DETECTION AND QUANTIFICATION OF GASTROINTESTINAL PARASITES AMONG INMATES OF SOCIAL WELFARE HOMES AND LOW SOCIO-ECONOMIC AREAS IN METROPOLITAN PORT HARCOURT

ABSTRACT

Background: Detection and quantification of gastrointestinal parasitic infections (GIPIs) causing public health problems among poorer layers of the society are still one of the Neglected Tropical Diseases (NTDs) in developing countries.

Objective: The aim of the study was to detect gastrointestinal parasites among Social Welfare Homes and Low Socioeconomic Areas in Metropolitan Port Harcourt.

Methods: A cross-sectional survey was carried out for the evaluation of all the 1500 participants for GIPs among residents of social welfare homes and low socioeconomic areas in Rivers State, Nigeria for a period of one year (July 2019- June 2020). Stool samples were collected from each participant for isolation of GIPs in stool sample. Formol-ether concentration methods and Modified Ziehl-Neelson Staining techniques was used for the isolation and identification of gastrointestinal parasites.

Results: Out of 1500, 1,381 (92.1%) participants showed negative report, while 119 (7.9%) participants were positive for GIPs. Females account for 837 (55.5%) while males were 663 (44.2%). Positivity in males accounted for 56.3% (67/119) and the females had 43.7% (52/119). Age group with high prevalence occurred among 11-15yrs (38.7%). Both variables were statistically significant ($p<0.05$). Seasonal distribution of GIPs was high during the wet season ($p<0.05$). Overall, *A. lumbricoides* was the most predominant, accounting for 35.3% of the total identified. Others were as follows; *T. Trichiura* 26.1%, hookworm 22.0%, *C. sinensis* 2.5%, tapeworm, *S. mansoni* and *H. nana* 1.7% each and *H. diminuta* had 0.8%. Co-infection of *A. lumbricoides* + hookworm and hookworm + *T. Trichiura* recorded 4.2% each. Protozoa species were not identified. Risk factor of the use of toilet papers was found to be statistically significant ($p<0.05$) among others.

Conclusion: We recommend that knowledge of epidemiology and transmission routes of *C. sinensis* and *H. diminuta* needs to be improved and effective health education on personal hygiene and mass treatment should be sustainable to control the spread of gastrointestinal parasites.

Comment [a1]: Please, briefly state in the method section the method of statistical analysis and level of significance used in the study

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1. *A. lumbricoides* was the most predominant what??????
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Keywords: Gastrointestinal Parasitic Infections, Social Welfare Homes, Low Socioeconomic Areas, Port Harcourt.

1. INTRODUCTION

Parasitic infections cause a tremendous burden of disease in both the tropics and subtropics as well as in more temperate climates. Of all parasitic diseases, malaria causes most deaths globally. Malaria kills more than 400,000 people each year, most of them young children in sub-Saharan Africa [1]. The Neglected Tropical Diseases (NTDs), which have suffered from a lack of attention to the public health community, include parasitic diseases such as lymphatic filariasis, onchocerciasis, and Guinea worm disease. The NTDs affect more than 1 billion people worldwide, largely in rural areas of low-income countries. These diseases extract a large toll on endemic populations, including lost ability to attend school or work, stunting of growth in children, impairment of cognitive skills and development in young children, and the serious economic burden placed on entire countries. However, parasitic infections also affect persons living in developed countries, including the United States [1]. Globally, gastrointestinal parasitic infections (GIPIs) are one of the main causes of human morbidity and mortality especially in developing countries where public health standards are poor [2]. These are common in developing countries in tropical and sub-tropical areas, particularly in Sub-Saharan Africa, Asia, Latin America, and the Caribbean, where high prevalence rates have been recorded [3]. These infections are associated with poor sanitation, poverty, outdoor defaecation, cultural practices and other environmental condition that are prevalent in such area [4,5,6].

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In most cases, gastrointestinal infections are asymptomatic, hence many infected persons serve as vehicle for the transmission of the parasites. For instance, the food handlers are considered common vehicle for the spread of disease and is a persistent problem worldwide [7], probably causing faecal contamination of foods with their hands during food preparation, and may be implicated in the transmission of many infections to the public in the local community [8]. This study was aimed at detecting gastrointestinal parasites among inmates of social welfare homes and low socio-economic areas of metropolitan Port Harcourt. The objectives were to: determine, characterize the overall prevalence and distribution of gastrointestinal parasites among inmates of social welfare homes and low socio-economic areas in metropolitan Port Harcourt in relation to age, gender, seasonal variation and risk factors.

Comment [a3]: Before stating the aim of the study, please cite other related literatures that discussed about gastrointestinal parasites among inmates in other countries (if any exists)

2. MATERIALS AND METHODS

2.1 Study Area

This cross-sectional study was conducted in Port Harcourt metropolis which is made up of two Local Government Areas: Port Harcourt City LGA and Obi-Akpor LGA. The low socio-economic areas and social welfare homes for this study comprising of: Waterfront (latitude- 4^{o} 45'54.378" N longitude-7^{o} 1'53.6268" E), Life Care Orphanage (latitude- 4 ^{o} 49'21.4788" N longitude-7^{o} 3'13.6944" E), Abuja Waterfront (4^{o} 45'42.4872" N longitude-7^{o} 1'25.2444" E), Port Harcourt Children Home (latitude- 4^{o} 44'34.6524" N longitude-7^{o} 2'27.3264" E), Port Harcourt Remand Home (latitude- 4^{o} 44'34.6524" N longitude-7^{o} 2'27.3264" E), Blesam Orphanage, (latitude- 4^{o} 53.1470" N longitude-6^{o} 54.1200" E), Goodnews Orphanage (latitude- 4^{o} 48.5580" N longitude-6^{o} 56.9220"E), David Bassey (latitude- 4 ^{o} 47.0360" N longitude-6 ^{o} 58.7540" E), Susan Brown (latitude- 4^{o} 46.9710" N longitude-6^{o} 58.5580" E), Nembe Waterfront (latitude- 4 ^{o}45.28.2996" N longitude-7^{o} 1.29.046" E), Gambia Diobu (latitude-4^{o} 47.7490" longitude-6^{o} 59.6720" E) and Yam Zone Waterfront **(**latitude- 4^{o} 45.4920" N longitude-7^{o} 1.6660" E) (Fig 1).

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2.2 Experimental Design

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The study was conducted between July 2019-June 2020 during wet (March-November) and dry (December-February) season with the cooperation of the Association of Orphanage and Vulnerable of Nigeria and the local community of the low socio-economic areas in Port Harcourt and Obi-Akpor in Rivers State. The age group for this study was from 1 year and above. The age grouping was generated from information given on participant's questionnaire of both social welfare homes and low socio-economic areas. The age was grouped into: 1-5yrs, 6-10yrs, 11-15yrs, 16-20yrs, 21-25yrs, 26-30yrs, 31-35yrs, 36-40yrs and 41yrs and above.

The fieldwork involved home-to-home visits, encouraging participation from each individual for the social welfare homes while the low socio-economic area was carried out by the means of Town cryer. Verbal informed consent was obtained from each individual before the study. Name, sex, age, education, sociodemographic factor, and personal hygiene details were collected.
Sample size of this study was determined using this formula: $n = Z^2 * p(1-p) / M^2$ of Godden [9].

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2.3 Sample Collection

Sample collection was carried out for a period of one year (wet and dry seasons). A small screw capped plastic bottle with plastic scoop was provided to each participant after enrollment. They were advised to fill half the bottle. The next day samples were collected and brought to the location and was immediately transported to the laboratory for processing. All the containers along with specimen were properly labelled with the respective sample number, date, and area. Where there was delay, the specimen was preserved with 10% formalin. Preservation of fecal specimens is essential to maintain protozoal morphology and also to prevent further development of helminthic eggs and larvae.

2.4 Laboratory Investigation

2.4.1 Formol-Ether Concentration Methods

Although, this formol ether technique cannot detect trophozoites, it is considered as the best concentration technique used in diagnostic parasitology laboratories for detection of cysts, ova, and larvae [10, 11]. About 2g of stool in 10-15mL of 10% formol saline. The suspension was allowed to stand for 10 minutes, and then strained through two layers of gauze into a 15mL conical centrifuge tube. A total of 3mL of diethyl ether was added, and then the tube was shaken vigorously for 30 seconds and centrifuged at 2000rpm for 5 minutes. The fecal debris layer was loosened by wooden stick and the tube rapidly inverted to discard the top three layers while the sediment remained at the bottom. The debris was then placed on a clean microscopic glass slide for examination under microscope using x10 and x40 objective lenses.

