82.0%)	27(13.2%)	5(2.4%)	21(10.2%)	5(2.4%)
Single	45(18.0%)	4(8.9%)	1(2.2%)	3(6.7%)	-
Education level					
None	2(0.8%)	-	-	-	-
Primary	131(52.4%)	17(12.9%)	2(1.5%)	13(9.9%)	4(3.1%)
Secondary	83(33.2%)	10(12.1%)	2(2.4%)	9(10.8%)	1(1.2%)
Post-secondary	34(13.6%)	4(11.8%)	2(5.9%)	2(5.9%)	-
Occupation					
Business	48(19.2%)	4(8.3%)	1(2.1%)	3(6.3%)	-
Farmer	25(10.0%)	6(24.0%)	-	5(20.0%)	1(4.0%)
Employed/Salaried	19(7.6%)	2(10.5%)	1(5.3%)	1(5.3%)	-
Housewife	132(52.8%)	15(11.4%)	2(1.5%)	13(9.9%)	3(2.3%)

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Demographic Factor	N (%)	STH Prevalence			
		STH combined	**Hookworm**	***A. lumbricoides***	***T. trichiura***
Casual labourer	8(3.2%)	1(12.5%)	1(12.5%)	-	1(12.5%)
Others	18(7.2%)	3(16.7%)	1(5.6%)	2(11.1%)	-
Trimester					
1st trimester	15(6.0%)	1(6.7%)	-	1(6.7%)	-
2nd trimester	142(56.8%)	17(11.9%)	5(3.5%)	12(8.5%)	3(2.1%)
3rd trimester	93(37.2%)	13(13.9%)	1(1.1%)	11(11.8%)	2(2.2%)
Individual WASH factors					
Hand washing behaviour	250(100.0%)	31(12.4%)	6(2.4%)	24(9.6%)	5(2.0%)
Hand washing with soap	232(92.8%)	27(11.6%)	6(2.6%)	20(8.6%)	4(1.7%)
Soil eating behaviour	60(24.0%)	9(15.0%)	2(3.3%)	6(10.0%)	1(1.7%)
Household WASH factors					
Have children below three years	75(30.0%)	7(9.3%)	2(2.7%)	4(5.3%)	3(4.0%)
How dispose children stool					
Child use latrine	16(21.3%)	1(6.3%)	-	1(6.3%)	-
Throw into latrine	55(73.3%)	6(10.9%)	2(3.6%)	3(5.5%)	3(5.5%)
Bury	4(5.3%)	-	-	-	-
Improved water source for drinking	155(62.0%)	16(10.3%)	4(2.6%)	13(8.4%)	2(1.3%)
Improved water source for household use	157(62.8%)	16(10.2%)	4(2.6%)	13(8.3%)	2(1.3%)
Treat water for drinking	118(47.2%)	15(12.7%)	2(1.7%)	11(9.3%)	2(1.7%)
Improved latrine	136(54.4%)	18(13.2%)	3(2.2%)	15(11.0%)	2(1.5%)
Share latrine with other households	160(64.0%)	18(11.3%)	3(1.9%)	14(8.8%)	4(2.5%)

-: indicates cases where there were insufficient/no observations

Prevalence and Intensity of Infections

Out of those surveyed, 12.4% (95%CI: 9.1%-16.9%) were infected with any STH. According to the individual species, hookworm infection was 2.4% (95%CI: 1.2% - 4.7%), *A. lumbricoides* was 9.6% (95%CI: 6.3% - 14.6%) and *T. trichiura* was 2.0% (95%CI: 0.8% - 5.3%). The overall mean intensity for hookworm infection was 101 (95%CI: 8 -1355), *A. lumbricoides* was 375 (95%CI: 107 - 1308), and *T. trichiura* was 3 (95%CI: 0 - 29). All infections were determined to be light infections.

Prevalence of any STH was highest in study participants attending Mbale Rural Health Centre (16.3%) followed by Ekwanda Health Centre (13.3%), Emuhaya Sub-County Hospital (12.0%) and Lyana Ginga (5.0%). Hookworm infections were highest in participants attending Lyana Ginga Health Centre (5.0%), *A. lumbricoides* was highest in participants attending Mbale Rural Health Centre (13.8%) and *T. trichiura* infections were highest in participants attending Ekwanda Health Centre (6.7%). *Table 2* and *Figure 1* summarize the prevalence and mean intensity of STH infections in health facilities.

