Annals of Medicine and Medical Sciences (AMMS)
Volume 03, 2024, *DOI: 10.5281/zenodo.13883818*
Available at: *http://ammspub.com*

Original Article

OPEN ACCESS

Prevalence, Intensity, and Knowledge of Hookworm Infection Among Rural Fishermen and Farmers in Rivers State, Nigeria: An Occupational Health Perspective

Bruce I *[1], Alali AA [1], Lawson SD [2], Cookey-Gam IF [1], Austin-Asomeji I [1], Ogba AA [3], Ogbonda PI [1], Perri, T [4]

[1]Department of Community Medicine, College of Medical Sciences, Rivers State University, Rivers State Nigeria.
[2]Department of Medical Microbiology, College of Medical Sciences Rivers State University, Rivers State Nigeria.
[3]Department of Public Health Sciences, Rivers State University, Rivers State Nigeria.
[4]Department of Environmental Management, Faculty of Environmental Sciences, Rivers State University, Rivers State Nigeria.

*Corresponding author; Ibiso Bruce; *ibiso.bruce@ust.edu.ng*

Abstract

Background: Hookworm infestation adversely affect humans especially in developing countries. Agricultural workers are predisposed to acquiring hookworm infection due to direct exposure to soil or water where the filariform larvae which is the infective stage live and penetrate the skin. ***Objectives:*** To determine the prevalence, infection intensity and knowledge of hookworm infestation among rural fishermen and farmers in Rivers State, Nigeria. ***Method:*** A multi-stage sampling technique was used in selecting the participants. 200 fishermen and 200 farmers were recruited between May and November 2021. Stool samples were processed using the Kato- Katz technique. 19 possible answers were summed up to assess knowledge. Data was analyzed using SPSS version 26 and presented in charts and tables. ***Result:*** The age of respondents ranged from 18 to 70 years with a mean age of 46 ± 12years. More than 50% of respondents have worked for 10 years. About half of respondents had only primary level of education while the average income was 30,000 Naira monthly. The prevalence of hookworm was 14.5% among fishermen and 12.5% among farmers. Both groups had majority of respondents with light intensity infection. For knowledge of hookworm infection, 55.86% of fishermen were assessed as having poor knowledge while 44.14% were deemed to have good knowledge. Among farmers, 44.13% had good knowledge and 55.86% had poor knowledge of hookworm infections. ***Conclusion:*** The prevalence of hookworm was 14.5% among fishermen and 12.5% among farmers. Most respondents had low density hookworm infection while level of knowledge was generally poor. These figures are worrisome thus there is need for awareness of hookworm in particular and other soil-transmitted Helminthes in general in this informal occupational group.

Keyword: ***Fishermen, Farmers, Hookworm, Infection, Knowledge, Prevalence, Rural.***

Background

Informal employment accounts for more than 90 percent of agricultural work worldwide according to ILO 2023 report. In the rural areas, informal and subsistent agriculture sustains the livelihood of the local population through exploration of natural resource. These workers are faced with a myriad of hazards at the workplace ranging from physical, chemical, and biological hazards. Hookworms are one of the most prevalent and widespread parasitic human diseases with a worldwide distribution. It is a public health problem in Africa and also occupationally related especially in rural agrarian communities [1]. They are one of the identified 13 Neglected tropical diseases (NTDs), so named by the World Health Organization (WHO) because they affect the poorest of the poor in developing countries [2]. In humans it is caused mainly by two species; Necator americanus and Ankylostoma duodenale. High-risk groups susceptible to hookworms include children, pregnant women, and farmers exposed to soil containing the eggs of these helminths and living in a rural setting.

Agriculture has undergone a tremendous transformation with improvements in science and technology which has led to improved yields and better harvests. However, agricultural workers still suffer the most extensive exposure to injury and disease of any occupational group especially the subsistence farmers who occupy part of the bottom billion, living in poverty, reinforced by lack of education and conflict [3,4]. Rivers State in Southern Nigeria has a mix of both freshwater and brackish water thus providing locals a natural source to ply their trade. Fish farming has become one of the fastest-growing farming businesses, turning Nigeria into the second biggest aquaculture producer in Africa [5]. Artisanal fishery, though involves the use of crude implements, with little or no access to credit and subsistence level of operation has contributed to making Nigeria an aquaculture hub. The neglected tropical parasitic diseases that have been reported in these group of people include but not

Received: August 30, 2024; **Revised:** September 27, 2024; **Accepted:** September 30, 2024

limited to hookworms and schistosomiasis [2]. Studies have shown that adults especially those involved in agriculture have a moderate to high intensity of this infection [6,7]. Although preventive chemotherapy have focused more on children and pregnant women, these infected adults sub-occupational group may constitute a potential parasite reservoir and a source of dissemination and persistence of these infections [8].