2.4.2 Modified Ziehl-Neelsen Stain (Acid Fast Staining) Techniques

The smear on slide was allowed to air-dry and then fixed with methanol for 10 minutes. Five-seven (5-7) drops of Carbol fuchsin were flooded for 2-3 minutes. Then, it was decolourized with 5% Sulphuric acid for 30 seconds. Then, the smear was counter-stained with methylene blue for a minute. Finally, the smear was rinsed, drained, air-dried and examined under x10, x40 and oil immersion (x100) objective lenses.

2.5 Ethical Clearance

Ethical Clearance was sought from the Rivers State Hospitals Management Board and the study was approved by the ministry of Social Welfare and Rehabilitation. Another approval was obtained from the community leaders of the study areas together with the informed consent and questionnaire for approval of the study. Confidentiality of the data were kept at all stages of the research work.

2.6 Data Analysis

The data collected from the study area were entered in Microsoft office excel 2016 before being imported to SPSS version 23. Descriptive analysis was evaluated. Logistic regression analysis was employed to determine the association between various independent risk factors and the occurrence of gastrointestinal parasites. *P*-values were set to be less than 0.05 were considered statistically significant.

3. RESULTS

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A total of 2500 questionnaires were sent out, but only 1500 returned stool samples and analyzed. Of these population in terms of gender, 663 respondents were males. Of the male population, 67(10.1%)

respondents were positive for gastrointestinal parasites while 596 (89.9%) were negative for gastrointestinal parasites. Female participants accounted for 837. Of the total female respondents, 52 (6.2%) were positive and 785 (93.8%) were negative. However, *p*-value was found to be statistically significant ($p<0.05$) (Table 1).

The overall prevalence of GIPIs was 7.9% (119/1500) of which gastrointestinal parasites identified were mainly gastrointestinal helminths.

On the study areas, Okujagu waterfront had *A. lumbricoides* 13(10.9%) as the most prevalent. This was followed by David Bassey with 7(5.9%) and the least occurred in Gambia Diobu. Port Harcourt children home had prevalence of 9(7.6%) for hookworm (*Ancylostoma duodenale/Necator americanus*) infections and is followed by Susan Brown with 4(3.4%). Among the trichuriasis infection, Okujagu waterfront, Goodnews orphanage and Port Harcourt children home had prevalence of 5(4.2%) each. Others were *Clonorchis sinensis,* tapeworm, *Hymenolepis diminuta, Hymenolepis nana* and *Schistosoma mansoni* with low prevalences. Poly-parasitic helminths of *A. lumbricoides* and hookworm (*Ancylostoma duodenale/Necator americanus*) and hookworm (*Ancylostoma duodenale/Necator americanus*) and *T. trichiura* 5(4.2%) each (Fig 3).

The prevalence of identified GIPs in the social welfare homes, Port Harcourt remand home had the most prevalent of 9(7.6%) for hookworm (*Ancylostoma duodenale/Necator americanus*). This was followed by Susan Brown with 4(3.4%) and the least prevalence of hookworm (*Ancylostoma duodenale/Necator americanus*) were found among Life care orphanage, Port Harcourt children home, Blesam orphanage and Goodnews orphanage of 1(0.8%) each. Trichuriasis prevalence of 5(4.2%) was observed among Port Harcourt children home and was followed by Life care orphanage and Port Harcourt remand home. Other study areas had 2(1.7%) each. They were found to be statistically insignificant ($p>0.05$) (Fig 3).

On the the contrary, the low socio-economic areas, *A. lumbricoides* was most prevalent among Okujagu waterfront 13(10.9%), followed by Abuja waterfront and Nembe waterfront with 4(3.4%) each and the least prevalent with Yam zone waterfront prevalence of 2(1.7%). Hookworm of equal 3(2.5%) each was seen in Nembe waterfront and Gambia Diobu. This is followed by Okujagu waterfront and Yam zone waterfront 2(1.7%). Equal prevalence of 5(4.2%) each was recorded with Okujagu waterfront and Gambia Diobu. Protozoa were not identified. Statistically, these findings were found to be non-significant ($p>0.05$) (Fig 3).

The gastrointestinal parasitic helminths were prevalent; no protozoa were identified. *A. lumbricoides* was predominant among other gastrointestinal helminths.

Regarding the parasitic infection in the Social Welfare Homes with specific age group, *T. trichiura* was found to be more prevalent among 11-15yrs age group with 77.8%. This was followed by age group 6-10 and 16-20yrs with prevalence of 16.7% and 5.6% respectively. Also, children with age group 11–15yrs was more infected than 1-5yrs and 6-10yrs age groups of the study (61.1% vs. 33.3 and 5.6%) respectively for *A. lumbricoides*. However, hookworm (*Ancylostoma duodenale/Necator americanus*) was also prevalent among 11-15yrs age group with 43.8% while age group 16-20yrs, 26-30 and 21-25yrs had 31.3%, 12.5% and 6.3% respectively. *H. diminuta* 1(0.8%) was recorded among age group 11-15yrs. Also, mixed infections of A. *lumbricoides* and hookworm (*Ancylostoma duodenale/Necator americanus*) (66.7%) was reported among age group 1-5yrs and 11-15yrs had 33.3% while hookworm (*Ancylostoma duodenale/Necator americanus*) and *T. trichiura* infection of one case each was reported among the age group 11-15yrs 1(0.8%) and 16-20yrs 1(2.2%). Consequently, the differences were not statistically significant ($p>0.05$) (Fig 4).

In terms of prevalence and distribution of gastrointestinal parasitic infections in the low socio-economic areas with specific age group, *A. lumbricoides* was found to be most prevalent in 6-10yrs age group with 41.7%. This was followed by age group 1-5yrs, 36-40yrs, 41yrs & above, and 11-15yrs with prevalence of 16.7%, 12.5% and 8.3% respectively. Also, *T. trichiura* infection was observed among children of age group 6-10yrs which was most prevalent (38.5%). This was followed by 11-5yrs and 16-20yrs age groups of the study (23.1%) each. For hookworm (*Ancylostoma duodenale/Necator americanus*) infection, age group 1-5yrs, 6-10yrs and 16-20yrs had 20% prevalence each while other age group had one case (10%) each. *Clonorchis sinensis* had three (3) cases of which age group 16-20yrs had 1(0.9%), 31-35yrs had 1(1.1%) and 41 & above had 1(0.6%) were affected. Also, tapeworm recorded 2(0.9%) among the 11-15yrs age group. Two (2) cases of *H. nana* were also recorded among age group 11-15yrs had 1(0.5%) and 16-20yrs had 1(0.9%). Furthermore, mixed infections of *A. lumbricoides* and hookworm (*Ancylostoma* *duodenale/Necator americanus*) (66.7%) was reported among age group 16-20yrs had 1(0.9%) and 41 & above had 1(0.6%) each while hookworm (*Ancylostoma duodenale/Necator americanus*) and *T. trichiura* infection of one case each was reported among the age group 6-10yrs (33.3%) and 11-15yrs (66.7%). The differences were not statistically significant (p>0.05) (Fig 4).

A total of 1500 respondents were evaluated of which males accounted for 633 and 837 were female respondents. Among the social welfare homes gender-related distribution of 325 respondents, 160 females of which 25 respondents were positive with high prevalence of *A. lumbricoides* 11(6.9%). Males had 165 respondents with 33 respondents positive with *T. trichiura* 11(6.7%) and hookworm (*Ancylostoma duodenale/Necator americanus*) 10(6.1%) most prevalent respectively. Male and female recorded 1(0.6%) each for *H. diminuta*. Mixed infections of *A. lumbricoides* & hookworm (*Ancylostoma duodenale/Necator americanus*) had 3(1.8%) among the males while hookworm (*Ancylostoma duodenale/Necator americanus*) & *T. trichiura* 1(0.6%) was recorded each for both genders. *P*-value was not statistically significant (p>0.05) (Fig 5).

Among the low socio-economic areas, gender-related distribution of 1175 respondents, males had 498 respondents with 34 respondents positive with *A. lumbricoides* 14(2.8%) followed by hookworm (*Ancylostoma duodenale/Necator americanus*) and *T. trichiura* 6(1.2%) each while *C. sinensis* had 2(0.4%) and *H. nana* and *S. mansoni* had 1(0.2%) each. In the female category, 677 females of which 27 respondents were positive with high prevalence of *A. lumbricoides* 10(1.5%) was recorded. This was followed by *T. trichiura* 7(1.0%), hookworm (*Ancylostoma duodenale/Necator americanus*) 4(0.6%). Males and females recorded 1(0.2%) and 1(0.1%) each of tapeworm infection. *H. nana* was reported to have 1(0.2%) among the males. Two mixed infection of *A. lumbricoides* & hookworm (*Ancylostoma duodenale/Necator americanus*) occurred among males 1(0.2%) and females 1(0.1%). Hookworm (*Ancylostoma duodenale/Necator americanus*) & *T. trichiura* infection of 3(0.4%) was recorded among females. *P*-value was not statistically significant (p>0.05) (Fig 5).

