

## Soil transmitted helminthes infection among pregnant women in peri-urban areas of Ibadan, Nigeria: A cross-sectional study

CE Umezurike<sup>1</sup>, IA Adeoye<sup>1</sup>, OA Oluwatoba<sup>2</sup> and TAO Oluwasola<sup>3</sup>

Departments of Epidemiology and Medical Statistics<sup>1</sup>, Medical Microbiology and Parasitology<sup>2</sup> and Obstetrics and Gynaecology<sup>3</sup>, College of Medicine, University of Ibadan, Ibadan, Nigeria

### Abstract

**Background:** Soil Transmitted Helminthes (STH) infection is an important public health problem in developing countries which adversely affects pregnant women and their newborn infants. The epidemiology of STH among pregnant women has not been fully explored in Nigeria. We examined the prevalence, intensity and risk factors of STH among antenatal care attendees in Ibadan.

**Methods:** A cross sectional facility-based study was conducted among the 326 pregnant women attending antenatal care clinics in six selected Primary Health Care centers, in the peri-urban areas of Ibadan Oyo State. An interviewer administered questionnaire was used to obtain information on the socio-demographic, maternal, environmental characteristics and hygiene practices. Kato-Katz method was used to identify the presence of STH from stool samples. Data were analysed using chi-square and bivariate logistic analysis.

**Results:** The overall prevalence of STH was 13.8%, 95% CI (10.0 -17.7). *Ascaris lumbricoides* 12.8%, 95% CI (9.5 -16.9) was the most prevalent followed by hookworm infection 0.6%, 95% CI (-0.2 - 0.15) and *Trichuris trichuria* 0.3%, 95% CI (- 0.2 - 0.9). Majority of the infection were of light intensity (44 out of 45). Walking bare footed in the home environment increased the likelihood of being infected with STH [OR 1.93 95% CI (1.01 -3.72) p=0.048] compared with women who wore shoes.

**Conclusion:** STH infection is prevalent among pregnant women in the peri-urban region of Ibadan. Therefore public health interventions like active surveillance of STH and the prescription of deworming drugs will be beneficial tofor pregnant women.

**Keywords:** Soil transmitted helminthes, pregnancy, prevalence, intensity.

### Résumé

**Contexte:** L'infection par les helminthes transmissibles par le sol (HTS) est un problème de santé publique important dans les pays en voie de développement, qui affecte négativement les femmes enceintes et leurs nouveau-nés. L'épidémiologie des HTS chez les femmes enceintes n'a pas été complètement explorée au Nigéria. Nous avons examiné la prévalence, l'intensité et les facteurs de risque des HTS chez des patientes en soins prénatals à Ibadan.

**Méthodes:** Une étude transversale a été réalisée parmi les 326 femmes enceintes fréquentant les cliniques de soins prénatals dans six centres de soins de santé primaires sélectionnés, dans les zones périurbaines d'Ibadan, l'État Oyo. Un questionnaire administré par l'intervieweur a été utilisé pour obtenir des informations sur les caractéristiques sociodémographiques, maternelles, environnementales et les pratiques d'hygiène. La méthode de Kato-Katz a été utilisée pour identifier la présence d'HTS à partir d'échantillons de selles. Les données ont été analysées en utilisant l'analyse chi-carré et la logistique bi-variée.

**Résultats:** La prévalence globale d'HTS était de 13,8%, IC 95% (10,0 - 17,7). *Ascaris lombricoïdes* 12,8%, 95% CI (9,5 -16,9) était la plus fréquente suivie par Ankylostomiase 0,6%, IC 95% (-0,2 - 0,15) et *Trichuris-trichuria* 0,3%, IC 95% (- 0,2 - 0,9). La majorité des infections était d'intensité faible (44 sur 45). Marcher pieds nus dans l'environnement du ménage a augmenté la probabilité d'être infecté par HTS [OR 1,93 95% CI (1,01 - 3,72) p = 0,048] par rapport aux femmes qui portaient des chaussures.

