

Research Article



Seasonality of Neglected Tropical Geohelminthes and Asymptomatic *P.falciparum* Malaria Prevalence Among Pregnant Women Attending Antenatal Care at Nandi-Hills Sub-county Hospital, Kenya

RAEL JEPKOGEI MASAI

Kisii University, Department of Biological Sciences, P.O. Box 408-40200, Kisii, Kenya.

Abstract | The large-scale geographical distributions of malaria and helminths are determined largely by climate, which determines mosquito and helminth free-living stage survival. The study was carried out in Nandi Hills Sub-County Hospital in Nandi County and data was collected from 300 pregnant study participants. The study period was stratified into wet season and dry season. Consenting participants provided stool samples that were processed by formal-ether concentration techniques and results recorded as either positive or negative. Capillary blood samples were collected for slide preparations and subjected to microscopy to determine presence of *P.falciparum*. A questionnaire was used to obtain information on study subjects' area of residence. Results were processed using SSPS and significance levels were obtained using chi square and logistic regression. Most respondents (200 (66.7%)) visited the hospital during dry season and only 33.3% visited during the rainy season. Infection prevalence of geohelminths was *A. lumbricoides*, *A. duodenale* and *T. trichiura*, 40% ($p < .05$), 25% ($p < .05$), and 1% infection prevalence were detected respectively during the wet season, and 24.5%, 10.5% and 1% respectively during the dry season, 16% of *P.falciparum* ($p < .05$) were infections during the wet season, representing 5.3% of *P.falciparum* infection among all the study participants and only 4% during the dry season, representing 2.3% of *P.falciparum* infection among all the study participants. Given the changing precipitation patterns as a result of climate change, this study can inform the policy makers on best ways of designing prevention and control measures of the parasites.

Keywords | Geohelminths, *P.falciparum*, Prevalence, Season

Editor | Muhammad Imran Rashid, Department of Parasitology, University of Veterinary and Animal Sciences, Lahore, Pakistan.

Received | July 12, 2024; **Accepted** | August 10, 2024; **Published** | August 25, 2024

***Correspondence** | Rael Jepkoge Masai, Kisii University, Department of Biological Sciences, P.O. Box 408-40200, Kisii, Kenya; **Email:** jmasai@kisiuniversity.ac.ke; jjepkoge@gmail.com

Citation | Masai RJ (2024). Seasonality of neglected tropical geohelminthes and asymptomatic *P.falciparum* malaria prevalence among pregnant women attending antenatal care at nandi-hills sub-county hospital, Kenya. J. Adv. Parasitol. 11: 5-13.

DOI | <http://dx.doi.org/10.17582/journal.jap/2024/11.5.13>

ISSN | 2311-4096



Copyright | 2024 by the authors. Licensee ResearchersLinks Ltd, England, UK.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

INTRODUCTION

Half the world's population live in malaria-endemic areas, with an estimated 500 million clinical cases and over one million deaths annually (WHO, 2008). Soil-transmitted helminths (STH) also known as geohelminthes, on the other hand, are a group of common parasites that infect more than a billion people worldwide (Bethony et al., 2006). Poly-parasitism is a public health problem in sub-Saharan Africa. Malaria parasites and geohelminthes

co-infection are currently receiving a lot of attention because of the likelihood of the complications arising from their coinfections (Wanyonyi et al., 2018). The large-scale geographical distributions of malaria and helminths are determined largely by climate, which determines mosquito and helminth free-living stage survival (Hay et al., 2000; Brooker and Michael, 2000). Thus, it is probable that the geographic congruence of malaria and geohelminthes, especially hookworm, reflect common climatic drivers of parasite geographic ranges. Among the geo-helminth spe-

cies, hookworms appear to have a wider thermal tolerance than *A. lumbricoides* or *T. trichiura* occurring throughout most of SSA, congruently with malaria.

Although they have distinct means of transmission, a variety of environmental and host-specific factors have been identified for each parasite that influences epidemiological and geographic patterns of infection and disease. Identifying common risk factors of malaria and helminth infection is important since apparent associations between the two infections may be due to common social or environmental factors rather than a true biological interaction (Mwangi, et al., 2006). Valencia et al. (2010) found an ecological correlation between malaria incidence and soil transmitted prevalence in Colombia. Malaria and soil transmitted helminths were found to be eco-syndemic.

Brooker et al. (2013), found that environmental factors associated with *Plasmodium falciparum* and hookworm co-infection were generally the same as those associated with hookworm infections and those for *Plasmodium falciparum*-*Schistosoma* co-infections were the same as those for *Schistosoma* infections. The findings suggested that environmental factors associated with individual helminth species were also associated with large scale spatial patterns of co-infections. According to Ojurongbe et al. (2011), malaria and soil transmitted helminths are highly prevalent in rural communities as a result of poor sanitary conditions prevailing in these areas. Africa bears 40% of neglected tropical parasitoses which are typical diseases of poverty, highly endemic in rural areas and Out of the 20 NTDs recognised by the WHO, 19 occur in Africa, with 11 (nearly 60%) of them being of parasitological aetiology (Lorusso, 2021). Efforts have been consistently been made to reduce and eliminate NTD as noted by the WHO (2020) NTD road map which recommends concrete actions within integrated platforms for delivery of the interventions needed to improve the cost-effectiveness, coverage and geographical reach of these integrated programmes. Geohelminthiasis and malaria were prevalent in Bungoma County therefore Wanyonyi et al. (2018) recommend that screening of these infections be incorporated in the antenatal care program to improve maternal and neonatal health. According to Riesel et al. (2010) there was a significant STH burden in rural villages in Kenya which required regular and effective deworming.