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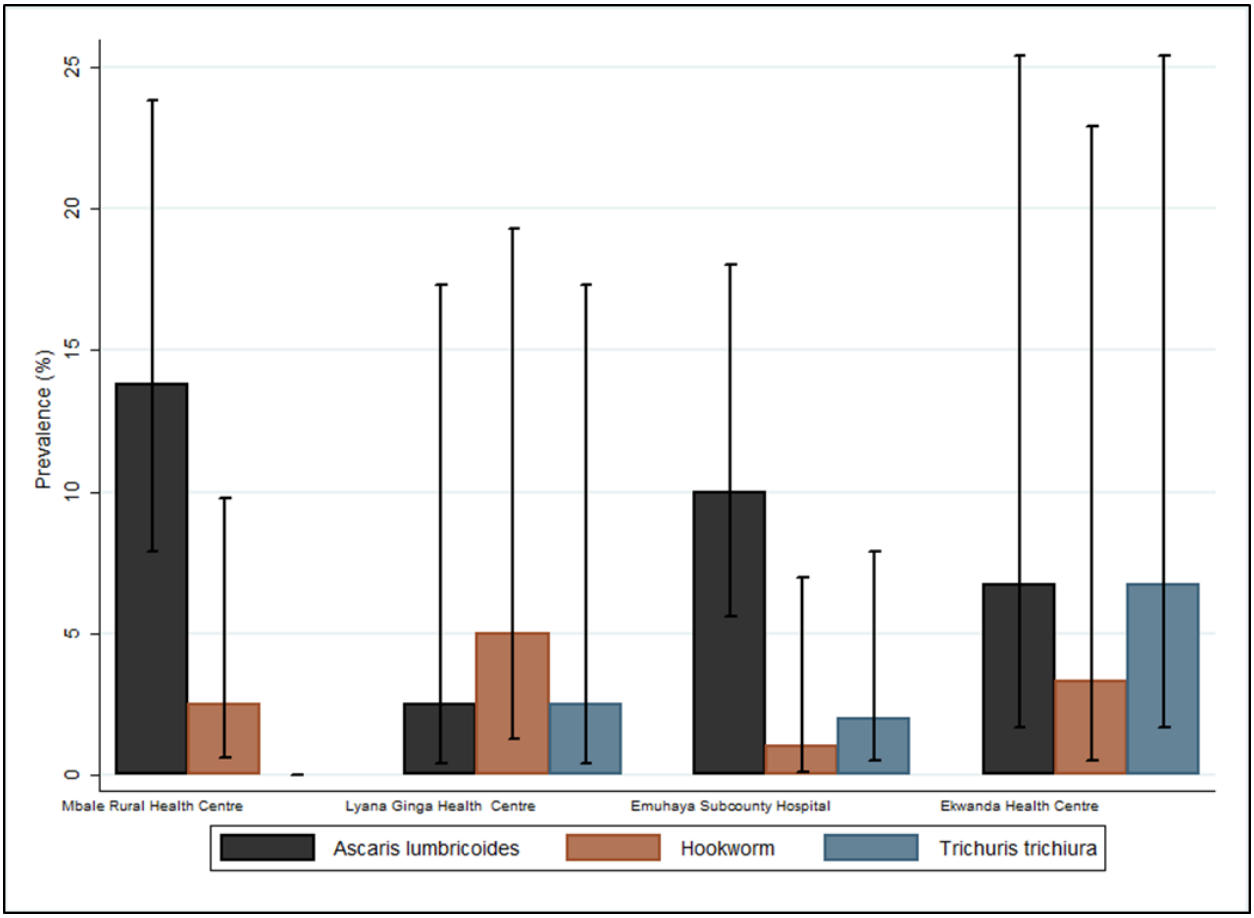
Table 2: STH prevalence and mean intensity by health facilities in Vihiga County, Kenya