The distribution of GIPs among the inmates in this study were found to be high during the wet season 103(86.6%) while the dry season had 16(13.4%). *A. lumbricoides* 37(35.9%) was most prevalent in this report followed by *T. trichiura* 28(27.2%) and hookworm (*Ancylostoma duodenale/Necator americanus*) 24(23.3%). These species were identified during the wet season. Dry season had 7(43.8%) for *A. lumbricoides, T. trichiura* 3(18.8%) while hookworm (*Ancylostoma duodenale/Necator americanus*) had 2(12.5%). Other species identified were Tapeworm, *S. mansoni*, *C. sinensis* and *H. diminuta.* Mixed infection of *A. lumbricoides* & hookworm (*Ancylostoma duodenale/Necator americanus*) had 0.4% and 0.3% for wet and dry seasons while hookworm (*Ancylostoma duodenale/Necator americanus*) & *T. trichiura* had 0.7% for wet season transmission. However, it was found to be statistically significant (p<0.05) (Fig 6).

The risk factors associated with gastrointestinal parasitic infections such as the use of drugs in the last 3 months, washing of hands with soap, washing of hands after playing with soil, methods of cooking vegetables, contact with domestic animal, putting on shoes outside appeared to be not statistically significant except for the use of toilet paper (Table 2).

Among the respondents that use drug in the last three months who were positive, 8.4% used drug in the last three months while 7.7% did not and was found not statistically significant (p>0.05).

Also, on the method of cooking vegetables, 7.6% of positive respondents had undercooked vegetables while 8.1% cooked their vegetables thoroughly. This observation was not significant (p>0.05).

The use of soap during handwashing, 9.1% of the positive respondents observed handwashing while 6.7% of the respondents did not observe handwashing and was not significant (p>0.05).

As for putting on shoes outside, 8.1% of the positive respondents practice this method while 6.4% of the positive respondents did not. Observation was statistically insignificant (p>0.05).

Contact with domestic animal, 5.1% of the positive respondents was in contact with domestic animal while 8.5% were without contact and was not significant (p>0.05).

Respondents who washed their hands after playing with soil, 7.7% were positive while 9.2% did not observed handwashing and observation was statistically insignificant (p>0.05).

On the use of toilet paper, 17.6% of the respondents had positive GIPs while 5.9%did not practice the use of toilet paper however were positive for GIPs. This observation was found to be statistically significant (p<0.05) (Table 2).

4. DISCUSSION

Gastrointestinal parasitic infections (GIPIs) caused by helminths and protozoans remain a major burden causing morbidity and mortality in many developing countries including Nigeria. The prevalence of GIPs among the inmates of social welfare homes and low socio-economic areas, positivity of gastrointestinal parasites was 48.7%(58/119) for the social welfare homes while the low socio-economic areas had 51.3%(61/119). Statistically, these prevalences were found to be non-significant (*p*>0.05). The prevalence rates in the study areas, shows that people are less concerned about the health status of their children under the care-giver especially in the social welfare homes in relation to the number of participants of the study [12]. Other studies elsewhere had different prevalence which could be due to personal/environmental hygiene, study participants and geographical locations. Moura et al. [13] and Can ˜ete et al. [14] observed higher prevalence rates of 62.9% and 71.1% in Brazil and Cuba. Lower prevalence rates of 26.7%, 20.7% and 15.8% were recorded in Iran, Nigeria and Ghana respectively [15,16,17]. Among the low socio-economic areas, lower prevalence rates of 41%, 25.4%, and 21.5% compared to our findings were reported by Espinosa [18], Gizaw et al. [19] and Bahrami et al. [20] (2018) in Columbia, Ethiopia and Iran. Da Silva et al. [21] study associated with GIPIs among young population in Northeast Brazil, had 68% prevalence rate while 75.7% was recorded in a comparative study of the prevalence of gastrointestinal parasites in low socio-economic areas from South Chennai, India [22]. The different prevalence rates from various studies are not in agreement with our findings.

In this study, a total prevalence of 7.9%(119/1500) of GIPs was observed. This overall prevalence rate reported was lower compared to other studies elsewhere. Michael et al. [23] had prevalence rate of 24.8% of gastrointestinal parasitic infections among school children in Port Harcourt City Local Government Area. Similarly, in the South-South region of Nigeria, Sapele Local Government Area, Wokem and Onosakponome [24] recorded a prevalence of 19.1% among school children in Delta state. Other studies in Ethiopia (22.6%), Western Iran (21.8%), Middle Belt of Ghana (19.3%), and North of Iran (12.1%) recorded prevalence rate higher than our study [25,26,27,28]. On the other hand, the overall prevalence of GIPs found in this study is slightly higher than findings from Haftkel County, Southwest of Iran which reported of prevalence of 4.8% in study by Saki et al. [29] and Akinbo et al. [30] recorded 3.9% in Delta and Benin state, Nigeria [30]. The significantly low prevalence of gastrointestinal parasitic infections observed in this study might be due to age, geographic difference, socio-economic status, awareness to control GIPs, transmission route as well as seasonal differences.

A. lumbricoides (35.3%) prevalence rate observed in our study was low compared to those reported from other geographical locations by different researchers. This predominance of *A. lumbricoides* than any other GIPs agreed with some other reports [31,32,33,17,34,35,36,37]. On the other hand, da Silva et al. [21], Khanal et al. [2] and Herna´ndez et al. [38] found *T. trichiura* predominant (55.1%: 32.0%: 12.3%) Kathmandu, Nepal and Colombia. Stool Sample of Orphanage and Destitute Home Children in Kalaburagi; showed most prevalent of 15.7% for *H. nana*, 2.2% of *S. stecoralis* and *Trichomonas. hominis* each, 1.1% of *A. lumbricoides* and *T. Trichiura* and *Enterobius vermicularis* each were also found [39]. Afshar et al. [40], Mahni et al. [41] and Kuzehkanani et al. [42] reported *Blastocystis* sp., *E. coli*, and *G. lamblia*. The high prevalence of *A. lumbricoides* may be due to the high resistance of the infective ova to desiccation and the direct mode of infection that enhances longevity and promotes infectivity [35].

Trichuris trichiura was relatively the second most common GIPs identified in this study. The prevalence value was 26.1%. This prevalence rate is low though is in agreement with the report of Manz et al. [43] 26.6% in Tanzania among their population-based study. In contrast, studies elsewhere with very low prevalence ranges in Uganda (0.4%), Indonesia (1.8%), Nigeria (2.9%), Ethiopia (8.4%) and Colombia (12.3%) [44,45,46,47,38]. Higher prevalence rates were recorded by da Silva et al. [21] (2016) 55.1% among Young Population in Northeast Brazil and Khanal et al. [2] 32.0% among school children in Kathmandu, Nepal. Soil pollution is a major factor in the transmission of *T. trichiura* infection in a community [48]. *T. trichiura* infections are transmitted by ingesting eggs, which develop in the soil [49]. Infections usually occur through ingestion of infective ova from contaminated hands, food or drinks. Flood and copraphagous animals play some part in the transportation of the ova to locations other than the defecation site [48].

Hookworm (*Ancylostoma duodenale/Necator americanus*) infections to occur, the L3 stage infective larvae must penetrate the skin. Poor personal and environmental hygiene are the principal factors in the aetiology of hookworm (*Ancylostoma duodenale/Necator americanus*) infections [48]. The prevalence of 22.0% was recorded for hookworm in this survey. This value is lower compared to 45%, 35.8% and

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29.4% in earlier reports in Ghana, Ethiopia and Ibadan [50,51,46]. However, da Silva et al. [21](2016) agreed with the findings of our report. On the contrary much lower prevalence were seen in recent studies by Štrkolcová et al. [36] 0.3% in Slovakia, Pauly et al. [52] 1.0% in Lao, Abe et al. [53] 17.80% in Nasarawa, Aniwada et al. [54] 9.7% in Enugu and Punsawad et al. [55] 10.7%. This reduction of hookworm (*Ancylostoma duodenale/Necator americanus*) prevalence could be indicative of a successful control measures intervention, mass drug administration and health enlightenment programs.