**Conclusion:** L'infection par l'HTS est prévalent chez les femmes enceintes dans la région périurbaine d'Ibadan. Par conséquent, les interventions de santé publique comme la surveillance active des HTS et la prescription de médicaments antihelminthiques pour les femmes enceintes.

**Mots-clés:** Helminthes transmissibles par le sol, grossesse, prévalence, intensité, facteurs

### Introduction

Soil Transmitted Helminthes (STH) are the most prevalent Neglected Tropical Disease (NTD)



affecting more than 1.5 billion people worldwide, largely in sub-Saharan Africa, Latin America, China and East Asia [1,2]. The STH is reported to be responsible for about 40% of the health burden of neglected tropical diseases [3]. The STH of public health importance include *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm (*Necator americanus* or *Ancylostoma duodenale*). Global estimates indicate that there are about 807-1227 million cases of *Ascaris lumbricoides*, 540-700 million cases of *Necator americanus* and *Ancylostoma duodenale* and 604 – 795 million cases of *Trichuris trichiura* [4]. Helminthes infection are majorly attributed to poverty, inadequate water supply, improper sanitation [3, 5]. Children, women of reproductive age, particularly pregnant women, and adults with high risk jobs such as miners [2] are most at risk of the infection. However, children especially school-age children have received more research focus and public interventions because of the associated malnutrition, impairment of growth and cognitive development in the age group [6].

In sub-Saharan Africa, approximately 24 million women become pregnant annually [7]. Pregnancy is associated with hormonal and immune changes that increase their susceptibility to infections including parasitic infections like STH [8, 9]. The prevalence of STH among pregnant women in Africa varies widely, with a prevalence of 76.2% in rural Kenya [10], 54% in Ethiopia [3] and 47.1 % in Cameroun [11] and 70.0% in Thai-Burmese border [12]. Although, the epidemiology of these parasites among pregnant women have not been fully documented in Nigeria, the few available studies have reported a prevalence that ranges from 13.8% - 23.74% [13- 15]. The STH in pregnancy is associated with increased risk of maternal and perinatal morbidity resulting from iron deficiency anaemia, impaired nutrition status, intrauterine growth restriction and low birth weight [7, 8, 11, 15]. Hookworm is a major cause of anaemia in pregnancy by ingesting blood and damaging the intestinal mucosa. Approximately one-third of all pregnant women in low and middle income countries (LMICs) have been estimated to be infected with hookworm infection (44 million out of 124 million pregnancies and 7.5 million pregnant women in sub-Saharan Africa [16]. *Trichuris trichiura* to a lesser degree also contributes to maternal anaemia through blood loss and reduced appetite [17]. *Ascaris lumbricoides* is usually asymptomatic but with heavy infestation, it can cause abdominal distension and pain, lactose intolerance and malabsorption [18].

Intensity of STH infection, measured by the number of eggs per gram of faeces, is the main epidemiological index used to describe STH infection [4]. The risk factors for infestation by STH include demographic, socioeconomic, environmental and behavioral factors but the distribution of these risk factors may differ from one region to another and sometimes within the population or the country itself [3, 7, 10]. Hence the need to understand the epidemiology of these infections in different locations in order to implement targeted and population specific interventions. Furthermore, WHO recommends periodic anti-helminthic medical therapy (deworming) without previous individual diagnosis, to all persons at-risk in endemic areas including pregnant women. Treatment should be given once a year when the prevalence of STH infections in the community is over 20% [19, 20]. Therefore, the aim of this study was to determine the prevalence, intensity and risk factors of STH so as to provide the needed evidence for the control of STH and the effect in pregnancy.

## Materials and methods

### Study setting

This study was conducted among pregnant women attending selected Primary Health Care Centers in two peri-urban local Government areas (LGAs) - Ido and Akinyele (LGAs) of Oyo state. Oyo state is one out of the 36 states in Nigeria, and it is located in the south western part of the country. Typically, Ibadan experiences dual seasons like most tropical areas - dry season between November to February and wet season between March and October each year. Ido and Akinyele Local Government areas have extensive fertile soil and large hectares of grassland, which are suitable for agriculture hence the predominant occupations of the people are farming and animal rearing.