Sub-County	N (%)	STH combined	Hookworms	*A. lumbricoides*	*T. trichiura*
Prevalence of infection (%)					
Luanda					
Emuhaya	100 (40.0%)	12.0 (7.1-20.4)	1.0 (0.1-7.0)	10.0 (5.6-18.0)	2.0 (0.5-7.9)
Ekwanda	30 (12.0%)	13.3 (5.4- 33.2)	3.3 (0.5-22.9)	6.7(1.7-25.4)	6.7 (1.7-25.4)
Vihiga					
Mbale	80 (32.0%)	16.3 (9.9-26.7)	2.5 (0.6-9.8)	13.8(7.9-23.8)	0
Lyana Ginga	40 (16.0%)	5 (1.3-19.3)	5.0 (1.3-19.3)	2.5 (0.4-17.3)	2.5 (0.4-17.3)
Total	**250 (100%)**	**12.4 (8.9-17.2)**	**2.4 (1.1-5.3)**	**9.6 (6.6-14.0)**	**2.0 (0.8-4.8)**
Mean intensity of infection					
Luanda					
Emuhaya	100 (40.0%)	-	1 (0-68)	295 (44 - 1983)	-
Ekwanda	30 (12.0%)	-	25 (0-7726)	476(5 - 44370)	-
Vihiga					
Mbale	80 (32.0%)	-	135 (1-12677)	454 (76 - 2723)	0
Lyana Ginga	40 (16.0%)	-	342 (4-32680)	339 (0 - 278479)	-
Average	**250 (100%)**	**-**	**101 (8-1355)**	**375 (107 - 1308)**	**3(0 - 29)**

-: indicates cases where there were insufficient/no observations

Figure 1: Prevalence percentages of STH as per each health facility in Vihiga County, Kenya



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Prevalence of STH was higher in participants who were among the age group 21 – 30 years (14.2%), followed by those below 20 years (12.2%) and those above 31 years (9.5%). It was also highest among housewives (11.4%) and those in the third trimester (13.9%). Infection with *A. lumbricoides* was more prevalent compared to other infections among the participants in the second (8.5%) and third trimester (11.8%). Infection with any STH was 12.4% in those who practiced hand washing. Participants who reported using soap for handwashing had a lower prevalence (11.6%) of any STH infection compared to those who did not use soap (22.2%).

Participants who reported soil eating behaviour had a higher prevalence of *A. lumbricoides* (10.0%) compared to other STH infections. Participants who had an improved water source for drinking water had a lower prevalence of STH infection (10.3%) compared to those who had unimproved sources (15.8%). Prevalence of STH infection among those who used improved latrine facilities was 13.2% while those who used unimproved latrines was 11.4%. *Table 2* summarizes the STH infection prevalence by various WASH characteristics.

Risk Factors Associated with STH Infection

Individual and Household Water, Sanitation, and Hygiene Characteristics

Hand washing behaviour was reported by all study participants and the majority (92.8%) reported that they use soap for washing of hands. Soil eating behaviour (geophagy) was reported by about a quarter (24%) of the participants. Less than one-third (30.0%) of the participants had children below three years and the majority, 73.3% of them disposed the children's stool into the latrine. Other methods of stool disposal reported were: burying (5.3%) and direct use of latrine by children (21.3%). Majority, 62% of the study participants had improved water sources for drinking water and 62.8% for their household use and slightly less than half, 47.2% of the participants treated their drinking water. More than half, 54.4% of the study participants had improved latrines in their homes, while 64% reported that they shared latrines with other households.

Univariable Analysis of Factors Associated with STH Infection

Univariable analysis of factors associated with infection did not reveal any significant associations. However, farmers had higher odds of STH and *A. lumbricoides* infections; (OR=3.47, p=0.076) and (OR=3.75, p=0.089) respectively compared to all other occupations. Participants in the third trimester had twice the odds of infection with any STH (OR=2.27, p=0.446)

Multivariable Analysis of Factors Associated with STH Infection

Three variables met the criteria for inclusion in the multivariable logistic regression model; improved water source for household use, shared latrine with other households, and occupation. However, none of the variables were significant with any STH infection ($p<0.05$). Nonetheless, the findings revealed that participants whose main occupation was farming had higher odds of STH infection compared to those in other occupations (aOR=3.11, p=0.110). Tables 3 and 4 below show a summary of the risk factors associated with STH infection.