Fishermen may be exposed to soil in the process of carrying out their activities depending on the type of aquafarming. The type of toilet systems known to be commonly used in the riverine areas in Rivers State is the jetty type of toilet facility (pier toilet). Fecal matters are known to settle by the river banks and thus can be a potential source of exposure to hookworms. Extensive open defecation on the fringes of water bodies is a common practice in fishing communities and can potentially deliver excreta directly to the water bodies. The hookworm larvae can survive for weeks in soil and water making farmers and fishermen susceptible to due to their occupation [9].

Hookworm infection through the oral and percutaneous route can often occur when infected water supply is used for irrigation, domestic and personal use [10]. It has been suggested that this pathogen could be distributed to other fishing communities via the river, thus potentiating hookworm transmission [11]. When these local fishermen wade through the marshy riverbanks to launch their fishing boats especially during ebbed tide, percutaneous infection of hookworm can occur (especially with Necator americanus). A noted occupational determinants of hookworm infection among rural farmers in the Niger Delta region of Nigeria is exposure and use of human excrements as fertilizers which constitute a potent pathway for hookworm transmission [12]. These set of workers who are self-employed and in the informal sector may not have received much attention in terms of occupational health policies and programs in contrast to their counterparts in larger and formal occupational groups [13,17]. This study aims to determine the prevalence, infection intensity of hookworm infections among rural farmers and fishermen in Rivers State and to and assess their level of knowledge of health problems of hookworm infection.

Methods

Study Setting: The design for this study was a descriptive cross-sectional and the study population comprised of workers above 18 years and are currently working in rural areas of selected Local Government Areas (LGAs) of Rivers State. Those who had taken anti-helminthic therapy in the last six months were excluded.

Sample Size was calculated using the Cochran's formula for cross-sectional studies with the assumption of a significance level of 95% (1.96), a proportion of hookworm infection from a previous study of 45% (0.45) [6], a precision of 5% and a non-response of 10% minimum estimated sample size of 380 respondents. 200 respondents were recruited for each group making a total of 400 participants.

Sampling Technique: This involved a multi-staged sampling technique to recruit 200 farmers and 200 fishermen from selected communities in Rivers State in four stages. Stage one involved simple random sampling to select three LGAs from upland Local Government Areas (LGA) which are predominantly engaged in farming, then the selection of three LGAs from riverine Local Government Areas which are predominant into fishing.

Stage two involved a simple random sampling method to select three wards from the selected LGAs. Stage three involved the selection of a community from each selected wards via a simple random sampling. In stage four, each of the selected farming and fishing communities, the list of workers was obtained. To determine the number to select from each community, proportionate to size allocation method was used. By balloting, 85 fishermen were randomly selected from a total of 143 spread across Asari-Toru communities, 50 fishermen out of 84 were selected from Okrika communities while 65 out of 109 were selected across Andoni communities making a total of 200 fishermen recruited for the study. For farmers,82 farmers were randomly selected from a total of 120 spread across Onelga communities, 71 farmers out of 103 were selected from Emohua communities while 57 out of 83 were selected across Eleme communities making a total of 200 farmers.

Data Collection and Analysis: The study instrument was a closed-ended questionnaire, partially adapted with modification from the Helminth Adults Education and Latrine Project (HELP) questionnaire and was interviewer-administered. The socio-demographic characteristics and the knowledge of hookworm infection among respondents were collected. The SPSS version 26 was used to analyze data. Descriptive statistics in the form of means and standard deviation was used for numerical data that are normally distributed. Categorical variables were expressed as frequencies and proportions. Data presentation involved appropriate frequency tables. Primary outcome variable measuring prevalence is the presence of hookworm ova or cyst in the stool samples of subjects.