### Study design and data collection

A cross sectional facility-based study was conducted among 326 pregnant women attending antenatal care clinics in six most functional Primary Health Care centers (PHCs) were purposively selected. In each of the PHCs, study participants were serially recruited into the study until the sample size was reached. Although women who had taken anthelmintic drugs within a month prior to study and those who were severely sick were excluded from the study. Pre-tested, semi-structured, interviewer administered questionnaires were used to obtain information on the socio-demographic, maternal, medical and environmental characteristics



as well as hygiene practices of participants. The sample size estimation for single proportion was used based on a 95% confidence interval (1.96), precision level of 5%;  $\alpha = 0.05$ ; and a prevalence rate of 23.74% of helminthes infection among pregnant women by Omorodion *et al* [13].

#### Specimen collection and processing

Fresh stool samples were obtained from the study participants using in screw capped labeled leak proof stool containers (universal bottles) and applicator sticks. The stool samples were transported in ice packs in order to maintain the viability of the helminthes ova to the laboratory. The stool samples were collected in the morning between 9am and 11am and were transported immediately to the Department of Medical Microbiology and Parasitology laboratory for examination. These stool

samples were examined microscopically using the direct wet preparation method and Kato-Katz technique of quantification of ova according to the WHO 2002 guidelines [22]. Egg counts (in eggs per gram of stool, epg) was used to classify infection intensities into light, moderate, or heavy infections respectively as follows: *Ascaris lumbricoides*: 1 – 4,999 epg, 5,000 – 49,999 epg and > 50,000 epg; *Trichuris trichiura*: 1 – 999 epg, 1,000 – 9,999 epg and > 10,000 epg; Hookworms (*Ancylostoma duodenale/Necator americanus*): 1 – 1,999 epg, 2,000 – 3,999 epg and > 4,000 epg [23].

#### Data analysis

The data was analysed using Stata version 12, quantitative variables were analyzed using mean and standard deviation, while categorical variables were presented with frequencies and proportions. The

**Table 1:** Socio-demographic and maternal characteristics of the pregnant women by soil transmitted helminthes

Characteristics	Total (N=326)	Soil-transmitted helminthiasis		p-value
		Yes (n=45)	No (281)	
<i>Age group</i>				
<20	11 (3.4)	1 (9.1)	10 (90.1)	0.759
20 -35	266 (81.8)	36 (13.5)	230 (86.5)	
>35	48 (14.8)	8(13.9)	40 (86.1)	
<i>Marital Status</i>				
Married	290 (89.0)	42 (14.5)	248 (85.5)	0.313
Not married	36(11.0)	3 (8.3)	42 (91.7)	
<i>Education</i>				
Primary or less	61(18.7)	6 (9.8)	55 (90.2)	0.471
Secondary	176 (54.0)	24 (13.6)	152 (86.4)	
Tertiary	89 (27.3)	15 (16.8)	74 (86.1)	
<i>Occupation</i>				
Unemployed	109 (33.4)	15 (13.8)	94 (86.2)	0.992
Self employed	118 (36.2)	16 (13.6)	102 (84.4)	
Employed	99 (30.4)	14 (14.1)	85 (85.9)	
<i>Ethnicity</i>				
Yoruba	254 (77.9)	33 (13.0)	221 (87.0)	0.425
Non Yorubas	72 (22.1)	6 (16.7)	30 (83.3)	
<i>Religion</i>				
Christianity	154 (47.2)	19 (12.3)	134 (87.7)	0.789
Islam	168 (51.5)	25 (14.9)	143 (85.1)	
Others	4 (1.2)	1 (25.0)	3 (75.0)	
<i>Monthly income</i>				
<10,000	218 (66.9)	6 (9.8)	55 (90.2)	0.952
10000 – 20000	61 (18.7)	24 (13.6)	152 (86.4)	
>20000	47 (14.4)	15 (16.8)	74 (86.1)	
<i>Gravidity</i>				
Primigravida	88 (27.0)	12 (13.6)	76 (86.4)	0.958
Multigravida	238 (73.0)	33 (13.9)	205 (86.1)	
<i>Gestational age</i>				
1 <sup>st</sup> trimester	42 (12.9)	4 (9.5)	38 (90.1)	0.689
2 <sup>nd</sup> trimester	110 (33.7)	16 (14.6)	94 (85.4)	
3 <sup>rd</sup> trimester	174 (53.4)	25 (14.4)	149 (85.6)	