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Table 3: Univariable analysis of risk factors associated with STH infection

Factor		**Number examined (%)**	**Univariable logistic regression [OR (95%CI); p-value]**	
			Any STH	***A. lumbricoides***
			(n=31)	**(n=24)**
Age	≤20	49(19.6%)	1.34, p=0.624	1.23, p=0.770
	21-30	127(50.8%)	1.58, p=0.332	1.85, p=0.254
	≥31	74(29.6%)	Reference	
Marital status	Married	205(82.0%)	1.55, p=0.433	1.59, p=0.464
	Single	45(18.0%)	Reference	
	None	2(0.8%)	-	-
Education level	Primary	131(52.4%)	1.12, p=0.850	1.76, p=0.470
	Secondary	83(33.2%)	1.03, p=0.966	1.95, p=0.411
	Post-secondary	34(13.6%)	Reference	
Occupation	Business	48(19.2%)	Reference	
	Farmer	25(10.0%)	3.47, p=0.076	3.75, p=0.089
	Employed/Salaried	19(7.6%)	1.29, p=0.777	0.83, p=0.878
	Housewife	132(52.8%)	1.41, p=0.560	1.64, p=0.457
	Casual labourer	8(3.2%)	1.57, p=0.704	-
	Others	18(7.2%)	2.20, p=0.336	1.88, p=0.512
Trimester	1st trimester	15(6.0%)	Reference	
	2nd trimester	142(56.8%)	1.90, p=0.546	1.29, p=0.812
	3rd trimester	93(37.2%)	2.27, p=0.446	1.88, p=0.561
Individual WASH factors	Handwashing behaviour	250(100.0%)	-	-
	Handwashing with soap	232(92.8%)	0.46, p=0.199	0.33, p=0.071
	Soil eating behaviour	60(24.0%)	1.35, p=0.485	1.06, p=0.904
	Household WASH factors			
	Have children below three years	75(30.0%)	0.65, p=0.338	0.44, p=0.143
How dispose children stool	Child use latrine	16(21.3%)	Reference	
	Throw into latrine	55(73.3%)	1.84, p=0.587	0.87, p=0.903
	Bury	4(5.3%)	-	-
	Improved water source for drinking	155(62.0%)	0.61, p=0.206	0.69, p=0.408
	Improved water source for household use	157(62.8%)	0.59, p=0.172	0.67, p=0.360
	Treat water for drinking	118(47.2%)	1.06, p=0.888	0.94, p=0.888
	Improved latrine	136(54.4%)	1.19, p=0.662	1.45, p=0.404
	Share latrine with other households	160(64.0%)	0.75, p=0.463	0.77, p=0.544

-: indicates cases where there were insufficient/no observations

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Table 4: Multivariable analysis of risk factors of STH infection among the study participants

Factor	Multivariable logistic regression [aOR, p-value] Any STH (n=31)
Improved water source for household use	0.68, p=0.350
Share latrine with other households	0.86, p=0.714
Occupation	
Business	Reference
Farmer	3.11, p=0.110
Employed/Salaried	1.36, p=0.738
Housewife	1.56, p=0.460
Casual labourer	1.35, p=0.804
Others	2.07, p=0.376

Discussion

In Western Kenya, STH infections have been reported to be common and pregnant women are particularly vulnerable to infection. The current study results reported an overall prevalence rate of 12.4% of STH infections among pregnant women in Vihiga. In related studies, a prevalence rate of 76.2% among 390 pregnant women was reported in rural Western Kenya (van Eijk et al., 2009). The usage of unprotected water sources and the absence of treatment of drinking water could explain the disparity in prevalence. We also noted that participants who had improved water sources for drinking water had a lower prevalence of STH infection (10.3%) compared to those who had unimproved sources (15.8%). The absence of water treatment is a marker for soil exposure and hence infection through contaminated water with soil (van Eijk et al., 2009).

In this study, we noted that 62.8% of the study participants had improved water sources for household use and the majority used improved latrines, and this ensures proper faeces disposal and clean water for drinking. The lower prevalence could be attributed to the use of protected water sources, hence the reduction in STH prevalence.

On the contrary, high geohelminth infection rates among pregnant women have been reported in Nepal (any geohelminth 89%, hookworm 74%) and Uganda (any geohelminth 71%, hookworm 66.6%)(Dreyfuss et al., 2000; Ndyomugyenyi et al., 2008). The temperature, soil type, rainfall, altitude, and humidity are the major environmental factors that influence the pre-existence of helminthic infections in one geographical area.