Nandi Hills sub county hospital serves women mostly from the villages around the town and the area is known to be a malaria epidemic zone whereby the type of malaria infection is mainly unstable malaria. It is characterised by variable transmission rate from year to year (Strickland et al., 2000). The report on research findings on geohelminths and *P. falciparum* malaria amongst pregnant women attending ANC and Nandi-Hills sub-county hospital Kenya

was motivated by Kripa et al. (2024) findings on the impact of climate change on disease transmission potential. They established that temperature fluctuations in tropical and temperate countries will have a potential impact on parasite development in the vector *Anopheles* mosquito and that the parasite extrinsic incubation period in the newly reported vector in Kenya (*A. stephensi*) will be faster posing a risk for disease transmission. Nandi-hills is a home to many casual labourers who work in the expansive tea plantations and tea factories who according to the Nandi county-CIDP, 2013-2017 are the most vulnerable population. A majority have moved from western part of Kenya which is a malaria endemic zone and has a high prevalence of geohelminth parasites. It was therefore imperative to determine effects of wet and dry seasons of parasite prevalence, determine effect of area of residence (rural and urban) on parasite prevalence during wet and dry seasons and to relate use of ITNs and IRS on the prevalence of asymptomatic malaria during wet and dry seasons.

METHODOLOGY

STUDY SITE

The study was carried out in Nandi Hills Sub-County Hospital in Nandi County (Plate 1)

The hospital serves residents mainly from Nandi Hills Sub County. The Sub County is situated in Western part of Kenya and it covers an area of 938.2km². It borders Nyan-do to the south, Nandi south to the West, Nandi North to the north, Uasin Gishu County to the North East and Kericho County to the South East (Appendix 15). It lies within latitudes 0° and 0°34' North and Longitudes 34°45" and 35°25" East (District Development Plan, Nandi East 2008-2012, 2009).

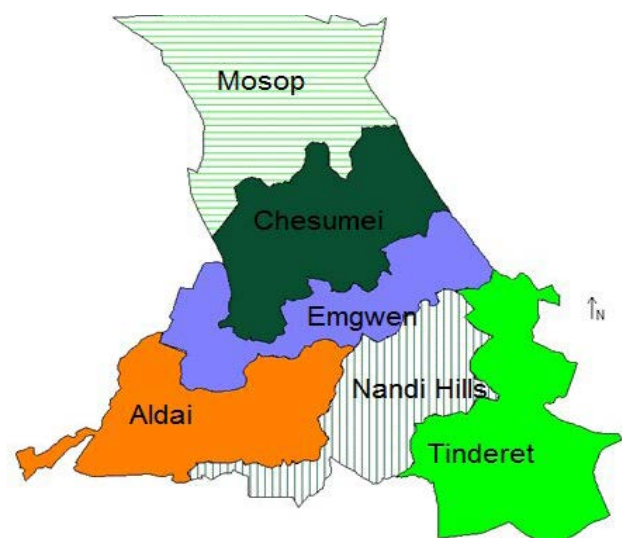


Plate 1: A map showing the study area

The Sub County has a cool and moderately humid climate with an average rainfall of between 1200 mm to 2000 mm

in a year. Long rains start in early March and continue to end of June while short rains start in September to November. Dry spell is experienced between December and March. Most parts of the Sub County experience temperature ranging between 18°C and 22°C during rainy seasons while higher temperatures (23°C) are recorded during the dry spell in the highlands. Temperatures of 26°C are experienced during the months of December and January in the lower side of Nandi escarpment (NE DDP 2008-2012, 2009).

Collection of data was done from March to December in the year 2015 and this period was stratified into two namely dry season (March, September, October, November and December) and wet seasons (April, May, June, July and August).

SAMPLE COLLECTION AND PROCESSING

The current study was a cross sectional survey of asymptomatic pregnant women attending ANC at Nandi Hills Sub-County hospital who were randomly selected to attain a sample size of 300.

Each participant was provided with a labeled screw capped stool cap and informed on how to collect about 5 grams of stool sample. Stool was processed immediately at the hospital using formal- ether concentration technique as described by Cheesbrough, (2006). Concentration technique was used because of its effectiveness in finding out the eggs even in light infections which are asymptomatic. The current study used pregnant women who were attending ANC, without presenting any ill health, implying that presence of ova in stool was mainly light infection. Microscopic examination was done and results recorded in terms of presence/absence and intensity of ova in stool.

Quantification of worm burden was done by direct smear egg count (Chakraborty, 2004) whereby an approximately 2mgs of faeces was mixed in a small drop of saline on a slide. A coverslip was applied on the evenly mixed material without forming air bubbles. The preparation was examined systematically with low power microscope and eggs of the present geo-helminth species were counted. Quantification of worm burden was applicable to the stool samples which had been found to have geo-helminth ova. Number of eggs per gram of faeces (epg) was obtained using the following formula (Chakraborty, 2004);

No. of eggs/ gram of faeces = $N/2 \times 1000$, where N = number of eggs.