overall prevalence of STH as well as age and gravidity specific prevalences and the 95% confidence intervals were determined. The associations between various risk factors (socio-demographic, maternal, environmental and hygiene practices) and STH were examined using chi-square statistic. Bivariate logistic regression was used to compute unadjusted odds ratio and also to identify independent determinants of STH in pregnancy. The level of significance for this study was set at  $p < 0.05$ .

**Ethical standard:** Ethical approval to conduct the study was obtained from the Oyo State Ministry of Health Ethical Review Board and permission to carry out the study was obtained from the Medical Officers of Health in charge of the LGAs. Informed consent was obtained from each respondent in this study, after the procedure of the study had been explained.

## Results

The socio-demographic and maternal characteristics of the respondents by their STH status are shown in Table 1. The mean age of the respondents was  $28.4 \pm 5.6$  years. Majority of these women were within the 20 – 35 age bracket (81.8%), married (89.0%), belonged to Yoruba ethnic group (77.9%) while about two-thirds (66.9%) earned less than 10,000 naira per month. Primigravida made up about a quarter (27.0%) of the population.

However, there was no statistical difference in the distribution of socio-demographic and maternal characteristics by their STH status ( $p > 0.05$ ). Prevalence (95% confidence interval) and Intensity of Soil transmitted Infections are shown in Tables 2 and 3. The overall prevalence of STH was 13.8%, 95% CI (10.0 -17.7). *Ascaris lumbricoides* 13.2%, 95%CI (9.5 -16.9) was the most prevalent

**Table 2:** Prevalence and 95% confidence intervals of soil transmitted helminthes among pregnant women by age and gravidity

	STH	<i>Ascaris lumbricoides</i>	Hookworm	<i>Trichuris trichura</i>
<b>Overall</b>	13.8(10.0 -17.7)	12.8 (9.5 -16.9)	0.6 (-0.2 -0.15)	0.3 (-0.2 – 0.9)
<b>Age</b>				
<20	9.1 (-8.8 – 27.0)	9.1 (-8.8 – 27.0)	-	-
20 -35	13.5 (9.4 – 17.7)	13.5 (9.4 – 17.7)	3.7 (-3.7 – 1.1)	0.4 (-0.3 -1.1)
35	16.7 (6.0 – 27.3)	14.5 (4.4 – 24.7)	2.0 (-2.0 – 6.2)	-
<b>Gravidity</b>				
Primigravida	13.6 (6.4 – 20.8)	13.6 (6.4 – 20.9)	-	-
Multigravida	13.9 (9.4 – 18.3)	13.0 (8.7 – 17.3)	0.8 (-0.3 – 2.0)	0.4 (-0.4 – 1.2)

**Table 3:** Intensity of soil-transmitted helminthiasis among the pregnant women

Type of STH	Intensity classification	Intensity	Number	Frequency (%)
<i>Ascaris lumbricoides</i>	< 5000	Light	41	93.4%
	5000 – 49,999	Moderate	1	
	≥50,000	Severe	0	
			42	
<i>Trichuris trichiura</i>	<1,000	Light	1	2.2%
	1,000 – 9,999	Moderate	0	
	≥10,000	Severe	0	
			1	
<i>Hookworm</i>	<1,000	Light	2	4.4%
	1,000 – 9,999	Moderate	0	
	≥10,000	Severe	0	
			2	