The predominant helminth species among pregnant women in the current study was *A. lumbricoides*, which is comparable to other studies (Feleke & Jember, 2018; Hailu et al., 2020). The 9.6% *A. lumbricoides* prevalence was significantly lower than that reported in a similar study in North West Ethiopia which was at 32.7% and higher than that reported in Kitale Western Kenya which was at 6.5%(Feleke & Jember, 2018; Wekesa et al., 2014). The differences in the prevalence of *A. lumbricoides* could be attributed to poor hand washing practices and ingestion of raw vegetables (Feleke & Jember, 2018). The current study results reported an 8.5% *A. lumbricoides* prevalence among pregnant women in the second trimester and 11.8% among those in the third trimester. The high prevalence of *A. lumbricoides* infection compared to other STHs could be due to the ability of a single worm to release up to 200,000 eggs per day coupled with the resistant nature of the eggs to harsh environmental conditions (Adewale et al., 2018; Asaolu & Ofoezie, 2019).

In the current study, STH prevalence was also reported at 13.9% among third-trimester pregnant women who were housewives and farmers which could be attributed to a lack of knowledge and awareness on how and when intestinal parasites are transmitted. A similar study conducted in Ethiopia also found out that the prevalence of STH was higher in pregnant women who were farmers and worked in fields and ate their food without washing

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their hands (Hailu et al., 2020). Pregnant women in many rural areas depend on pit latrines for waste disposal with no facilities for hand washing after defecation. Such a scenario, accompanied by seasonal flooding and possible latrine overflow of human waste into drinking water sources, is likely to lead to the high prevalence of STH reported. A low prevalence of STH has been reported among pregnant women who used soap and water for hand washing and had improved drinking water sources and improved latrine facilities (Amuta et al., 2010).

Hookworm infection was the second most common helminth among the study participants at a rate of 2.4% followed by *T. trichiura* which was 2.0%, however, these results were insignificant. The prevalence of *T. trichiura* was higher than 0.9% reported in a similar study conducted among pregnant women in Ghana (Baidoo et al., 2010). The hookworm rate of infection was lower than that of another study that was conducted in Entebbe, Uganda, and reported a prevalence of 45%. The difference could be as a result of the sample size which was 2507 and the study was conducted for two years (Ndibazza et al., 2010). The current study results also reported a lower prevalence of hookworm infection compared to that of a similar study conducted in Uganda which was 11%. Results of the current study show that hookworm is prevalent and its predominance in tropical areas is due to the favourable environment (Apili et al., 2020; Bartsch et al., 2016).

We observed that there was an association between soil eating behaviour and helminth infection, with 24% of the study participants indicating that they engaged in soil eating behaviour. A similar study conducted in Ethiopia also showed that women who had a habit of soil eating were 2.6 times more likely to be infected by STH as compared to those who do not (Gebrehiwet et al., 2019). In this study, a high prevalence of *A. lumbricoides*, 10.0% was observed among participants who ate soil compared to the other infections. This could be due to poor hand washing techniques or soil contamination with *A. lumbricoides* eggs, however, a prevalence of 46.4% has been reported in a similar study conducted in Nigeria and this was associated with soil eating behaviour of pregnant women. There was evidence of soil contamination with *A. lumbricoides* eggs from the ingested soils (Ivoke et al., 2017).

Conclusions and Recommendations

These findings showed that STH infections are present among pregnant women as opposed to many studies which have focused only on PSAC and SAC. Pregnant women need to be dewormed and educated on geophagy and its effects. In addition, they also need to be sensitized on the need of proper hand washing techniques before and after visiting the toilet, using soap and water, and taking drinking water from safe water sources to limit STH infections.

The study recommends testing of STH among pregnant women attending antenatal clinics and integration of deworming in the health program, especially in areas where STH infections are highly prevalent. The study further recommends the provision of anthelmintic drugs among women of reproductive age. There should also be a provision for iron sources from supplements or food to prevent them from eating soil that predisposes them to STH infections.