Clonorchis sinensis (2.5%) was recorded in this study. *C. sinensis* is also known as the Chinese liver fluke. These are most commonly found in Eastern Asia but are also commonly found in Russia. These liver flukes are common parasites of fish-eating mammals. Cats and dogs of endemic areas are the most common hosts but can be passed to humans who eat infected fish. When infected, *C. sinensis* will live within the biliary system of humans. These parasites, when present with a large parasite burden in humans, can have serious complications if not found and treated promptly [56,57]. In parts of Asia, the fluke worms are a public health problem. There is rare information of studies on *C. sinensis* in most parts of SSA including Nigeria. In Enugu, Nigeria, 0.7% prevalence rate was recorded by Ukwah and Ezeonu [58] using different diagnostic techniques for investigation of GIPs. Duedu et al. [17] in their study GIPs in association with malnutrition at a Ghanaian Orphanage, discovered 2.0% of *C. sinensis.* Recently in northern Vietnam, Nguyen et al. [59] recorded 40.4% prevalence rate among rural communities. *C. sinensis* is endemic in China, Taiwan, Korea, eastern Russia and north Vietnam [56,60] and may spread to non-endemic regions due to the expansion of international markets and increased migration and travelling [60,61].

Tapeworms comprises of *Taenia saginata* and *Taena solium* affecting humans. Our study reported 1.7% prevalence value which is in accordance with research works by Adu-Gyasia et al. [27] and Humphries et al. [50] for soil transmitted helminth infections in the middle-belt and in Kintampo North Municipality of Ghana. However, studies by Damen et al. [62] in Jos, Abaver et al. [63] in Abuja, Ojurongbe et al. [64] in Osogbo and Duede et al. [17] in Ghana had low prevalence as with our findings. Slightly higher prevalence rate was observed in studies in India (2.74%), Korea (4.8%) and Nigeria (8.4%) [65,66,67]. The level of occurences in the different studies are due to beef consumption rate.

Schistosomiasis caused by *Schistosoma* species is an important NTDs that attracts more attention due to its chronic nature, association with water resources, and lack of a protective vaccine. Out of the six *Schistosoma* species affecting humans, *S. mansoni* is responsible for intestinal schistosomiasis in African countries [68]. It is dominant in rural poor communities among agriculture and fishing workers, moreover, contact with infected water as in car and clothes washing, as well as recreational activities increases the risk of infections. *S. mansoni* accounted for 1.7% of occurrence in our study which is higher than the prevalence reported by Omorodion et al. [69] among school-age children in Delta State, Nigeria. Duedu et al. [17] 3.0% in Ghana recorded prevalence slightly higher than ours. On the contrary, elsewhere, prevalences were much higher than we recorded at baseline ranging from 8.0% to 82.7% in Yemen, Ethiopia, Côte d'Ivoire, Nigeria and Democratic Republic of Congo [70,71,72,73,74]. These differences in prevalence from various geographical locations could be as a result of water contact activities such as washing clothes in rivers, bathing in rivers, crossing rivers, and lack of protective shoes among the study populations.

In this study, *Hymenolepis nana* recorded 1.7% of identified GIPs. This is lower compared to past studies by Khanal et al. [2] 16.0%, Mulatu et al. [75] 3.8%, Erismann et al. [76] 6.5% and Srivinas et al. [39] (2017) 15.9%. However, 3.1%, 8.9% and 22.0% were recorded in Ethiopia and Iran [47,40]. This variation could be due to environmental and living conditions of the study participants. The normal mode of transmission *H. nana* infection is the ingestion of the eggs in food contaminated with faeces rather than ingestion of contaminated drinking water [77].

Hymenolepis diminuta, or rat tapeworm, is a tapeworm species of rats and mice that is rarely found in man; its cysticercoid larvae are harbored by beetles, fleas, caterpillars, and other insects [78,79]. The rat is infected when it eats an infected beetle. This species has been reported from humans on rare occasions [78,79]. This tapeworm is found commonly in areas where large amounts of grain or other dry food products, which are the favorite foods for rats, are stored [78,79]. About 500 cases of *H. diminuta* infection had been reported worldwide, from the United States, Africa and Asia [78,79]. Different surveys have reported parasitization rates ranging from between 0.001%-5.5% [80]. Our study recorded 1 case (0.8%) of *H. diminuta.* This is in agreement with a case of a young male infected with *H. diminuta* in

Odisha which was reported by Karuna and Khadanga [81]. In contrast, Wiwannitkit [82] reported 10 cases of which 1 case was lethal of *H. diminuta*.

This study recorded prevalence of GIPIs among children to be 83.2%(99/119), which is relatively high. This high prevalence is in accordance with findings from varous studies [54,83,84]. The act of ricky behaviour that predisposes them to infection and less awareness of hand washing practices might be the probable reasons for increased chances of acquiring GIPs in lower age groups.

In seasonal variation of transmission pattern of GIPs, rainfall is one aspect of seasonality that is predicted to have strong e□ects on helminth parasitism [85]. These e□ects can come about in several ways. First, variation in rainfall can change host susceptibility by altering resource quantity and quality, driving changes in body condition [86] and immunity [87], both of which can influence susceptibility to infection. The wet season had more prevalence of GIPs which is in agreement with the study of helminthiasis among school children in some rural communities of Abia State [88]. This was found to be statistically significant ($p<0.05$). On the contrary in Iran, Kiani et al. [89] (2016) in Nahavand County and its weather in summer, had high prevalence of GIPs. This could be as a result of the existence of more agricultural practices during summer.

The risk factors associated with gastrointestinal parasitic infections such as the use of drugs in the last 3 months, washing of hands with soap, washing of hands after playing with soil, methods of cooking vegetables, contact with domestic animal, putting on shoes outside appeared to be not statistically significant except for the use of toilet paper that was statistically significant ($p<0.05$). These findings are in contrast with other studies of which in studies by Hailegebriel [90], Abossie and Seid [91] all in Ethiopia do not have significant risk among sex. This variation might be as a result of outdoor activities especially use of bare-footed involved by the males. Kiani et al. [89] in their study had significant risk factors during summer. Age, educational level, employment status, occupation, contact with domestic animals in this study were considered not significant risk factors. Other study in Iran had significant risk factors of GIPs [90] .

Based on this study, prevalence was significantly higher among males and younger age groups, which covered the school age in the inmates of social welfare homes and low socio-economic areas. *A. lumbricoides* was the most predominant gastrointestinal parasites among this study population. Furthermore, in spite of a significant reduction in the prevalence of gastrointestinal parasites the prevalence and incidence still a major public health concern in Port Harcourt. Thus, effective and sustainable control policies should be considered for public health advantages.

There is room for further improvement on knowledge of the epidemiology and transmission routes on the identification of *C. sinensis* in this geographical location as there are more fish and snail consumers. Knowledge of the epidemiology and transmission routes of *H. diminuta* needs to be improved since rodents, particularly rats, are the definitive hosts and natural reservoirs. There is a need for effective health education for behavioural changes related to personal hygiene and mass treatment for the sustainable control of gastrointestinal parasitic infections.

REFERENCES

1. CDC. Centre for Disease Control and Prevention: About Parasites. https://www.cdc.gov/parasites/about.html. September, 2020.
2. Khanal LK, Choudhury DR, Rai SK, Sapkota J, Barakoti A, Hada S. Prevalence of intestinal worm infestations among school children in Kathmandu, Nepal. Nepal Med Coll J. 2011;13(4):272-4.
3. De Silva NR, Brooker S, Hotez PJ, Montresor A, Engels D, Savioli L. Soil-transmitted helminth infections: updating the global picture. Trends Parasitol. 2003;19(2):547-51.
4. WHO. World Health Organization: Prevention and control of schistosomiasis and soil-transmitted helminthiasis; report of a WHO expert committee. Geneva: p. 63. WHO technical report series no. 912. 2002.
5. Mbanugo JI, Onyebuchi CJ. (2002). Prevalence of intestinal parasites in Ezinifite community, Aguata Local Government Area of Anambra State. Nig J Parasitol. 2002;23(1):27-34.
6. Adeyeba OA, Akinlabi AM. (2002). Intestinal parasitic infections among school children in a rural community, South West Nigeria. Nig J Parasitol. 2002;23(1):11-18.

Comment [a13]: The highlighted part is utterly cumbersome and unnecessary, the section is full of irrelevant comparison as most of the factors are not even statistically significant, this made the reference list to get to 90+ without any strong discussion. The author(s) should summarize this section with less comparisons/references, the section should focus more on a strong discussion with less irrelevant comparison.

Comment [a14]: The author(s) used different referencing styles all through, please cross-check and stick to the referencing style recommended by the journal.