In measuring the overall level of knowledge of hookworm, 19 possible answers were used to assess knowledge. This section was scored 1 point for each correct response by the participant and 0 point for each wrong response. All answers were summed. Participants with an overall good knowledge of hookworm were graded as 13-19, 7-12 fair knowledge, 0-6 poor knowledge respectively based on review of previous studies [14]. Ethical approval was obtained from the Ethics committee of University of Port-Harcourt Teaching Hospital.

Results

This study was conducted amongst rural farmers and fishermen in Rivers State with the aim of determining the prevalence, infection intensity and the level of knowledge of hookworm infection among rural farmers and fishermen working in Rivers State, Nigeria. The majority of respondents in both groups were within the ages of 42 - 61 with a mean age of 46.91 ± 12.79 years for farmers and 46.57 ± 12.95 years for fishermen. The majority of respondents in both groups were females, 116 (58%) for the fishermen, and 123(61.5%) for the farmers compared with males where we have 84(42%) for fishermen and 77(38.5) for the farmers. More respondents had a primary level of education, 97 (48%) of fishermen group and 99 (49%) for farmers group. For the number of years worked, 122(61%) of fishermen and (103) 51.5% of farmers have been engaged in their respective trades for more than 10 years. Additionally, 194(97%) of the fishermen and 192(96%) of farmers practiced Christianity.

The prevalence of hookworm infection among the Fishermen is 14.5% (29 fishermen) while the prevalence in Farmers is 12.5% (25 farmers). Out of the 29 fishermen who had hookworm present, 27 (93%) had low intensity infection and 2 (7%) moderate intensity infection while of the 25 farmers who had hookworm present, 20 (80%) had low intensity infection while 5 (20%) moderate intensity infection. None had high intensity infection.

With regards to the knowledge of hookworm, more fishermen have heard of hookworm when compared with farmers (89.5% vs 80.5%). The common source of information varied slightly for both occupational groups as more fishermen heard it in course of their work activities while more farmers heard of it from their neighborhood or place of abode. Regarding the knowledge of

modes of transmission of hookworm, 96(59%) of fishermen and 112 (62%) of farmers who responded to this question mentioned that eating without washing hands was a mode of transmission. Other responses for mode of transmission for fishermen and farmers respectively included; drinking unclean water (62% vs 64%), walking/working on dirty soil (49% vs 54%), using human waste as fertilizer (34% vs 39%), eating raw vegetables (54% vs 58%).

However, more fishermen knew that not wearing shoes was a potent source of hookworm infection (55% vs 39%,) and 87 (54%) of fishermen and 105 (58.6%) of farmers knew that eating raw vegetables without washing it could be a source of hookworm infection. For the knowledge of symptoms, more farmers listed lack of appetite as a symptom compared to fishermen (63% vs 48%.). while itch at the site of penetration was listed as a symptom by 50% of fishermen compared to 42% of farmers. With regards the knowledge of prevention of hookworm infections, in general, more of the fishermen knew how hookworm could be prevented (90% vs 83%) but more farmers knew that washing fruits before consumption can prevent hookworm (78% vs 62%).

From the study, 52% of fishermen and 50% of farmers were aware that the use of hand gloves and boot/shoes (PPEs) could prevent hookworm infection while significant number of farmer (55%) responded to the fictitious question that avoiding excess fruits can prevent hookworm compared to 21% of fishermen. Between both groups, more farmers (50% vs 39%) stated that they are aware of the need to avoid open defecation to prevent hookworm infection. In general, good and fair knowledge of hookworm were 70(43.48%) and 52 (32.10%) respectively while 39(24.22%) had poor knowledge for fishermen group. For farmers, 79(44.13%) had good knowledge, 72(40.22%) had fair knowledge while 28(15.64%) had poor knowledge.