Study Limitations

The study did not compare the sensitivity of using the Kato-Katz technique against other more sensitive techniques like Polymerase Chain Reaction due to budget constraints. The study did not follow up participants at their homes to evaluate their household and socio-economic conditions which could have been related to their current infection status.

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Data Availability

All data generated or analysed during this study are included in this published article (and its additional files).

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Conflict of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

Authors' Contributions.

Sylvie Araka conceived the study and participated in data collection and manuscript development. Collins Okoyo participated in data collection, data analysis, and manuscript development. Janet Masaku participated in study design and manuscript development. Bridget Kimani and Elses Simiyu participated in data collection. Sultani Matendechero participated in data collection and provided the deworming drugs that were administered to the study participants who tested positive. Doris W. Njomo was responsible for the study design and overall scientific guidance. All authors have read, edited, and approved the final manuscript.

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REFERENCES

Adewale, B., Rahaman, O., Aina, O., & Sulyman, M. A. (2018). Schistosoma mansoni and Soil Transmitted Helminth (STH) Infections among Pregnant Women Attending Primary Health Care Facilities in Lagos Mainland, Nigeria. *Journal of Biosciences and Medicines*, *06*(12), 64– 70. https://doi.org/10.4236/jbm.2018.612006

Amuta, E. U., Houmsou, R. S., & Mker, S. D. (2010). Knowledge and risk factors of intestinal parasitic infections among women in Makurdi, Benue State. *Asian Pacific Journal of Tropical Medicine*, *3*(12), 993–996. https://doi.org/10.1016/S1995-7645(11)60016-3

Apili, F., Ochaya, S., Osingada, C. P., Mbalinda, S. N., Mukunya, D., Ndeezi, G., & Tumwine, J. K. (2020). Hookworm Infection among Pregnant Women at First Antenatal Visit in Lira, Uganda: A Cross-Sectional Study. *International Journal of Reproductive Medicine*, *2020*, 1–8. https://doi.org/10.1155/2020/8053939

Asaolu, S. O., & Ofoezie, I. E. (2019). Ascaris spp. In Water and Sanitation for the 21st Century: Health and Microbiological Aspects of Excreta and Wastewater Management (Global Water Pathogen Project). Michigan State University. https://doi.org/10.14321/waterpathogens.41

Baidoo, S. E., Tay, S. C. K., & Abruquah, H. H. (2010). Intestinal helminth infection and anaemia during pregnancy: A community based study in Ghana. *African Journal of Microbiology Research*, *4*(16), 1713– 1718. http://www.academicjournals.org/ajmr

Bartsch, S. M., Hotez, P. J., Asti, L., Zapf, K. M., Bottazzi, M. E., Diemert, D. J., & Lee, B. Y. (2016). The Global Economic and Health Burden of Human Hookworm Infection. *PLOS Neglected Tropical Diseases*, *10*(9), e0004922. https://doi.org/10.1371/journal.pntd.0004922

Brooker, S, Bethony, J., Parasitology, P. H.-A. in, & 2004, U. (2004). Human hookworm infection in the 21st century. *Ncbi.Nlm.Nih.Gov*. https://www.ncbi.nlm.nih.gov/pmc/articles/pmc2268732/

Brooker, Simon, Hotez, P. J., & Bundy, D. A. P. (2008). Hookworm-Related Anaemia among Pregnant Women: A Systematic Review. *PLoS Neglected Tropical Diseases*, *2*(9), e291. https://doi.org/10.1371/journal.pntd.0000291

Dreyfuss, M., Stoltzfus, R., Shrestha, J., Pradhan, E. K., Leclerq, S., Khatry, S. K., Katz, J., Shrestha, S. R., Katz, J., Albonico, M., & West, K. P. (2000). Hookworms, malaria and vitamin A deficiency contribute to anemia and iron deficiency among pregnant women in the plains of Nepal. *The Journal of Nutrition*. https://academic.oup.com/jn/article-abstract/130/10/2527/4686110

Feleke, B. E., & Jember, T. H. (2018). Prevalence of helminthic infections and determinant factors among pregnant women in Mecha district, Northwest Ethiopia: A cross sectional study. *BMC Infectious Diseases*, *18*(1), 1–6.