**Table 4:** Environmental characteristics and hygiene practices of the pregnant women by the status of soil transmitted helminthiasis

Characteristics	Soil-transmitted helminthiasis		p-value
	Yes (n=45)	No (281)	
<i>Washing hands with soap</i>			
Yes	35 (14.5)	205 (85.4)	0.495
No	10 (11.6)	76(88.4)	
<i>Type of toilet facility</i>			
Pit latrine	5 (9.4)	48 ( 90.8)	0.387
Water closet	38 (15.3)	211 (84.7)	
Open defaccation	2 (8.3)	22 (91.7)	
<i>Wearing of shoes at home</i>			
Yes	6 (9.9)	145 (90.1)	0.046
No	129 (17.6)	136 (82.4)	
<i>Roofing types</i>			
Thatched roof	6 (15.8)	32 (84.2)	0.706
Corrugated iron	39 (13.5)	24 (96.5)	
<i>Rearing animals at home</i>			
Yes	18 (15.4)		0.769
No	27 (13.0)	182 (87.1)	
<i>Pets</i>			
Yes	8 (15.1)	45 (84.9)	0.536
No	37 (13.6)	182 (87.1)	
<i>Use of human feces as fertilizers</i>			
Yes	6 (15.4)	33 (84.6)	0.76
No	39 (13.6)	248 (86.4)	
<i>Geophagy</i>			
Yes	0 (0.0)	16 (100.0)	0.101
No	44 (14.1)	267 (85.5)	

followed by hookworm infection 0.6%, 95% CI (-0.2 – 0.15) then *Trichuris trichuria* 0.3%, 95% CI (-0.2 – 0.9). The prevalence of STH increased with age. However, the prevalence was similar between primigravidae [13.6%, 95% CI (6.4 -20.8)] and multigravidae [13.9%, 95%CI (9.4 -18.3)]. Majority of the infection were of light intensity (44 out of 45): 41 (12.6%) *Ascaris lumbricoides*, one (0.3%) *Trichuris trichiura* and two (0.6%) of hookworm infections.

Environmental characteristics and hygiene practices of the pregnant women by STH status are shown in Table 4. Wearing of shoes in the home

environment was the only variable significantly associated with STH with the women who walked bare footed having higher proportions of STH compared with those who wore shoes (17.6% versus 9.9%, p=0.046). Although, use of thatched roofing sheets (15.8% versus 13.5%), rearing animals at home (15.4% versus 13.0%) and use of human faeces as fertilizers (15.4% versus 13.6%) were higher among women with STH, these associations were not statistically significant (p> 0.05). Factors associated with soil transmitted infections are presented in Table 5 along with the odds ratio and 95% confidence interval. Walking bare footed in the

**Table 5:** Odds ratio and 95% confidence Interval of factors associated with soil transmitted helminthiasis among pregnant women

Factor	Odds Ratio	95% Interval	Confidence	p-value
<i>Shoes at home</i>				
Yes	1.00	-		
No	1.93	1.01 – 3.72		0.048



home environment was only variable tested in the bivariate logistic model. These women were found to be almost twice at risk [OR = 1.93; 95% CI (1.01 – 3.72)  $p=0.048$ ] of being infected by STH compared with women who wore shoes.