Intensity was then categorized into light, moderate and heavy infections using a threshold proposed by WHO, (1987). Light intensity is described to be 1-4,999 epg,

1-1,999 epg, and 1-999 epg for *A. lumbricoides*, hookworm and *T.trichiura* respectively. Moderate intensity is estimated to be 5000-49000 epg, 2000-3999 epg and 1000-9,999 epg for *A. lumbricoides*, hookworm and *T.trichiura* respectively, while heavy intensity is estimated to be 50000 epg, 4000 epg and 10,000 epg for *A. lumbricoides*, hookworm and *T.trichiura*, respectively. (Montresor et al., 1998).

Consenting participants donated capillary blood sample through a finger prick Thick and thin blood smears were prepared and stained using Field Stains A and B. Microscopic examination was done under oil immersion at x100 objective to identify parasite species following the method of Cheesbrough, (2006).

DATA ANALYSIS

Data was processed using statistical package for social sciences

Differences in infection proportions in wet and dry seasons were determined using chi square analysis and significance levels considered at $p < 0.05$. Odds ratios (OR) was determined with 95% confidence interval by logistic regression to show whether season of the year was a risk factor of parasite infection and co-infection

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

Consent to carry out the study in the hospital was obtained from the hospital management board through the hospital superintendent. Sampled pregnant women gave informed consent to participate in the study. Written consent was obtained whereby the pregnant women were asked to sign an informed consent form (ICF) after explaining the objectives and value of the study to them. ICF written in English was explained in Swahili and sometimes in their mother tongue to enhance understanding. Ethical clearance was obtained from Jaramogi Oginga Odinga Teaching and Referral Hospital. Ethics of research were adhered to throughout the study period.

RESULTS

PARASITIC PREVALENCE OF PREGNANT WOMEN ATTENDING ANC AT NANDI-HILLS SUB-COUNTY HOSPITAL DURING WET AND DRY SEASONS OF THE STUDY PERIOD

The period for current study was stratified into dry and wet seasons which recorded 100 (33.3%) of the pregnant women and a dry season which recorded 200 (66.7%) pregnant women (Figure 1).

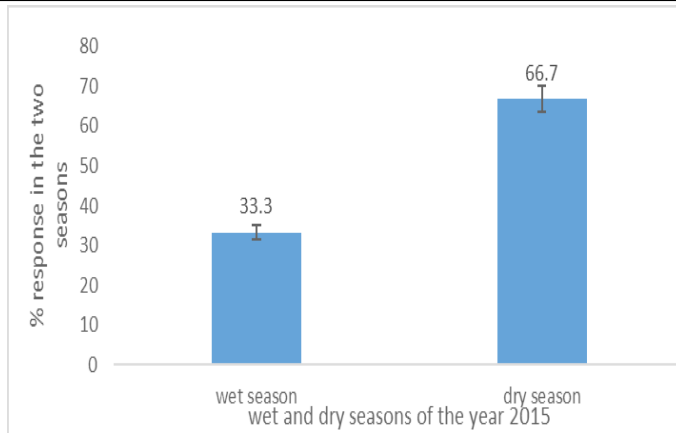


Figure 1: Percentage of respondents in wet and dry season of the study period

SINGLE PARASITE INFECTION AMONG PREGNANT WOMEN IN RELATION TO WET AND DRY SEASON OF THE STUDY PERIOD

Out of the total 23 (8%) *P.falciparum* cases, 16% were infections during the wet season which recorded 100 participants and 4% were infected during the dry season, (Figure 2). Differences in infection proportions with *P.falciparum* in wet and dry season was significant ($P=0.000$) (Table 1). For geo-helminth infection, *A. lumbricoides*, *A. duodenale* and *T. trichiura*, 40%, 25%, and 1% infection prevalence were detected respectively during the wet season, and 24.5%, 10.5% and 1% respectively during the dry season. (Figure 2). Difference in infection proportions during the dry and wet season by *A. lumbricoides* and *A. duodenale* was significant ($P=0.006$ and $P=0.001$ respectively) but there was no statistical significant difference in infection by *T. trichiura* parasites ($P=1.000$) between wet and dry seasons. Wet and dry seasons were not risk factors of infection for *P.falciparum* and *A. duodenale*; $OR<1$ (Table 1).

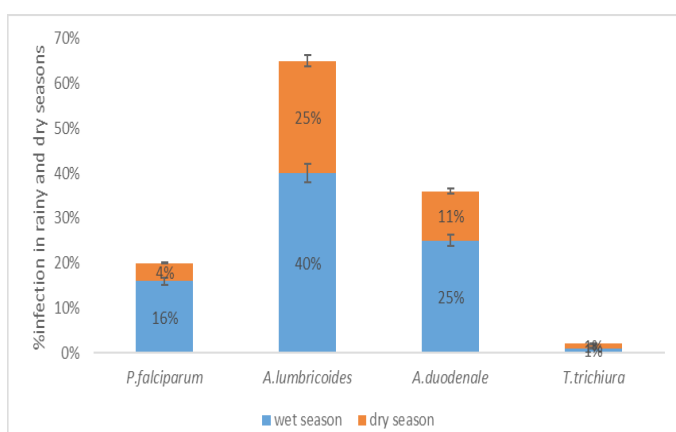


Figure 2: Parasite infection among pregnant women during the wet and dry seasons of the year 2015.