Table 1: Socio-Demographic characteristics of Respondents

Variables	**Fishermen(N=200)**		**Farmers(N=200)**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Age (Years)				
< 21	3	1.5	5	2.5
22 – 41	68	34.0	62	31.0
42 – 61	107	53.5	111	55.5
62+	22	11.0	22	11.0
Mean (SD)	**46.57 ± 12.95**		**46.91 ± 12.79**	
Sex				
Male	84	42.0	77	38.5
Female	116	58.0	123	61.5
Marital Status				
Single	39	19.5	37	18.5
Married	119	59.5	132	66.0
Divorced	5	2.5	4	2.0
Separated	9	4.5	13	6.5
Widow/Widower	28	14.0	14	7
Level of Education				
None	25	12.5	37	18.5
Primary	97	48.5	99	49.5
Secondary	69	34.5	59	29.5
Tertiary	9	4.5	5	2.5
Religion				
Islam	2	1.0	4	2.0
Christianity	194	97.0	192	96.0
Traditionalist	4	2.0	4	2.0

Table 2: Prevalence of Hookworm Infection among participants

Variables	**Fishermen(N=200)**		**Farmers(N=200)**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Hookworm Infestation				
Present	29	14.50	25	12.5
Absent	171	85.50	175	87.5

Table 3: Hookworm Infection Intensity among Respondents.

Variables	**Fishermen(N=29)**		**Farmers(N=25)**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Hookworm Ova Density				
1-1999 (Low Density)	27	93.10	20	80.0
2000-3999 (Moderate Intensity)	2	6.89	5	20.0
4000 and above (High Density)	0	0.0	0	0.0

Table 4A: Knowledge of Transmission of Hookworm Infection among Respondents

Variables	Fishermen n=200		Farmers n=200	
	Frequency	Percentage	Frequency	Percentage
Ever heard of Hookworm				
Yes	161	80.5	179	89.5
No	39	19.5	21	10.05
Source(s) of Information				
Neighbors	48	29.81	65	36.52
Work colleague/Co-operative	59	36.65	57	32.02
Radio/Television	36	22.36	28	15.73
Others	18	11.18	28	15.73
Eating Without Washing Hands				
Yes	96	59.63	112	62.57
No	65	40.37	67	37.43
Drinking Unclean Water				
Yes	100	62.11	115	64.25
No	61	37.89	64	35.75
Walking/Working on Dirty Soil				
Yes	79	49.07	98	54.75
No	82	50.93	81	45.25
Use Human Waste as Fertilizer				
Yes			70	39.11
No			109	60.89
Not Wearing Shoes				
Yes	90	55.90	71	39.66
No	71	44.10	108	60.34
Eating Raw Vegetables				
Yes	87	54.04	105	58.66
No	74	45.96	74	41.34

Table 4B: Knowledge of symptoms of Hookworm Infection among Respondents

Variables	Fishermen(N=161)		Farmers(N=179)	
	Frequency	Percentage	Frequency	Percentage
Easy Tiredness				
Yes	73	45.63	90	50.28
No	88	54.38	89	49.72
Difficulty Concentrating				
Yes	42	26.09	58	32.40
No	119	73.91	121	67.60
Diarrhea				
Yes	108	67.08	103	57.54
No	53	32.92	76	42.46
Abdominal Pain				
Yes	129	80.12	141	78.77
No	32	19.88	38	21.23
Lack Of Appetite				
Yes	77	48.13	113	63.13
No	83	51.88	66	36.87
Penetration site itch				
Yes	82	50.93	81	46.02
No	79	49.07	95	53.98

Table 4C: Knowledge of Risk and Prevention of Hookworm Infection among Respondents

Variables	Fishermen(N=161)		Farmers(N=179)	
	Frequency	Percentage	Frequency	Percentage
Are you at risk of Hookworm?				
Yes	136	84.47	104	58.10
No	15	9.31	43	24.02
I don't Know	10	6.21	32	17.88

Can Hookworm be prevented?				
Yes	146	90.68	148	83.62
No	2	9.32	17	9.60
I don't Know	0	0.0	12	6.78
De-Worming				
Yes	143	94.70	142	92.21
No	8	5.30	12	7.79
Washing Fruits and Vegetables Before Consumption				
Yes	94	62.25	121	78.57
No	57	37.75	33	21.43
Washing Hands after working				
Yes	85	56.29	108	70.59
No	66	43.71	45	29.41
Use Of glove and Boots while working				
Yes	79	52.32	78	50.65
No	72	47.68	76	49.35
Avoid too much fruits				
Yes	33	21.85	85	55.92
No	118	78.85	67	44.08
Avoid Open Defecation				
Yes	59	39.07	78	50.65
No	93	61.59	76	49.35