7. Andargie G, Kassu A, Moges F, Tiruneh M, Huruy K. Prevalence of bacteria and intestinal parasites among food-handlers in Gondar town, Northwest Ethiopia. J Health Popul Nutr. 2008;26(4):451-55.
8. Kaferstein F. Foodborne diseases in developing countries: aetiology, epidemiology and strategies for prevention. Int J Environ Health Res. 2003;13(1):161-8.
9. Godden W. Sample size formulas. http://williamgodden.com/samplesizeformula. 2004.
10. Wakid MH. Distribution of intestinal parasites among food handlers in Jeddah, Saudi Arabia. J Parasitic Dis. 2006;30(2):146-52.
11. Garcia LS. (2007). Washington: ASM Press; Diagnostic Medical Parasitology.
12. Brouwer WB, van Exel NJ, van den Berg B, van den Bos GA, Koopmanschap MA. Process utility from providing informal care: the benefit of caring. Health Policy. 2005;74(1):85-99.
13. +Moura RGF, Ramos ELP, Colombo MS, Aidar FDD, Hernández CG, Silva MB. Prevalence of intestinal parasites in child day care centers: epidemiological significance. J Trop Pathol. 2017;46(1), 75-84.
14. Can ˜ete R, Dı ´az MM, Avalos Garcı ´a R, Lau ´d Martinez PM, Manuel Ponce F. Intestinal Parasites in Children from a Day Care Centre in Matanzas City, Cuba. PLoS ONE. 2012; 7(12): e51394.
15. Faraji R, Ahmadian F, Javadi GR, Barshahi PM. Prevalence of Giardiasis among children in childcare centers in Kermanshah, Iran. Int J Res Med Sci. 2015;3(7):1717-20.
16. Nwaneri DU, Omuenu VO. Intestinal helminthiasis and nutritional status of children living in Benin City, Nigeria. Niger J Clin Pract. 2013;16:243-8.
17. Duedu KO, Peprah E, Anim-Baidoo I, Ayeh-Kumi PF. Prevalence of intestinal parasites and association with malnutrition at a Ghanaian Orphanage. Human Parasit Dis. 2015;(7):5-9.
18. Espinosa AF. Environmental risk factors associated with intestinal parasitic infections and respiratory symptoms in pregnant women residing in low-income neighborhoods in Bogotá, Colombia. (Ph.D Thesis). 2019 http://doi: 10.5282/edoc.26708.
19. Gizaw Z, Addisu A, Gebrehiwot M. Socio-economic predictors of intestinal parasitic infections among under-five children in rural Dembiya, Northwest Ethiopia: A community-based cross-sectional study. Environ Health Insights. 2019;13:1-6.
20. Bahrami F, Haghighi A, Zamini G, Khadem-Erfan MB, Azargashb E. Prevalence and associated risk factors of intestinal parasitic infections in Kurdistan province, northwest Iran. Cogent Med. 2018; 5(1503777):1-14.
21. Da Silva JVL, Fontes G, Santos CD, Santos RV, Da Rocha EMM. Factors Associated with Gastrointestinal Parasitic Infections among Young Population in Northeast Brazil. Canadian J Infect Dis Med Microbiol. 2016;6239434.
22. Dhanabal J, Selvadoss PP, Muthuswamy K. Comparative Study of the Prevalence of Intestinal Parasites in Low Socio-economic Areas from South Chennai, India. J Parasitol Res. 2014, ID630968, 7 pages.
23. Michael EI, Abah A, Marcus P. Prevalence of gastrointestinal parasitic infection among school children in Port Harcourt City Local Government Area. Nig J Bacteriol Parasitol. 2017;8(5):1-4.
24. Wokem GN, Onosakponome EO. Soil transmitted helminthiasis in Sapele local Government Area, Delta in Port Harcourt, Nigeria. Nig J Parasitol. 2014;35(1&2):143-8.
25. Sisay A, Lemma B. Assessment on the prevalence and risk factors of gastrointestinal parasites on schoolchildren at Bochesa Elementary School, around Lake Zwai, Ethiopia. BMC Res Notes. 2019;12:410.
26. Kiani H, Ali Haghighi A, Salehi R, Azargashb E. Distribution and risk factors associated with intestinal parasite infections among children with gastrointestinal disorders. Gastroenterology and Hepatology from Bed to Bench, 2016;9(Suppl. 1):S80-S7.
27. Adu-Gyasia D, Asantea KP, Frempong MT, Gyasia DK, Iddrisua LF, Ankraha L, et al. Epidemiology of soil transmitted Helminth infections in the middle-belt of Ghana, Africa. Parasite Epidemiol Control. 2018;3(3):e00071.
28. Gholipoor Z, Hooshang Khazan H, Azargashb E, Youssefi MR, Rostami A. Prevalence and risk factors of intestinal parasite infections in Mazandaran province, North of Iran. Clin Epidemiol Glob Health. 2020;8(1):17-20.

29. Saki J, Khademvatan S, Foroutan-Rad M, Gharibzadeh M. Prevalence of Intestinal Parasitic Infections in Haftkel County, Southwest of Iran. Int J Infect. 2017;4(4):e15593.
30. Akinbo FO, Omoregie R, Eromwon R, Igbenimah IO, Airueghiomon UE. Prevalence of intestinal parasites among patients of a tertiary hospital in Benin city, Nigeria. North Am J Med Sci. 2011;3(10):462-64.
31. Ahmed A, Sani A. Prevalence and risk factors associated with Helminthic Infections among pre-school children in Katsina Metropolis, Katsina State, Nigeria. Int J Zool Appl Biosciences. 2019;4(3):126-33.
32. Pullan RL, Gething PW, Smith JL., Mwandawiro CS, Sturrock HJW, Gitong CW, et al. Spatial modelling of soil-transmitted helminth infections in Kenya: a disease control planning tool. PLoS Negl Trop Dis. 2011;5(2):e958.
33. Chammartin F, Scholte RGC, Malone JB, Bavia ME, Nieto P, Utzinger J, et al. Modelling the geographical distribution of soil-transmitted helminth infections in Bolivia. Parasites & Vectors. 2013;6:152.
34. Schule SA, Clowes P, Kroidl I, Kowuor DO, Nsojo A, Mangu C, et al. *Ascaris lumbricoides* infection and Its relation to environmental factors in the Mbeya region of Tanzania, a cross-sectional, population-based study. PLoS One. 2014;9(3):e92032.
35. Oluwole AS, Adeniran AA, Mogaji HO, Olabinke DB, Abe EM, Bankole SO, et al. Prevalence, intensity and spatial co-distribution of schistosomiasis and soil transmitted helminths infections in Ogun state, Nigeria. Parasitol Open. 2018;4e8:1-9.
36. Štrkolcová G, Mravcová K, Barbušinová E, Mucha R, Várady M, Goldová M. Prevalence of Intestinal Parasites in Children Living in Various Living Conditions in Slovakia. J Pediatr Perinatol Child Health. 2019;3(3):174-85.
37. Mogaji HO, Dedeke GA, Bada BS, Bankole S, Adeniji A, Fagbenro MT, et al. Distribution of ascariasis, trichuriasis and hookworm infections in Ogun State, Southwestern Nigeria. PLoS One. 2020;15(6): e0233423.
38. Herna´ndez PC, Morales L, Chaparro Olaya J, Sarmiento D, Jaramillo JF, Ordoñez GA, et al. Intestinal parasitic infections and associated factors in children of three rural schools in Colombia. A cross-sectional study. PLoS One. 2019;14(7):e0218681.
39. Srinivas VA, Rajhans NK, Srinivasan V, Vittal PS, Parandekar P. Screening of Parasites in Stool Sample of Orphanage and Destitute Home Children in Kalaburagi. Int J Curr Microbiol Appl Sci. 2018;7(12):2575-86.
40. Afshar MJA, Mehni MB, Mostafa RM, Mohebali M, Baigi V, Amiri S, et al. Prevalence and associated risk factors of human intestinal parasitic infections: a population-based study in the southeast of Kerman province, southeastern Iran. BMC Infect Dis. 2020;20:12.
41. Mahni MB, Rezaeian M, Eshrat Beigom K, Raeisi A, Khanaliha K, Tarighi F, et al. Prevalence of intestinal parasitic infections in Jiroft, Kerman Province, Iran. Iran J Parasitol. 2016;11(2):232-8.
42. Kuzehkanani AB, Rezaei S, Babaei Z, Niyyati M, Hashemi S, Rezaeian M. Enteric protozoan parasites in rural areas of Bandar-Abbas, southern Iran: comparison of past and present situation. Iran J Public Health. 2011;40(1):80-5.
43. Manz KM, Clowes P, Kroidl I, Kowuor DO, Geldmacher C, Ntinginya NE, et al. *Trichuris trichiura* infection and its relation to environmental factors in Mbeyaregion, Tanzania: A cross-sectional, population-based study. PLoS One. 2017;12(4):e0175137.
44. Oboth P, Gavamukulya Y, Barugahare BJ. Prevalence and clinical outcomes of *Plasmodium falciparum* and intestinal parasitic infections among children in Kiryandongo refugee camp, mid-Western Uganda: a cross sectional study. BMC Infect Dis. 2019;19:295.
45. Kurscheid J, Laksono B, Park MJ, Clements ACA, Sadler R, McCarthy J. S, et al. Epidemiology of soil-transmitted helminth infectionsin Semarang, Central Java, Indonesia. PLoS Negl Trop Dis. 2020;14(12):e0008907.
46. Alli J A, Kolade AF, Okonko IO, Nwanze JC, Dada VK, Ogundele M. Prevalence of intestinal nematode infection among pregnant women attending antenatal clinic at the University College Hospital, Ibadan, Nigeria. Adv Appl Sci Res. 2011;2(4):1-13.
47. Tadesse M, Dobo B, Birmeka M. Prevalence and associated risk factors of intestinal parasitic infections among school children in Bamo no.2 primary school, Adele town, East Arsi, Ethiopia. Sub-Saharan Afr J Med. 2019;6(2):77-85.