PARASITE CO-INFECTIONS AMONG PREGNANT WOMEN ATTENDING ANC AT NANDI-HILLS SUB-COUNTY HOSPITAL DURING WET AND DRY SEASONS OF THE

STUDY PERIOD

During the wet season, 14(14%) out of the 100 study participants were co-infected with *A.lumbricoides* and *A.duodenale* while only one (1%) had *A.lumbricoides* and *T.trichiura*. These co-infections were however insignificant ($p=0.059$ and $p=0.218$ respectively). During the dry season, 11(5.5%) out of 200 participants had significant co-infection prevalence of *A.lumbricoides* and *A.duodenale* whereas 2(1%) had *A.lumbricoides* and *T.trichiura* co-infections (Table 2).

Wet and dry season recorded insignificant co-infections of *P.falciparum* and geohelminth parasites. 3% of pregnant women were co-infected with *P.falciparum* and *A. lumbricoides* during the wet season and there were no co-infections of *Plasmodium* and *A. lumbricoides* during the dry season. Pregnant women co-infected with *P.falciparum* and *A. duodenale* during the wet season were 6% whereas those co-infected during the dry season were 0.5% (Table 2). There were no cases of malaria parasites and *T. trichiura* co-infections in both seasons of the year 2015.

Association between *P. falciparum* and *A. lumbricoides* co-infection during the wet season was insignificantly negative ($r^2=-0.189$) and that of *P.falciparum* and *A. duodenale* co-infection in both wet and dry seasons was insignificantly positive ($r^2=0.126$ and $r^2=0.024$ respectively). *P. falciparum* and *A. lumbricoides* remained counter syndemic while *P. falciparum* and *A. duodenale* infection remained syndemic in both seasons of the year 2015.

EFFECT OF RESIDENTIAL AREAS ON GEOHELMINTH AND MALARIA INFECTION DURING DRY AND WET SEASONS OF THE STUDY PERIOD

Residential areas were stratified into urban and rural areas and most of the study subjects were rural dwellers 244 (81.3%) while a minority were urban dwellers 56(18.7%) (Figure 3).

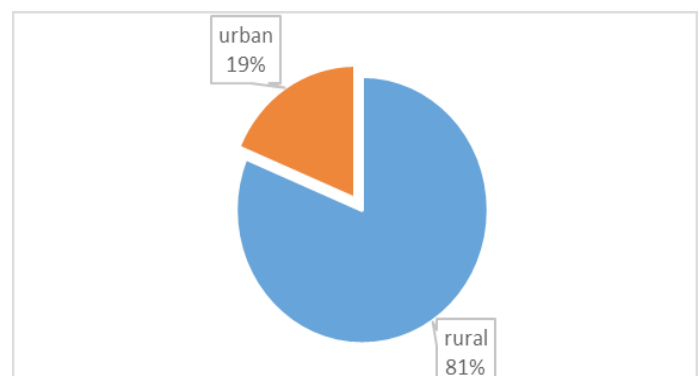


Figure 3: Percentage respondents from rural and urban areas during the study period

During the wet season comprising 100 individuals (74 and 26 drawn from rural and urban areas respectively).

Table 1: Single parasite infection prevalence of pregnant women during wet and dry seasons.

	<i>P.falciparum</i>		<i>A.lumbricoides</i>		<i>A. duodenale</i>		<i>T.trichiura</i>	
	Positive	Negative	Present	Absent	Present	Absent	Present	Absent
Wet season (n=100)	16 (16%)	84 (84%)	40 (40%)	60 (60%)	25 (25%)	75 (75%)	1 (1%)	99 (99%)
Dry season (n=200)	7 (3.5%)	193 (96.5%)	49 (24.5%)	151 (75.5%)	21 (10.5%)	179 (89.5%)	2 (1%)	198 (99%)
P value	0.000*		0.006*		0.001*		1.000	
OR	0.449		1.381		0.809		1.518	

Table 2: Parasite co-infection prevalence of pregnant women during wet and dry seasons.

Season	<i>P.falciparum</i> - <i>A. lumbricoides</i>	<i>P.falciparum</i> - <i>A. duodenale</i>	<i>A.lumbricoides</i> - <i>A. duodenale</i>	<i>A.lumbricoides</i> - <i>T. trichiura</i>
Wet (n=100)	3 (3%)	6 (6%)	14 (14%)	1 (1%)
P value	0.058	0.208	0.059	0.218
Dry (n=200)		1 (0.5%)	11 (5.5%)	2 (1%)
P value		0.739	0.002	0.013

Table 3: Effect of residential areas of pregnant women on parasite infection prevalence during wet and dry seasons of the study period

Season	Residential area	<i>P.falciparum</i> Positive p value	<i>A.lumbricoides</i> Positive p value	<i>A.duodenale</i> Positive p value
Wet season	Rural (n=74)	9(12.1%) .077	32(43.2%) .264	20(27%) .430
	Urban(n=26)	7(27%)	8(30.8%)	5(19.2%)
Total	N=100	16(16%)	40(40%)	25(25%)
Dry season	Rural(n=170)	7(3.5%) .258	40(23.5%) .447	16(9.4%) .232
	Urban(n=30)	0(0%)	9(30%)	5(16.7%)
Total	N=200	7(3.5%)	49(24%)	21(10.5%)

Table 4: Effect of ITNs and Residual sprays on *P.falciparum* prevalence of pregnant women during wet and dry seasons of the study period