Article DOI: https://doi.org/10.37284/eajhs.5.1.670

https://doi.org/10.1186/S12879-018-3291-6/TABLES/3

Gebrehiwet, M. G., Medhaniye, A. A., & Alema, H. B. (2019). Prevalence and associated factors of soil transmitted helminthes among pregnant women attending antenatal care in Maytsebri primary hospital, North Ethiopia. *BMC Research Notes*, *12*(1), 644. https://doi.org/10.1186/s13104-019-4684-3

Guideline: Preventive Chemotherapy To Control Soil-Transmitted Helminth Infections In At-Risk Population Groups. (2017). http://apps.who.int/bookorders.

Hailu, T., Abera, B., Mulu, W., Kassa, S., Genanew, A., & Amor, A. (2020). Prevalence and Factors Associated with Intestinal Parasitic Infections among Pregnant Women in West Gojjam Zone, Northwest Ethiopia. *Journal of Parasitology Research*, *2020*. https://doi.org/10.1155/2020/8855362

Hotez, P. J., & Kamath, A. (2009). Neglected tropical diseases in sub-Saharan Africa: Review of their prevalence, distribution, and disease burden. In *PLoS Neglected Tropical Diseases* (Vol. 3, Issue 8). PLoS Negl Trop Dis. https://doi.org/10.1371/journal.pntd.0000412

Ivoke, N., Ikpor, N., Ivoke, O., Ekeh, F., Ezenwaji, N., Odo, G., Iyaji, F., Onoja, U., & Eyo, J. (2017). Geophagy as risk behaviour for gastrointestinal nematode infections among pregnant women attending antenatal clinics in a humid tropical zone of Nigeria. *African Health Sciences*, *17*(1), 24–31. https://doi.org/10.4314/ahs.v17i1.5

Katz, N., Chaves, A., … J. P. instituto de medicina tropical, & 1972, U. (1972). A simple device for quantitative stool thick-smear technique in Schistosomiasis mansoni. *Cabdirect.Org*. https://www.cabdirect.org/cabdirect/abstract/19732900729

Kenya National Bureau of Statistics. (2019). VOLUME I: POPULATION BY COUNTY AND SUB-COUNTY Counting Our People for Sustainable Development and Devolution of Services REPUBLIC OF KENYA.

McClure, E. M., Meshnick, S. R., Mungai, P., Malhotra, I., King, C. L., Goldenberg, R. L., Hudgens, M. G., Siega-Riz, A. M., & Dent, A. E. (2014). The Association of Parasitic Infections in Pregnancy and Maternal and Fetal Anemia: A Cohort Study in Coastal Kenya. *PLoS Neglected Tropical Diseases*, *8*(2). https://doi.org/10.1371/journal.pntd.0002724

Montresor, A., Crompton, D. W. T., Hall, A., Bundy, D. A. P., & Savioli, L. (1998). Guidelines for the evaluation of soil-transmitted helminthiasis and schistosomiasis at community level: a guide for managers of control programmes. https://apps.who.int/iris/bitstream/handle/10665/63821/WHO_CTD_SIP_98.1.pdf

Mupfasoni, D., Mikhailov, A., Mbabazi, P., King, J., Gyorkos, T. W., & Montresor, A. (2018). Estimation of the number of women of reproductive age in need of preventive chemotherapy for soil-transmitted helminth infections. *PLoS Neglected Tropical Diseases*, *12*(2). https://doi.org/10.1371/journal.pntd.0006269

Mwandawiro, C., Okoyo, C., Kihara, J., Simiyu, E., Kepha, S., Campbell, S. J., Freeman, M. C., Brooker, S. J., & Njenga, S. M. (2019a). Results of a national school-based deworming programme on soil-transmitted helminths infections and schistosomiasis in Kenya: 2012-2017. *Parasites and Vectors*, *12*(1), 1–18. https://doi.org/10.1186/S13071-019-3322-1/FIGURES/9

Mwandawiro, C., Okoyo, C., Kihara, J., Simiyu, E., Kepha, S., Campbell, S. J., Freeman, M. C., Brooker, S. J., & Njenga, S. M. (2019b). Results of a national school-based deworming programme on soil-transmitted helminths infections and schistosomiasis in Kenya: 2012–2017. *Parasites & Vectors 2019 12:1*, *12*(1), 1–18. https://doi.org/10.1186/S13071-019-3322-1