48. Mordi RM, Ngwodo POA. A study of blood and gastrointestinal parasites in Edo State/ Afr J Biotechnol. 2007;6(19):2201-7.
49. Cross JH. Enteric Nematodes of Humans. In: Baron S, editor. Medical Microbiology. Galveston (TX): University of Texas Medical Branch at Galveston the University of Texas Medical Branch at Galveston. 1996.
50. Humphries D, Mosites E, Otchere J, Twum WA, Woo L, Jones-Sanpei H,et al. Epidemiology of Hookworm Infection in Kintampo North Municipality, Ghana: patterns of malaria coinfection, anaemia, and albendazole treatment failure. Am J Trop Med Hyg. 2011;84(5):792-800.
51. Getachew M, Tafess K, Zeynudin A, Yewhalaw D. Prevalence of soil-transmitted helminthiasis and malaria co-infection among pregnant women and risk factors in Gilgel Gibe Dam Area, southwest, Ethiopia. BMC Research Notes, 2013;6:263.
52. Pauly M, Sayasinh K, Muller CP, Sayasone S & Black AP. High prevalence of helminth infections in mother-child pairs from three central provinces of Lao People's Democratic Republic. Parasite Epidemiol Control. 2019;7:e00122.
53. Abe EM, Echeta OC, Ombugadu A, Ajah L, Aimankhu PO, Oluwole AS. Helminthiasis among school-age children and hygiene conditions of selected schools in Lafia, Nasarawa State, Nigeria. Trop Med Infect Dis. 2019;4(112):1-12.
54. Aniwada EC, Uleanya ND, Igbokwe LN, Onwasigwe C. Soil-transmitted helminths; prevalence, perception and determinants among primary school children in rural Enugu State, Nigeria. Int J Trop Dis Health. 2016;15(1):1-12.
55. Punsawad C, Phasuk N, Bunratsami S, Thongtup K, Viriyavejakul P, Palipoch S, et al. Prevalence of intestinal parasitic infections and associated risk factors for hookworm infections among prim.ary schoolchildren in rural areas of Nakhon Si Thammarat, southern Thailand. BMC Public Health. 2018;18:1118 https://doi.org/10.1186/s12889-018-6023-3.
56. Hong ST, Fang Y. (2012). *Clonorchis sinensis* and clonorchiasis, an update. Parasitol Int., 2012;61(1):17-24.
57. Wang KX, Zhang RB, Cui YB, Tian Y, Cai R, Li CP. Clinical and epidemiological features of patients with clonorchiasis. World J Gastroenterol. 2004;10(3):446-8.
58. Ukwah BN, Ezeonu IM. Prevalence of Cryptosporidium and other intestinal parasites using different diagnostic techniques in Enugu Metropolis, South-Eastern Nigeria. Afr J Microbiol Res. 2017;7(15):1366-70.
59. Nguyen TTB, Dermauw V, Dahma H, Bui DT, Le TTH, Phi NTT, et al. Prevalence and risk factors associated with Clonorchis sinensis infections in rural communities in northern Vietnam. PLoS Negl Trop Dis. 2020;14(8):e0008483.
60. Qian MB, Utzinger J, Keiser J, Zhou XN. Clonorchiasis. Lancet. 2016;387(10020):800-10.
61. Chai JY, Darwin Murrell K, Lymbery AJ. Fish-borne parasitic zoonoses: Status and issues. Int J Parasitol. 2005;35(11-12):1233-54.
62. Damen JG, Lar P, Mershak P, Mbaawuga EM, Nyary BW. A comparative study on the prevalence of intestinal helminthes in dewormed and non-dewormed students in a rural area of North-Central Nigeria. Lab Med. 2010;41(10):585-89.
63. Abaver DT, Nwobegahay JM, Goon DT, Iweriebor BC, Anye DN. Prevalence of intestinal parasitic infections among HIV/AIDS patients from two health institutions in Abuja, Nigeria. Afr Health Sci. 2011;11(S1):S24-7.
64. Ojurongbe O, Raji OA, Akindele AA, Kareem MI, Adefioye OA, Adeyeba AO. Cryptosporidium and other enteric parasitic infections in HIV-seropositive individuals with and without diarrhoea in Osogbo, Nigeria. Br J Biomed Sci. 2011;68(2):75-8.
65. Lateef M, Nazir M, Zargar SA, Tariq KA. Epidemiology of *Taenia saginata* taeniasis with emphasis on its prevalence and transmission in a Kashmiri population in India: A Prospective study. Int J Infect Dis. 2020;98:401-5.
66. Eom KS, Yong TS, Sohn WM, Chai YJ, Min YD, Rim JH, et al. Prevalence of helminthic infections among inhabitants of Lao PDR. Korean J Parasitol. 2014;52(1):51-6.
67. Eke SS, Oguniyi T, Omalu ICJ, Otuu CA, Udeogu VO, Luka J, et al. Prevalence of human taeniasis among school children in some selected primary schools in Bosso Local Government Area, Minna, Niger State, Nigeria. Int J Appl Biol Res. 2014;6(2):80-6.

68. Taman A, El-Beshbishi SN. Laboratory diagnosis of *Schistosomiasis mansoni*: Current status and future trends. Asian Pacific J Trop Med. 2019;12(6):243-9.
69. Omorodion AO, Goddey NOP, Clement IC, Ogbeneovo UD, Oijiangbe AA. Distribution of intestinal parasites among school-age children in Delta and Edo States of Nigeria. Parasitologist United J. 2012;5(2):121-26.
70. Sady H, Al-Mekhlafi HM, Atroosh WM, Al-Delaimy AK, Nasr NA, Dawaki S, et al. Knowledge, attitude, and practices towards schistosomiasis among rural population in Yemen. Parasit Vectors. 2015;8(1):1-13.
71. Abide M, Nibret E,Munshea A. Prevalence of intestinal helminthic infections and malnutrition among school children of the Zegie peninsula, Northwestern Ethiopia. J Infect Public Health. 2017;10(1):84-92.
72. Assaré RK, Hürlimann E, Ouattara M, N'Guessan NA, Tian‐Bi YNT, Yapi A, et al. Sustaining the control of *Schistosoma mansoni* in western Côte d'Ivoire: baseline findings before the implementation of a randomized trial. Am J Trop Med Hyg. 2016;94(2):352-60.
73. Morenikeji OA, Idowu BA. Studies on the prevalence of urinary schistosomiasis in Ogun State, South-Western Nigeria. West African J Med. 2011;30(1):62-5.
74. Linsuke S, Nundu S, Mupoyi S, Mukele R, Mukunda F, Kabongo MM, et al. High prevalence of *Schistosoma mansoni* in six health areas of—Kasansa health zone, Democratic Republic of the Congo: short report. PLoS Negl Trop Dis. 2014;8(12): e3387.
75. Mulatu G, Zeynudin A, Zemene E, Debalke S, Beyene G. Intestinal parasitic infections among children under five years of age presenting with diarrhoeal diseases to two public health facilities in Hawassa, South Ethiopia. Infect Dis Poverty. 2015;4:49.
76. Erismann S, Diagbouga S, Odermatt P, Knoblauch AM, Gerold J, Shrestha A, et al. Prevalence of intestinal parasitic infections and associated risk factors among schoolchildren in the Plateau Central and Centre-Ouest regions of Burkina Faso. Parasit Vectors. 2016;9(1):554.
77. WHO. World Health Organization: Guidelines for drinking-water quality. Geneva: World Health Organization. 2011.
78. Andreassen J, Bennet-Jenkins EM, Bryant C. Immunology and biochemistry of *Hymenolepis diminuta*. Adv Parasitol. 1999;42:223-75.
79. Weisse ME, Raszka WV. Jr. Cestode infection in children. Adv Paediatr Infect Dis. 1996;12:109-53.
80. Watwe S, Dardi CK. *Hymenolepis diminuta* in a child from rural area. Indian J Path Microbiol. 2008;51(1):149-50.
81. Karuna T, Khadanga S. A case of *Hymenolepis diminuta* in a young male from Odisha. Trop Parasitol. 2013;3(2):145-7.
82. Wiwanitkit V. Overview of *Hymenolepis diminuta* infection among Thai patients. MedGenMed. 2004;6(2):7.
83. Meles W, Merid I, Asfaw M. A study of the incidence of intestinal helminthic diseases and their risk factors among school Children in Lumame town, Northwest, Ethiopia. Afr J Parasitol Res 2015;2(10):152-60.
84. Golia S, Sangeetha KT, Vasudha CL. (2014). Prevalence of parasitic infections among primary school children in Bangalore. Int J Basic Appl Med Sci. 2014;4(1):356-61.
85. Turner WC, Getz WM. Seasonal and demographic factors influencing gastrointestinal parasitism in ungulates of Etosha National Park. J Wildlife Dis. 2010;46(4):1108-19.
86. Marshal JP, Krausman PR Bleich VC. Body condition of mule deer in the Sonoran Desert is related to rainfall. SouthWest Nationalist. 2008;53(3):311-18.
87. Fair JM, Whitaker SJ. Avian cell-mediated immune response to drought. Wilson J Ornithol. 2008;120(4):813-19.
88. Amaechi EC, Ohaeri CC, Ukpai OM. Prevalence of helminthiasis among school children in some rural communities of Abia State, Nigeria. Animal Res Int. 2013;10(3):1817-25.
89. Kiani, H., Haghighi, A., Rostami, A., Azargashb, E., Javad, S., Tabaei, S., Solgi, A. & Zebardast, N. (2016a). Prevalence, risk factors and symptoms associated to intestinal parasite infections among patients with gastrointestinal disorders in Nahavand, Western Iran. Revista do Instituto de Medicina Tropical de Sao Paulo, 58, 42.