Season	Factor		<i>P.falciparum</i>		Total	P value	r ²
			Positive	Negative			
Rainy	ITNS	yes	12(12%)	64	76	0.919	-0.010
		No	4(4%)	20	24		
	Total		16	84	100(100%)		
Dry	ITNs	yes	7(3.5%)	163	170	0.258	0.080
		No	0	30	30		
	Total		7	193	200		
Rainy	IRS	yes	8(8%)	38	46	0.726	0.035
		No	8(8%)	46	54		
	Total		16	84	100		
Dry	IRS	yes	1(0.5%)	31	32	0.900	-.009
		No	6(3%)	162	168		
	Total		7	193	200		

Within the rural set up, 9(12.1%) harboured *P.falciparum*, 32(43.2%) and 20(27%) were found to be infected with *A.lumbricoides* and *A.duodenale* respectively. in the urban set up, 7(27%) of them were positive for *P.falciparum*, 8(30.8%) for *A.lumbricoides* and 5(19.2%) for *A.duodenale*. These differences in infections proportions were however insignificant. (p= 0.07 for *P.falciparum*; p=0.264 for *A.lumbricoides*; and p=0.430 for *A.duodenale*) (Table 3).

During the dry season comprising 200 participants (170 and 30 drawn from rural and urban areas respectively), the overall parasitic infection was 7(3.5%) for *P.falciparum*, 49(24.5%) and 21(10.5%) for *Alumbricoides* and *A.duodenale* respectively. All the 7 *P.falciparum* positive individuals were rural dwellers, 40(23.5%) and 9(30%) were parasitized with *A.lumricoides* in rural and urban areas respectively while 16(9.4%) and 5(16.7%) had *A.duodenale* in rural and urban areas respectively. Infection proportions between rural and urban dwellers during the dry season was not significant ($p=0.258$ for *P.falciparum*; $p=0.449$ for *A.lumbricoides* and $p=0.232$ for *A.duodenale* parasites) (Table 3).

EFFECT OF INSECTICIDE TREATED NETS (ITNs) AND RESIDUAL SPRAYS (R.S) ON *P.FALCIPARUM* INFECTION DURING WET AND DRY SEASONS OF THE STUDY PERIOD

Among 100 study participants in the rainy season, 76 of them responded positive to the use of insecticide treated nets. In this category, 12(12%) of them harboured *P.falciparum* parasite whereas 64 were not infected. Only 24 participants in the rainy season did not use ITNs and 4(4%) of them were infected with *P.falciparum* parasite. Out of the 200 participants in the dry season, 170 used the ITNs and 7(3.5%) of them tested positive for the *p.falciparum* parasite. Among those who did not use the ITNs, all the 30 of them did not harbour *P.falciparum* parasites. *P.falciparum* infection in relation to use of ITNs during the rainy and dry seasons of the study period was not significant. Insignificant negative association and positive association was noted between use of ITNs and *P.falciparum* infection during rainy and dry seasons respectively (Table 4).

Use of residual sprays was utilized by 46 respondents out of the total 100 in the rainy season and 8(8%) of them tested positive for *P.falciparum* parasite. Those who did not use residual sprays comprised 54 individuals in this category and 8(8%) of them were infected with *P.falciparum*. During the dry season, only 32 individuals out of the total 200 applied residual sprays to their houses whereas 168 did not use residual sprays in their houses. *P.falciparum* was present in 1(0.5%) individual amongst those who used R.S and 6(3%) of those who did not use R.S during this season. *P.falciparum* infection in relation to use of R.S. during the rainy and dry seasons of the study period was not significant. There was insignificant positive and negative association between *P.falciparum* infection and residual sprays during wet and dry seasons respectively (Table 4).

EFFECT OF RESIDENTIAL AREAS ON GEOHELMINTH INFECTION INTENSITY OF PREGNANT WOMEN DURING WET AND DRY SEASONS OF THE STUDY PERIOD

All *A.lumbricoides* infections were of light intensity (1-4,999epg) in both rural and urban areas during wet and

dry seasons of the study period. Light and moderate intensity was recorded for *A.duodenale* infections. During the wet season, 14(19%) participants from the rural areas had light intensity *A.duodenale* infections (1-1,999epg of faeces) while 6(8%) had moderate infections (2000-3,999epg of faeces). Within the urban set up in the same season, 4(15.4%) had light infections while only 1(3.8%) had moderate infection. Differences in *A.duodenale* infection intensity between rural and urban dwellers in the wet season was statistically insignificant ($P=0.674$). During the dry season 13(7.64%) and 3(1.76%) had light and moderate *A.duodenale* infection intensity respectively in the rural set up. Intensity for those in the urban set up was 4(13.3%) and 1(3.33%) light and moderate respectively. Difference in infection intensity amongst rural and urban dwellers during both rainy and dry seasons on the year was insignificant ($P=0.488$)