Ndibazza, J., Muhangi, L., Akishule, D., Kiggundu, M., Ameke, C., Oweka, J., Kizindo, R., Duong, T., Kleinschmidt, I., Muwanga, M., & Elliott, A. M. (2010). Effects of deworming during pregnancy on maternal and perinatal outcomes in entebbe, Uganda: A randomized controlled

Article DOI: https://doi.org/10.37284/eajhs.5.1.670

Trial. *Clinical Infectious Diseases*, *50*(4), 531–540. https://doi.org/10.1086/649924

Ndyomugyenyi, R., Kabatereine, N., Olsen, A., & Magnussen, P. (2008). Malaria and hookworm infections in relation to haemoglobin and serum ferritin levels in pregnancy in Masindi district, western Uganda. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *102*(2), 130– 136. https://doi.org/10.1016/j.trstmh.2007.09.015

Organization, W. H. (2017). Guideline: preventive chemotherapy to control soil-transmitted helminth infections in at-risk population groups. https://apps.who.int/iris/bitstream/handle/10665/258983/9789241550116-eng.pdf

Salawu, O. T., & Odaibo, A. B. (2014). Maternal schistosomiasis: A growing concern in sub-Saharan Africa. In *Pathogens and Global Health* (Vol. 108, Issue 6, pp. 263–270). Maney Publishing. https://doi.org/10.1179/2047773214Y.0000000150

Sousa-Figueiredo, J. C., Gamboa, D., Pedro, J. M., Fançony, C., Langa, A. J., Soares Magalhães, R. J., Stothard, J. R., & Nery, S. V. (2012). Epidemiology of Malaria, Schistosomiasis, Geohelminths, Anemia and Malnutrition in the Context of a Demographic Surveillance System in Northern Angola. *PLoS ONE*, *7*(4), e33189. https://doi.org/10.1371/journal.pone.0033189

Speich, B., Ali, S. M., Ame, S. M., Albonico, M., Utzinger, J., & Keiser, J. (2015). Quality control in the diagnosis of Trichuris trichiura and Ascaris lumbricoides using the Kato-Katz technique: Experience from three randomised controlled trials. *Parasites and Vectors*, *8*(1). https://doi.org/10.1186/s13071-015-0702-z

STATE DEPARTMENT OF DEVOLUTION. (2020). VIHIGA COUNTY COUNTY INTEGRATED DEVELOPMENT PLAN 2018-2022.

Steketee, R. W. (2003). Pregnancy, nutrition and parasitic diseases. *Journal of Nutrition*, *133*(5 SUPPL. 1). https://doi.org/10.1093/jn/133.5.1661s

van Eijk, A. M., Lindblade, K. A., Odhiambo, F., Peterson, E., Rosen, D. H., Karanja, D., Ayisi, J. G., Shi, Y. P., Adazu, K., & Slutsker, L. (2009). Geohelminth Infections among Pregnant Women in Rural Western Kenya; a Cross-Sectional Study. *PLoS Neglected Tropical Diseases*, *3*(1), e370. https://doi.org/10.1371/journal.pntd.0000370

W. Gyorkos, M. C. E. et al. (2004). *Improving Maternal and New Born Health in Hook Worm—Endemic Areas by Adding a Single-Dose Anthelminthic to Prenatal Care*. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=W.+Gyorkos%2C+M.+Casapia+EG+et+a.+Improving+Maternal+and+New+Born+Health+in+Hook+Worm— Endemic+Areas+by+Adding+a+Single- Dose+Anthelminthic+to+Prenatal+Care.+In%3A+Global+Forum+for+Health+Research.+200

Wekesa, A. W., Mulambalah, C. S., Muleke, C. I., & Odhiambo, R. (2014). Intestinal helminth infections in pregnant women attending antenatal clinic at kitale district hospital, Kenya. *Journal of Parasitology Research*, *2014*. https://doi.org/10.1155/2014/823923

WHO. (2011). Helminth control in school-age children. A guide for managers of control programmes. *Geneva: World …*, 90. http://www.who.int/neglected_diseases/en

World Health Organization. (2019). WHO | Deworming in pregnant women. *WHO*. http://www.who.int/elena/titles/deworming_pregnancy/en/