### Discussion

Soil transmitted helminthes is the most prevalent Neglected Tropical Disease (NTD) to which pregnant women are vulnerable. In this study, we investigated the prevalence, pattern, intensity and risk factors of STH among 326 pregnant women attending selected antenatal clinics in the peri-urban areas in Ibadan. The overall prevalence of STH was 13.8% which increased with age as adolescent women recorded the lowest prevalence of 9.1% and women 35 years and older had highest prevalence of 16.7%. However, primigravida and multigravida had similar vulnerabilities towards the infections. Our findings are similar to those of some other investigators such as Shrinivas *et al* (2014) who reported a prevalence of 12.4% among pregnant attending antenatal clinic in a tertiary facility in India [19] and Wekesa *et al* (2014) who similarly reported a prevalence rate of 13.8% among the pregnant women attending antenatal clinic at Kitale district hospital, Kenya [20]. Conversely, other studies that have examined STH in pregnancy have reported much higher prevalences: 32.4% in Nigeria [14], 41% in Southwest Ethiopia [3] and 76% in rural Kenya [10]. Remarkably, most of the studies reporting higher prevalence rates were conducted in the rural areas [10, 14, 17] which are likely to have higher level of poverty coupled with poor sanitary facilities and hygiene practices. Laroque and co-workers in Peru [19] noted women living in rural areas had significantly higher prevalence of hookworm infestation compared with those living in the peri-urban areas. Our study was conducted in the peri-urban areas of Ibadan where sanitary facilities are likely to be better compared with those found in the rural areas. For example, while only 7 percent of our study participants practiced open defaecation, 76 percent reported using water closet. Furthermore, the application of different methods for the detection of helminthes infection could also partly contribute to the variations in the prevalence rates. While some authors had used faecal concentration, others used the Kato-Katz method [3, 10, 14, 15], even though the sensitivity of these methods for detecting STH have been noted to vary widely [18, 26]. The other plausible explanation might be the difference in the geographical location

of the studies as soil types and climatic conditions have been attributed to STH endemicity [3].

Specifically *A. lumbricoides* had the highest prevalence (12.8%), followed by hookworms (0.6%) and *Trichuris trichiura* (0.3%) as reported by studies from Venezuela and Kenya [20, 27]. In Nigeria, Egwunyenga *et al* in 2001 [15] reported the prevalence of 19.1%, 14.2% and 7% for *A. lumbricoides*, hookworm and *T. trichiura* respectively. In addition, single specie infection (monoparasitism) was the predominant pattern in our study population. This is unlike other studies, that have reported multiple parasite infection (polyparasitism) [3, 11, 15, 18].

Furthermore, the Peruvian study highlighted the importance of measuring the STH intensity since higher intensity of infection was associated with higher proportion of anaemia among 1,042 second trimester pregnant women while there was no association found with the mere presence of infection [17]. This implies that adverse effects of STH infections are related to the intensity of infection. Intensity of infection, a measure of burden of worms harboured in the host, is the main epidemiological index used to describe soil-transmitted helminthic infection and is measured by the number of eggs per gram of faeces [4]. Most of the respondents in this study had light intensity infection for STH, and one person with moderate intensity infection. The intensity of *Ascaris lumbricoides* and *T. trichura* infection tends to decrease with age, such that heavy intensity infections are commonly found in children aged 5-15 years [17].

Generally, several determinants influence the occurrence of STH, but from our study the environmental characteristics and hygiene practices seem to be most significant. Particularly, women who walked bare footed were twice at risk (OR = 1.93) of having STH compared with those who wore shoes, and this is similar to previous reports [11, 17, 25]. Faecal pollution of soil has been implicated in the transmission of STH as walking bare-footed can facilitate the spread of infection by increasing the exposure to helminthic eggs and larvae in the soil. Nevertheless, *Ascaris lumbricoides*, the most predominant STH in our study, is transmitted primarily by faeco-oral route in which eggs are ingested through contaminated food or water. Therefore hygiene practices like hand washing before eating and after defaecation has been found to lower the odds of STH infection (3, 28) although the association was not statistically significant in our study. Moreover, walking bare footed may also be a marker for other environmental and hygiene practices



related to STH. In this study, it was noted that rearing of animals at home and the use of human faeces for fertilizers were higher among women with STH compared with those without STH. Humphries *et al* (1997) had equally shown that the use of human faeces for fertilizers was associated with intensity of hookworm infection among Vietnamese women [29].