DISCUSSION

Most pregnant women in Nandi-hills sub-county did not attend antenatal clinic during the rainy season. This led to a small proportion of study participants (33.3%) as compared to the dry season (66.7%). However, this proportion was taken to be a representative sample of the wet season stratum. Infection proportions with malaria parasites (*P.falciparum*), *A. lumbricoides* and *A. duodenale* were significantly different in relation to the wet and dry seasons during the year 2015 ($p<0.05$). Wet and dry seasons of the study period were not risk factors of infection with *P.falciparum* and *A.duodenale* parasites ($OR<1$; 95% CL). Season was however a risk factor for *A.lumbricoides* infection ($OR>1$; 95%CL). Most infections occurred during the wet season according to the current study. Large scale geographical distribution of malaria and helminths are determined by climate which determines mosquito and helminth free living stage survival (Hay et al., 2000). Infective stages of *A. duodenale* flourish in climates providing adequate rainfall and well drained soils but drying and direct sunlight are destructive (Reynolds et al., 2008). *A. lumbricoides* is a more prevalent helminth worldwide because the female worm produces prodigious number of eggs that are relatively resistant to drying and extreme temperature. Eggs in the soil are viable to infect enormous number of people (Strickland et al., 2000).

Differences in co-infections with *P. falciparum*-*A. duodenale* was statistically insignificant in both wet and dry seasons. *P. falciparum* and *A. duodenale* had an insignificant positive association in relation to wet and dry season of the year 2015. According to Brooker et al. (2013), environmental factors associated with *P.falciparum* and hookworm co-infections were generally the same as those associated with hookworm infections and Sartorius et Al. (2021)

noted that geographical overlap of parasitic infections is favoured by environmental factors. The findings suggested that environmental factors associated with individual helminth species were also associated with large scale spatial patterns of co-infection.

Co-infection proportions were insignificantly different for *P. falciparum*-*A. lumbricoides* during the wet season and there were no co-infection in the dry season. *P. falciparum* and *A. lumbricoides* had a negative association in both seasons during the year 2015. This was suggestive of decreased spread of *A. lumbricoides* infective eggs during dry season hence reduced contact and subsequent infection of the participants. Irrespective of season, Populations in malaria-endemic areas of southern Ethiopia were found to be multi-parasitized with up to four helminths. Mass deworming may be a simple practical approach in endemic areas in reducing the risk of severe malarial attack particularly for those at high risk of both infections (Mulu et al., 2013).

Nandi-hills sub-county hospital serves residents of the entire sub-county majority being rural dwellers (81%) as reflected in the study outcome. A higher proportion though insignificant ($p > .05$) infections of *A. lumbricoides* (43.2%) and *A. duodenale* (27%) were recorded amongst pregnant women from the rural areas during the wet season. Gontie et al. (2020) attributed varying proportions of infection to the difference in geographical location among the study areas. Most rural dwellers in Nandi-Hills sub-county engage in farming and as casual labourers in tea plantations as their source of livelihood. As a result of these activities, they are completely susceptible to parasite infective stages. Woodburn et al. (2009), adduced that risk factors for helminth infection depend on the route of transmission and lifecycle of the helminth, but are usually related to hygiene, sanitation and, for some species, environmental conditions required for the intermediate hosts or for a free-living soil-dwelling stage. Women are mainly known to do gardening/farming where they could be exposed to infective stages of geohelminth parasites and most farming/gardening activities take place during the wet seasons of the year. This was evident with a higher proportion of women infected in rural areas during the wet season.

A slightly higher proportion (27%) of pregnant women from urban area of Nandi-hills sub-county tested positive for *P. falciparum* parasites. This outcome in concurrence with a study by Molla et al. (2024), whereby subjects from towns had significantly higher proportion in all seasons compared to rural sites. Woodburn et al. (2009) made a recommendation that Interventions for helminths, malaria and HIV need to target young women both in and out of school which should include antenatal interventions for malaria and HIV. Africa where most communities re-

side in the rural areas harbours numerous parasitic infections which require to be addressed according to the One Health approach, due to the dependence of parasites and their potential vectors or intermediate hosts on numerous environmental factors which include availability and type of hosts (humans, domesticated or wild animals), habitat conditions mainly physiographic factors as temperature, humidity, availability and type of waters. It is nonetheless essential that control campaigns consider all hosts on which competent mosquitoes feed and the outdoor component of malaria transmission (Lorusso, 2021).

Pregnant women who were found to be using ITNs during the rainy/wet season were more (76%) than those who did not use the ITNs (24%). Irrespective of net use, 14% in this category harboured *P. falciparum* parasites. Among those who used ITNs in the dry season, 3.5% had *P. falciparum* parasites whereas those who did not use the nets in this category were free from malaria parasites. Infection proportions in relation to use of ITNs was however insignificant ($p < .05$). Ownership of nets and its use are determined by socio-economic factors, according to Bwogo et al. (2022), most participants who were found to have LLTNs had either torn nets or did not use them well while sleeping. It is possible to own a net and lack a bed for proper usage and protection. It has also been noted that increased vector resistance to pyrethroids and insecticides is reversing the progress of public health interventions in keeping malaria under control (Oladipo et al., 2022). Most pregnant women reported did not apply indoor residual sprays to their houses during both wet (54%) and dry seasons (84%) of the study period. Difference in infection proportions during these seasons were insignificant ($p < 0.05$).

Between 2000 and 2015, SSA had a reduction in malaria infections by half and clinical disease by 40%, mainly due to mass scale-up of malaria control interventions such as the massive deployment of long-lasting insecticidal nets (LLINs), indoor residual spraying (IRS), prompt diagnosis and treatment with effective antimalarial drugs, with insecticide-treated nets and vector control pivotal to the success contributing to about 68% and 78% of the progress made respectively (Maskin et al., 2019., Janko et al., 2018; Bhatt et al., 2015).