Table 4D: Level of Knowledge of Hookworm Infection among Respondents

Variables	**Fishermen (N=161)**		**Farmers (N=179)**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Knowledge				
≤6 (Poor)	39	24.22	28	15.64
7-12 (Fair)	52	32.30	72	40.22
13-19 (Good)	70	43.48	79	44.13

Discussion

This study set out to determine the prevalence of hookworm infection among subsistent rural agricultural workers in Rivers State Nigeria. It also determined the level of knowledge of infection of hookworm in this occupational group. There was a lower prevalence among respondents in this study when compared with the studies done in Bayelsa, [6] Lagos,[15] and Nassarawa States [16]. Similar lower prevalence was recorded in a study done in the North-Western part of Ethiopia [17]. These differences could be attributed to the fact that the present study was carried out with subjects drawn from all over the State while these other studies were localized to a community. Also, some variations could be due to the difference in climatic and soil conditions noted in these countries. Furthermore, these studies used in comparison were done in a whole community rather than a sub-occupational group as done in this present study. The present study was carried out in a rain forest vegetation of Rivers State as opposed to the Sahel and Sudan vegetation that exists in the Northern part of Nigeria. A lower prevalence in Northern Ethiopia [18] compared to this present study could be due to the higher altitude in the Horn of Africa when compared to my study area that had a lower altitude thus more studies on the impact of altitude on hookworm eggs viability may be necessary.

Majority of the infections noted in the occupational groups were of light intensity while a handful of moderate intensity infection was recorded. There was no heavy intensity infection recorded. This further explains why hookworm is regarded as causing more morbidity than mortality even though there are general concerns about the low sensitivity of the Kato-Katz technique especially areas with a higher prevalence of light infections.

The knowledge of hookworm infection and its health effects, transmission and prevention as seen in this study shows that more than 80% of respondents have previously heard of hookworm and were able to identify some risk factors in their domestic and work practices for acquiring it. For example, about 60% of farmers and 44% of fishermen knew that not wearing shoes when working on the farmlands or wading through the swamps could expose them to hookworm infection. Slightly more than half of fishermen and just under half of farmers were able to identify skin penetration and itch as a likely symptom of hookworm infection. However, with regards to knowledge of risks while working, more fishermen who responded were aware that their job puts them at a higher risk of exposure to hookworms than farmers who responded. Among both groups of respondents, only about half knew that using protective gloves and boots could prevent hookworm infections. These findings show that across the tropics and developing world, knowledge of these common infections is still very poor among rural dwellers.

Conclusion

From this study, subsistent rural farmers and fishermen had recordable hookworm infection amongst them in Rivers State, Nigeria. While it is generally thought that low-intensity, single specie infection could cause little measurable morbidity and likely no mortality, the wider effect of long-term infection and possible polyparasitism could affect the general health of these workers. The level of knowledge of hookworm infection was deemed to be sub-optimal in these workers. This has obvious public health implications and measures that could help combat it is the provision

of educational and enlightenment programs, provision of safety gadgets like gloves, boots for fishermen who wade in the swamps can go a long way to prevent this infection. Health education can be achieved by establishing health posts at designated wards and villages that are manned by community health extension workers. These workers will carry out health promotion and preventive services as well as diagnosis of work-related conditions where necessary so that the appropriate referral can be made. This forms part of the provision of basic occupational health service (BOHS) as prescribed by the WHO/ILO. This should ideally be incorporated in to the primary health care system. Secondly, targeted population control of hookworm involving this group of adults will go a long way to achieve the goal of morbidity reduction in line with the WHO advisory committee on STH (STHAC) meeting in 2020 that recommended that a wider community approach including other at-risk groups to control programs is more effective than focusing on just school aged children. To add to this, the importance of water, sanitation and hygiene in combating hookworms and soil-transmitted helminths cannot be over-emphasized. The use of single dose preventive chemotherapy will no doubt help to actualize the 2012 declaration for NTD control.