90. Hailegebriel T. Prevalence of intestinal parasitic infections and associated risk factors among students at Dona Berber primary school, Bahir Dar, Ethiopia. BMC Infect Dis. 2017;17:362.
91. Abossie A, Seid M. Assessment of the prevalence of intestinal parasitosis and associated risk factors among primary school children in Chencha town, Southern Ethiopia. BMC Public Health. 2014;14(166):1-8.

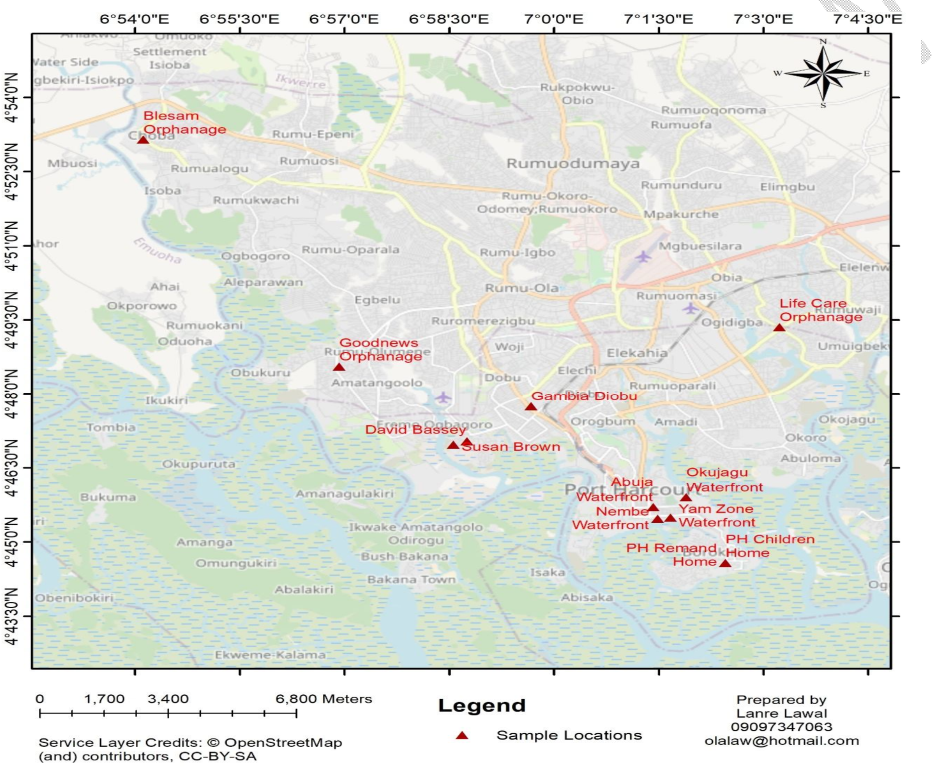

Fig 2: Sampling Points in Obio-Akpor and Port Harcourt LGAs.

Table 1: Demographic characteristics of respondents.

Variables	+ve cases N(%)	-ve cases N(%)	Total cases N(%)	*p*-value	Chi-square (X^2)
Sex					
Female	52(6.2)	785(93.8)	837(100)	0.006	7.6761
Male	67(10.1)	596(89.9)	663(100)		
Age					
1 - 5yrs	15(9.1)	150(90.9)	165(100)	0.001	30.0533
6 - 10yrs	23(8.1)	261(91.9)	284(100)		
11 - 15yrs	46(13.5)	294(86.5)	340(100)		
16 - 20yrs	15(9.3)	147(90.7)	162(100)		
21 - 25yrs	4(4.5)	85(95.5)	89(100)		
26 - 30yrs	4(3.8)	102(96.2)	106(100)		
31 - 35yrs	1(1.1)	87(98.9)	88(100)		
36 - 40yrs	4(4.1)	94(95.9)	98(100)		
41& above	7(4.2)	161(95.8)	168(100)		
Season					
Wet	103(14.0)	632(86.0)	735(100)	0.001	72.9466
Dry	16(2.1)	749(97.9)	765(100)		

Legends: +ve: Positive; -ve: Negative

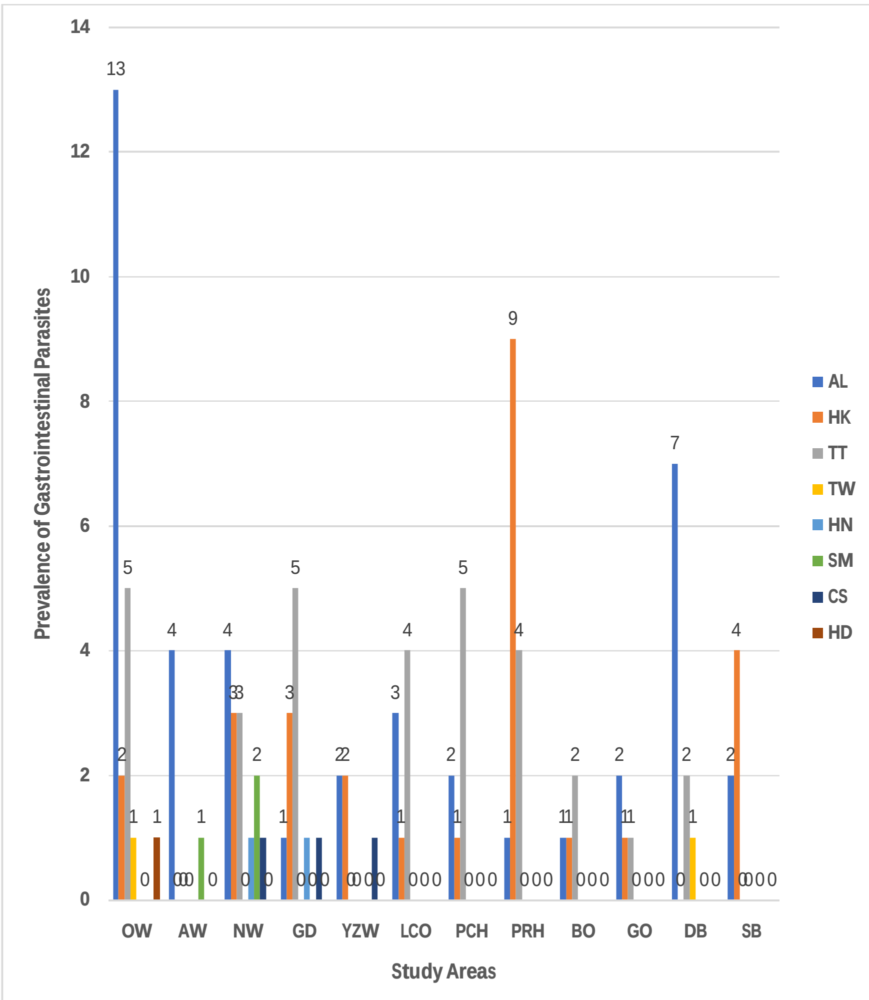

Fig 3: Characterization and identification of gastrointestinal parasites in the study areas.