There was no significant difference in *A. duodenale* infection intensity in both rural and urban areas during wet and dry seasons of the study period. Moderate-to-heavy infections for at least one STH species are still occurring in the southern part of West Africa and extending to Central Africa including Cameroon, Burundi and DRC (Afolabi et al., 2022).

CONCLUSION AND RECOMMENDATION

A high proportion of single parasite infection (*P.falciparum*, *Alumbricoides* and *A.duodenale*) was recorded during the wet season of the study period. There was a significant co-infection between *A.lumbricoides*–*A.duodenale*, co-infections between *P.falciparum*–*A.lumbricoides* and *P.falciparum*–*A.duodenale* were insignificant during wet and dry seasons. Residential areas (rural and urban) of study participants had no significant impact on parasitic infections during wet and dry seasons. Use of ITNs and application of IRS did not protect from *P.falciparum* infections during wet and dry seasons.

It is important to incorporate diagnosis of geohelminth parasites during routine ANC visits. Public education on mitigation of parasitic infections should be intensified. Vector eradication should be prioritized to eradicate *P.falciparum* infection.

CONFLICT OF INTEREST

The author declare that there is no conflict of interest in the publication of this paper.

ACKNOWLEDGEMENTS

I am grateful to the laboratory staff of Nandi-Hills sub county hospital led by Philip Sang and Caroline Kiptum. Much thanks goes to Dr. K. Olale of the Department of Chemistry, Kisii University for his help in data analysis.

CONFLICT OF INTEREST

the author declares that there is no conflict of interest in the publication of this paper.

NOVELTY STATEMENT

This article demonstrates the need to incorporate geohelminth investigation in antenatal visits in the developing nations. It also points to the need to intensify prevention and control of NTD in the face of climate change which may favor parasite infective stages and increase disease transmission potential.

AUTHORS CONTRIBUTION

Masai RJ carried out the research, and prepared the manuscript.

- Afolabi MO, Adebisi A, Cano J, Sartorius B, Greenwood B, et al. (2022) Prevalence and distribution pattern of malaria and soil-transmitted helminth co-endemicity in sub-Saharan Africa, 2000–2018: A geospatial analysis. *PLOS Neglect. Trop. Dis.* 16(9): e0010321. <https://doi.org/10.1371/journal.pntd.0010321>
- Bethony J, Brooker S, Albonico M, Geiger SM, Loukas A, Diemert D, Hotez PJ (2006). Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. *Lancet.*, 67: 1521–1532.
- Bhatt S., Weiss D.J., Cameron E., et al. (2015). The effect of malaria control on *Plasmodium falciparum* in Africa between 2000 and 2015. *Nature.*, 526 (7572):207–211. <https://doi.org/10.1038/nature15535>.
- Brooker S.J., Michael E. (2000). The potential Geographical Information System and Remote Sensing and epidemiology and control of human helminth infections. *Adv. Parasitol.*; 47:245–288
- Brooker S.J., Putan R.L., Gitonga C.W., Ashton R.A., Kolaczinski J.H., Kabatereine N.B., Snow R.W. (2013). *Plasmodium*–Helminth co-infection and its sources of heterogeneity across East Africa. *J. Infect. Dis.*, (12):2007–2016
- Bwogo P. C., Mong'are S., Masai R, Nyabayo J, Ingonga J, Kimani F, Kamau L, Mwangi M, Cirindi J, Matoke D. (2022). Socio- Demographic Factors Influencing the Ownership and Utilization of Long Lasting Insecticide Nets Among Endemic Sub-Counties in Kisii County, Kenya. *Asian J. Res. Infect. Dis.* 9 (1):24–42. <https://doi.org/10.9734/ajrid/2022/v9i130260>.
- Chakraborty P. (2004). Text Book Of Medical Parasitology. New Central Book Agency (P) LTD. India. Kolkata 700 064.
- Cheesbrough M. (2006). District Laboratory Practice in Tropical Countries. Part II. Steven and Sons Limited, Hertford, England
- Gontie G.B., Wolde H.F., Baraki A.G. Prevalence and associated factors of malaria among pregnant women in Sherhole district, Benishangul Gumuz regional state, West Ethiopia. *BMC Infect. Dis.* 20: 573. <https://doi.org/10.1186/s12879-020-05289-9>
- Hay S.I., Omumbo J.A., Craig M.H., Snow R.W. (2000). Earth observation, Geographic Information System and *Plasmodium falciparum* malaria in Sub-Saharan Africa. *Adv. Parasitol.*; (47):173–215
- Janko M.M., Churcher T.S., Emch M.E., Meshnick S.R. (2018). Strengthening long-lasting insecticidal nets effectiveness monitoring using retrospective analysis of cross-sectional, population-based surveys across sub-Saharan Africa. *Sci. Rep.*, 8(1) <https://doi.org/10.1038/s41598-018-35353-z>.
- Kripa P.K., Thanzen P.S., Jaganathasamy N. et al., (2024). Impact of climate change on temperature variations and extrinsic incubation period of malaria parasites in Chennai, India: implications for its disease transmission potential. *Parasit. Vectors.* 17: 134
- Lorusso V. (2021). Parasitology and One Health-Perspectives on Africa and Beyond. *Pathogens.* 10(11):1437. <https://doi.org/10.3390/pathogens10111437>.
- Maskin E., Monga C., Thuilliez J., Berthélemy J.C. (2019). The economics of malaria control in an age of declining aid. *Nat. Commun.*, 10(1):2269. <https://doi.org/10.1038/s41467-019-09991-4>.