Limitations of the Study

The majority of the questionnaires were interviewer administered and this was prone to interviewer bias. Efforts were made to avoid this by repeatedly reading every question to respondent. The questions were made to be very direct to reduce the possibility of interpretation or explanation. Those that were transformed to local dialects were asked such that it didn't deviate from the original question. All these were put in place during the training of the research assistants and implemented in the field.

The sensitivity of the Kato-Katz method was another course for concern. One major contributor to this is the heterogeneous variation of eggs within the stool. This limitation was reduced by taking a sizeable amount of stool, doing a concentration technique to separate parasites from fecal debris thereby increasing the chances of ova detection. Two Kato-Katz thick smears was prepared from each stool specimen to increase the diagnostic sensitivity. From the duplicate Kato-Katz thick smears produced, both were microscopically examined within one hour of preparation of the slide because the eggs tend to disintegrate rapidly after this time frame.

Contribution to knowledge

This research contributes valuable insights into the epidemiology of hookworm infection among rural farmers and fishermen in Rivers State, Nigeria, laying a foundation for tailored Public Health strategies aimed at improving awareness and reducing the burden of this parasitic disease in vulnerable populations and occupational sub-groups. In prevalence and demographics, the study identified a prevalence of 14.5% among fishermen and 12.5% among farmers, highlighting the specific risk profiles within each group. Detailed demographic data including age distribution, gender ratios, educational levels, and years of occupational engagement provide a nuanced understanding of the population affected by hookworm.

Regarding knowledge levels, this research found varying levels of awareness about hookworm infection between fishermen and farmers, with fishermen generally having slightly higher awareness. We identified common sources of information and differences in knowledge about transmission modes, symptoms, and preventive measures. Farmers showed better awareness of symptoms such as lack of appetite compared to fishermen. Fishermen demonstrated better knowledge of specific preventive measures like wearing shoes to prevent infection.

The findings of this study have significant implications for Public Health. It highlighted areas where educational interventions could improve knowledge, such as emphasizing the importance of washing hands and wearing shoes. It identified gaps in knowledge that could inform targeted health education programs to reduce the prevalence and impact of hookworm infections in these communities.

List of Abbreviations

ILO: International Labour Organization
NTD: Neglected Tropical Disease
WHO: World Health Organization
LGAs: Local Government Areas
HELP: Helminth Education and Latrine Project
BOHS: Basic Occupational Health Service
STH: Soil-Transmitted Helminths
STHAC: Soil Transmitted Helminths Advisory Committee

Declaration

Ethical Approval

This was obtained from the ethics committee of the University of Port Harcourt Teaching Hospital with approval number UPTH/ADM/90/Vol11/1086. Consent was collected from participants before the study. Those who were positive for hookworm were identified and de-wormed with oral mebendazole.

Conflicts of Interest

The authors declare that this is their own work; all the sources used in this paper have been duly acknowledged and there are no conflicts of interest.

Author Contribution

Data acquisition: BI, AI, PO, PT, LSD
Interpretation of the data: BI, AAA, OAA, PO, AI, CIF, LSD, PT
Drafting of the paper: BI, AI, OAA
Critical revision of the paper: AAA, LSD, BI, PT, OAA,

Data Availability

Data was collected and analysed based on the stated methods and materials and the findings were generated accordingly. The manuscript incorporated all the data and there are no additional files left out.

Funding Statement

This project was not funded by any funding organization.

Acknowledgement

We are grateful to the laboratory technicians at the University of Port Harcourt teaching headed by Mr George Karibo as well as the research assistants that aided in the collection of data in the rural communities.

References

[1] Adebayo AM, Owoaje ET, Famakin M; Helminthic Infections among Farmers in a Rural Community in Oyo State, South-western Nigeria. Journal of community Med Prim Health care. 2015;27(1):1-10.

[2] Hotez P. NTDs V.2.0: "Blue Marble Health"—Neglected Tropical Disease Control and Elimination in a Shifting Health Policy Landscape. PLoS Negl Trop Dis. 2013;7(11):e2570.

[3] Opoku DK. The Bottom Billion: Why the Poorest Countries Are Failing and What Can Be Done about It. Paul Collier. Afr Today. 2009;55(4):134-6.