The main limitation of this study is the low prevalence of soil transmitted helminthes among the study population which perhaps is due to the low endemicity of STH in the study area. However, a larger sized, community-based study that will give a higher yield of the study outcome, will more precisely investigate the relationship between the risk factors of STH among pregnant women. On the other hand, since that data was collected over a period of 4 months particularly during the dry season when transmission was lower, the prevalence might be been underestimated as the effect on the seasonal variation could not be ascertained while the use of a cross section study design precluded the examination of causal relationships. In addition, Kato-Katz method of quantification was used which has been reported to be unsuitable for hookworm egg identification [26]. These limitations notwithstanding, our study has provided information on the local epidemiology of STH among pregnant women in attending antenatal clinic in the PHCs in the peri-urban region in Ibadan Nigeria. Future studies exploring STH among pregnant women need to be conducted in areas of higher endemicity like the rural areas as comparative studies involving the urban, semi-urban and the rural settings would offer better information.

In conclusion, the prevalence of STH infection among pregnant women resident in Ido/Akinyele LGAs of Ibadan was 13.8%. This was below the cutoff point of 20% recommended for implementing antihelminthic therapy. Light intensities were reported for the three major STH (*A. lumbricoides*, hookworms and *T. trichiura*) in this study. The factors that were associated with STH in this study were majorly environmental and hygiene practices particularly walking bare footed around the home environment.

## References

1. Hotez PJ, Molyneux DH, Fenwick A, *et al* Control of Neglected Tropical Diseases N Engl J Med 2007; 357:1018-1027
2. World Health Organization (WHO) Soil-transmitted helminth infections, Fact sheet N°366. (2015) (Accessed 11<sup>th</sup> January, 2017)
3. Million, G., Delenesaw, Y., Ketema, T., *et al*. Anaemia and associated risk factors among pregnant women in Gilgel Gibe dam area, Southwest Ethiopia. Parasites and Vectors, 2012; 5:296
4. Bethony, J., Brooker, S., Albonico, M., *et al*. Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. Lancet, 2006; 367 (9521): 1521–1532.
5. Centre of Disease Control. Soil-transmitted helminth infections, Fact sheet, [www.cdc.gov/parasites/sth/20](http://www.cdc.gov/parasites/sth/20) (Accessed 11<sup>th</sup> January, 2017)
6. World Health Organization. Prevention and control of Schistosomiasis and Soil-Transmitted Helminthiasis, *WHO technical report series*, 2002; 912, Geneva, Switzerland
7. de Silva NR, Brooker S, Hotez PJ, *et al*. Soil-transmitted helminth infections: updating the global picture. Trends in Parasitology 2003; 19:547-551.
8. Dreyfuss, M.L., Stoltzfus, R.J. and Shrestha, J.B. Hookworms, malaria and vitamin A deficiency contribute to anaemia and iron deficiency among pregnant women in the plains of Nepal. The Journal of Nutrition, 2000; vol. 130, no. 10, pp. 2527–2536.
9. Mpairwe, H., Tweyongyere, R. and Elliott, A. Pregnancy and helminth infections. Parasite Immunol. 2014 Aug; 36(8):328-337.
10. van Eijk AM, Lindblade KA, Odhiambo F, *et al*. Geohelminth Infections among Pregnant Women in Rural Western Kenya; a Cross-Sectional Study. PLoS Negl Trop Dis 2009; 3(1): e370. doi:10.1371/journal.pntd.0000370
11. Ndamukong, K.J.N., Asoba, G.N. and Achidi, E.A. Intestinal Helminth Infections among pregnant Cameroonian women, East AMJ, 2011; 88(11): 377 – 383.
12. Boel M, Carrara VI, Rijken M, *et al*. Complex Interactions between Soil-Transmitted Helminths and Malaria in Pregnant Women on the Thai-Burmese Border. PLoS Negl Trop Dis 2010; 4(11): e887. doi:10.1371/journal.pntd.0000887
13. Omorodion, O.A., Isaac, C. and Nmorsi, O.P.G. Prevalence of intestinal parasitic infection among tertiary institution students and pregnant women in south-south, Nigeria. J. Microbiology Biotech. Research; 2012, 2 (5):815-819
14. Dimejesi, Umeora O and Eqwuatu V, “Prevalence and pattern of soil-transmitted helminthiasis among pregnant tertiary health facility in southeast Nigeria”, Afr. J M Sci, 2014; 13(1), 56-61.