- Molla E, Dugassa S, Alemayehu L, et al. (2024). Seasonal Dynamics of Symptomatic and Asymptomatic Plasmodium falciparum and Plasmodium vivax Infections in Coendemic Low-Transmission Settings, South Ethiopia. *American J. Trop. Med. Hyg.* <https://doi.org/10.4269/ajtmh.24-0021>
- Montresor A. D., Crompton W. T., Hall A., Bundy D. A. P., Savioli L. (1998). Guidelines for the Evaluation of Soil Transmitted Helminthiasis at Community Level Ministry of Health and Welfare, Government of Japan. WHO/CTD/SIP/98.1;
- Mulu A., Legesse M., Erko B. et al. (2013). Epidemiological and clinical correlates of malaria-helminth co-infections in southern Ethiopia. *Malar J.* 12: 227 <https://doi.org/10.1186/1475-2875-12-227>
- Mulu A., Legesse M., Erko B. et al. (2013). Epidemiological and clinical correlates of malaria-helminth co-infections in southern Ethiopia. *Malar J.* 12: 227 <https://doi.org/10.1186/1475-2875-12-227>
- Mwangi T.W., Bethony J., Brooker S. (2006). Malaria and helminth interaction in humans: an epidemiological view point. *Ann. Trop. Med. Parasitol.*; 100 (7): 551-570.
- Ojurongbe O, A.M.Adegbayi, O.S.Bolaji, A.A.Akindele, O.A.Adefioye, O.A. Adyeba (2011). Asymptomatic falciparum Malaria and Intestinal Helminth co-infection Among School Children in Osogbo, Nigeria. *J. Res. Med. Sc.* 16 (5): 680-686
- Oladipo HJ, Tajudeen YA, Oladunjoye IO, Yusuff SI, Yusuf RO, Oluwaseyi EM, AbdulBasit MO, Adebisi YA, El-Sherbini MS. (2022) Increasing challenges of malaria control in sub-Saharan Africa: Priorities for public health research and policymakers. *Ann. Med. Surg. (Lond).* <https://doi.org/10.1016>
- Republic of Kenya, County Government of Nandi (2013-2017). County Integrated Development Plan.
- Republic Of Kenya, Nandi East District Development Plan 2008-2012 (2009). Office of the Prime Minister, Ministry Of State for Planning, National Development and Vision 2030
- Reynolds S.J., Bollinger R.C., Quinn T.C. (2008). Parasitic Diseases during Pregnancy. *Global Lib. Women's Med.*; (ISSN: 1756-2228) <https://doi.org/10.3842/>
- Riesel JN, Ochieng' FO, Wright P, Vermund SH, Davidson M. (2010). High prevalence of soil-transmitted helminths in Western Kenya: failure to implement deworming guidelines in rural Nyanza Province. *J. Trop. Pediatr.* Feb;56(1):60-2. <https://doi.org/10.1093/tropej/fmp043>.
- Sartorius B, Cano J, Simpson H, Tusting LS, Marczak LB, Miller-Petrie MK, et al. (2020). Prevalence and intensity of soil-transmitted helminth infections of children in sub-Saharan Africa, 2000–18: a geospatial analysis. *Lancet Global Health.* 2021;9(1):e52–e60.
- Strickland G.T., W.L Laughlin, F.T.T sai, J.A. Magill, G.J. Olson, J.R. Hay, B. Caballero, S.J. Keystone (2000). *Hunter's TROPICAL MEDICINE AND Emerging Infectious Diseases.* Eighth Edition. W.B. SAUNDERS COMPANY.
- Valencia C.A., Fernandez J.A., Cucunuba Z.M., Reyes P., Lopez M.C., Duque S. (2010). Correlation between malaria incidence and prevalence of Soil Transmitted Helminthes in Colombia: An ecological evaluation. *Biomedica.*; 30: 501-8
- Wanyonyi WA, Mulambalah CS, Mulama DH, Omukunda E, Siteti DI. (2018). Malaria and Geohelminthiasis Coinfections in Expectant Women: Effect on Maternal Health and Birth Outcomes in a Malaria Endemic Region in Kenya. *J. Parasitol. Res.* :2613484. <https://doi.org/10.1155/2018/2613484>. PMID: 30631589; PMCID: PMC6304650.
- WHO (1987). Prevention and control of intestinal parasitic infections. Geneva technical report series, ISBN 924120949 3
- WHO: World Malaria Report (2008). 2008, Geneva: World Health Organization
- Woodburn PW, Muhangi L, Hillier S, Ndibazza J, Namujju PB, Kizza M, et al. (2009) Risk Factors for Helminth, Malaria, and HIV Infection in Pregnancy in Entebbe, Uganda. *PLoS Negl. Trop. Dis.* 3(6): e473. <https://doi.org/10.1371/journal.pntd.0000473>
- World Health Organization (2020). Ending the neglect to attain the Sustainable Development Goals: a road map for neglected tropical diseases 2021–2030. Geneva: Licence: CC BY-NC-SA 3.0 IGO.