[4] Lustigman S, Prichard RK, Gazzinelli A, Grant WN, Boatin BA, McCarthy JS, (et al). A Research Agenda for Helminth Diseases of Humans: The Problem of Helminthiases. PLoS neglected tropical diseases. 2012 Apr 24;6(4): e1582.

[5] Ogunji J.; Wuertz, S. Aquaculture Development in Nigeria: The Second Biggest Aquaculture Producer in Africa. Water 2023, 15(24),4224. https://doi.org/10.3390/w15244224

[6] Agi P, Awi-Waadu G. Hookworm infection in Amassoma Community in the Niger Delta, Nigeria. J Appl Sci Environ Management. 2010;12(2):17-20.

[7] Humphries D. Epidemiology of Hookworm infection in Kintampo North Municipality, Ghana. Am J Trop Med. 2011;84(5):792-800.

[8] Bopda J, Nana-Djeunga H, Tenaguem J, Kamtchum-Tatuene J, Gounoue-Kamkumo R, Assob-Nguedia C, Kamgno J. Prevalence and intensity of human soil transmitted helminth infections in the Akonolinga health district (Centre Region, Cameroon): Are adult hosts contributing in the persistence of the transmission? Parasite Epidemiol Control. 2016 Mar 22;1(2):199-204. doi: 10.1016/j.parepi.2016.03.001. PMID: 29988185; PMCID: PMC5991827.

[9] Stufano A, Foti C, Lovreglio P, Romita P, Marco A, Lia RP et al. Occupational risk of cutaneous larva migrans: A case report and a systematic literature review. PLoS Negl Trop Dis. 2022;16(5):e0010330.

[10] Chollom SC, Chollom R, Gbise SD, Kaigama AJ, Dyek YD Gideon B. et al Prevalence and Speciation of Hookworm in Plateau State, Nigeria Journal of Parasitology and Vector Biology Vol. 4(2), pp. 14 - 19,2012

[11] Classen T, Boisson S, Routray P, Torondel B, Bell M, Cumming O, et al. Effectiveness of a Rural Sanitation Programme on Diarhoea, Soil-Transmitted Helminth Infection and Childhood Malnutrition in Odisha, India. A cluster randomised trial. Lancet Glob Heal. 2014;2(11):e645-53.

[12] Funso-Aina OI, Chineke HN, Adogu PO. A Review of Prevalence and Pattern of Intestinal Parasites in Nigeria (2006-2015). EJMED. 2020;2(1).

[13] Cadiz APB, Fadrilan-Camacho VF, Quizon RR, Josef RG. Occupational Health and Safety of the Informal Mining, Transport and Agriculture Sectors in The Philippines. SouthEast Asian Journal of Tropical Medicine and Public Health, 2016 47(4) 833-843.

[14] Palmeirim M, Ouattara M, Esse C, Koffi V, Assare R, Hurlimann E, et al. Are school children less infected if they have good knowledge about parasitic worms? A case study from rural Cote d' Ivoire. BMC Public Health. 2018;18(951).

[15] Eke S, Otuu C, Ibrahim S, Omalu I, Hassan S, Boyi A. Hookworm Infection Among Humans in Panda, Panda Development Area, Karu LGA of Nassarawa State. Int J Appl Biol Res. 2014;6(1):66-73.

[16] Ibidapo CA, Okwa OM. The prevalence and intensity of soil-transmitted helminths in a rural community, Lagos suburb, South-western Nigeria. Int J Agric Biol. 2009;10(1):89-92.

[17] Pingle S, Basic Occupational Health Service. Indian journal of occupational and environmental medicine.2009 13(1): 1-2 Forrer, A., Vounatsou, P., Sayasone, S., Vonghachack, Y., Bouakhasith, D., Utzinger, J., Akkhavong, K., & Odermatt, P. (2015). Risk Profiling of Hookworm Infection and Intensity in Southern Lao People's Democratic Republic Using Bayesian Models. PLoS Neglected Tropical Diseases, 9(3). https://doi.org/10.1371/journal.pntd.0003486

[18] Alemu M, Kinfe B, Tadesse D. Wondemagegn M, Tadasse H, Endalew Y. Intestinal Parasitosis and Anemia among Patients in a Health Center, North Ethiopia. BMC Res Notes 10, 632 (2017). https://doi.org/10.1186/s13104-017-2957-2.