15. Egwunyenga AO, Ajayi JA, Nmorsi OP *et al.* Plasmodium/intestinal helminth co-infections among pregnant Nigerian women. *Mem Inst Oswaldo Cruz* 2001; 96:1055-1059.
16. Bundy DA, Chan MS and Savioli L. Hookworm infection in pregnancy. *Trans R Soc Trop Med Hyg* 1995; 89:521-2.
17. Larocque R, Casapia M, Gotuzzo E, *et al* Relationship between intensity of soil-transmitted helminth infections and anemia during pregnancy. *Am J Trop Med Hyg* 2005; 73: 783–789.
18. Alli, J.A., Okonko, I.O., Kolade, A.F., *et al* Prevalence of intestinal nematode infection among pregnant women attending antenatal clinic at the University College Hospital, Ibadan, Nigeria, *Advances Appl. Sci. Res*, 2011; 2 (4): 1-13
19. World Health Organization (WHO). Preventive chemotherapy in human helminthiasis. Coordinated use of anthelmintic drugs in control interventions: a manual for health professionals and programme managers. 2006 Geneva: World Health Organization.
20. McClure E, Meshnick, S. Mungai, P. Malhotra and I. King, C. "The Association of Parasitic Infections in Pregnancy and Maternal and Fetal Anemia: A Cohort Study in Coastal Kenya", *PLoS Negl Trop Dis*, 2014; 8(2) e2724.
21. Gyorkos W., Casapia, M and Gotuzzo, E "Improving Maternal and New Born Health in Hookworm—Endemic Areas by Adding a Single-Dose Anthelmintic to Prenatal Care. Forum 8", *Global Forum for Health Research*, 2004 Mexico City, Mexico, 2004.
22. World Health Organization. Prevention and Control of Schistosomiasis and Soil transmitted helminthiasis, WHO technical report series, 2002; 912, Geneva, Switzerland
23. World Health Organization. Preventive chemotherapy in human helminthiasis. Coordinated use of antihelminthic drugs in control interventions: a manual for health professionals and programme managers. 2006; Geneva. World Health Organization.
24. Shrinivas, K., Sreelatha, R and Kavitha, K. Study of Helminthiasis in Pregnancy and its Correlation with Haemoglobin Level. *J. Clinical Diagn. Res*, 2014; 8(10): OC07–OC09
25. Wekesa, A. W., Mulambalah, C. S., Muleke, C. I., *et al.* Intestinal Helminth Infections in Pregnant Women Attending Antenatal Clinic at Kitale District Hospital, Kenya. *J. Parasitology*, 2014; ID 823923.
26. Tarafder M., Carabin H., Joseph L., *et al* Estimating the sensitivity and specificity of Kato-Katz stool examination technique for detection of hookworms, *Ascaris lumbricoides* and *Trichuris trichiura* infections in humans in the absence of a 'gold standard'. *Inter. J. Parasitology*, 40: 399–404, 2010.
27. Rodríguez-Morales, AJ. Rosa, A. Barbella, *et al* "Intestinal Parasitic Infections among Pregnant Women in Venezuela". *J. Infectious Dis. Obst. Gynec.* 2006, ArticleID23125, 1–5. DOI10.1155/IDOG/2006/23125
28. E. Strunz, "Water, Sanitation, Hygiene, and Soil-Transmitted Helminth Infection: A Systematic Review and Meta-Analysis", *PLOS medicine* 2014 11: e1001620, 2014.
29. Humphries DL, Stephenson L Pearce EJ, *et al* The use of human faeces for fertilizer is associated with increased intensity of hookworm infection in Vietnamese women *Trans R Soc Trop Med Hyg.* 1997 91 (5): 518-520