Comment [a15]: To make the article more reader-friendly, my suggestion is for the author(s) to make fig3-fig 6 in tables, in order to prevent too much "0" in the figures

Legends: OW: Okujagu Waterfront; AW: Abuja Waterfront; NW: Nembe Waterfront; GD: Gambia Diobu; YZW: Yam Zone Waterfront; LCO: Life Care Orphanage; PCH: Port Harcourt Children Home; PRH: Port Harcourt Remand Home BO: Blesam Orphanage; GD: Goodnews Orphanage; DB: David Bassey; SB: Susan Brown; AL: *A. lumbricoides*; HK: Hookworm (*Ancylostoma duodenale/Necator americanus*); TT: *T. trichiura*; TW: Tapeworm; HN; *Hymenolepis nana*; SM; *Schistosoma mansoni*; CS; *Clonorchis sinensis*; HD: *Hymenolepis diminuta; p*>0.05

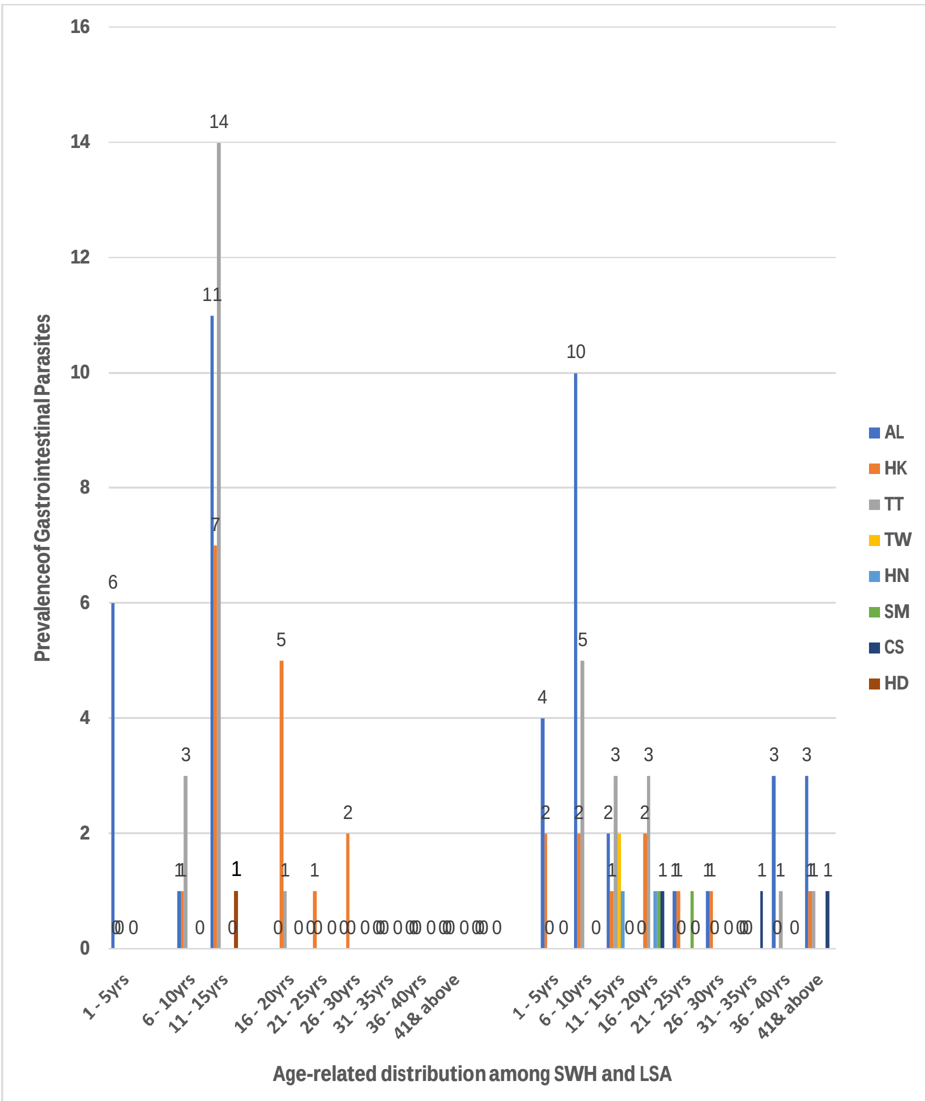

Fig 4: Age-related prevalence of GIPs among inmates of SWH and LSA

Legends: GIPs: Gastrointestinal Parasites; SWH: Social Welfare Homes; LSA: Low socio-economic Areas; AL: *A. lumbricoides*; HK: Hookworm (*Ancylostoma duodenale/Necator* *americanus*); TT: *T. trichiura*; TW: Tapeworm; HN; *Hymenolepis nana*; SM; *Schistosoma mansoni*; CS; *Clonorchis sinensis*; HD: *Hymenolepis diminuta; p*>0.05

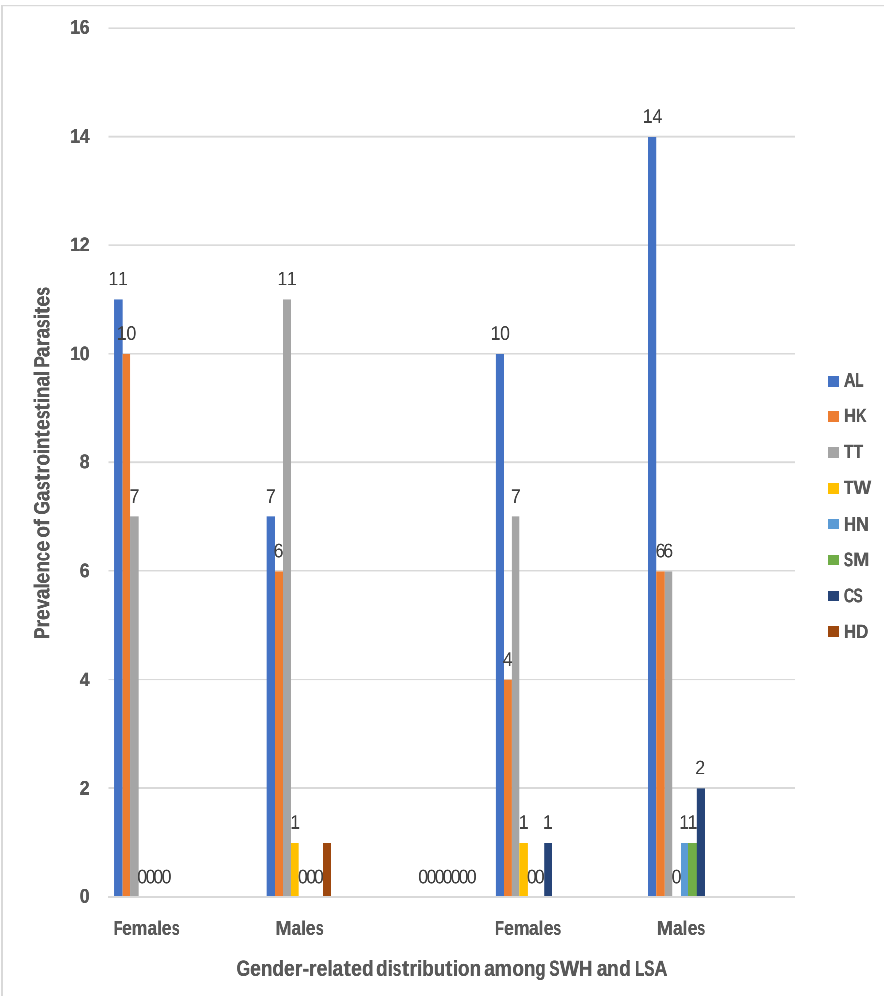

Fig 5: Gender-related prevalence of gastrointestinal parasites among the study population

Legends: SWH: Social Welfare Homes; LSA: Low Socio-economic Areas; AL: *Ascaris lumbricoides;* HK: Hookworm (*Ancylostoma duodenale/Necator americanus*); TT: *Trichuris* *trichiura;* TW: Tapeworm; HN; *Hymenolepis nana*; SM; *Schistosoma mansoni*; CS; *Clonorchis sinensis*; HD: *Hymenolepis diminuta; p*>0.05.

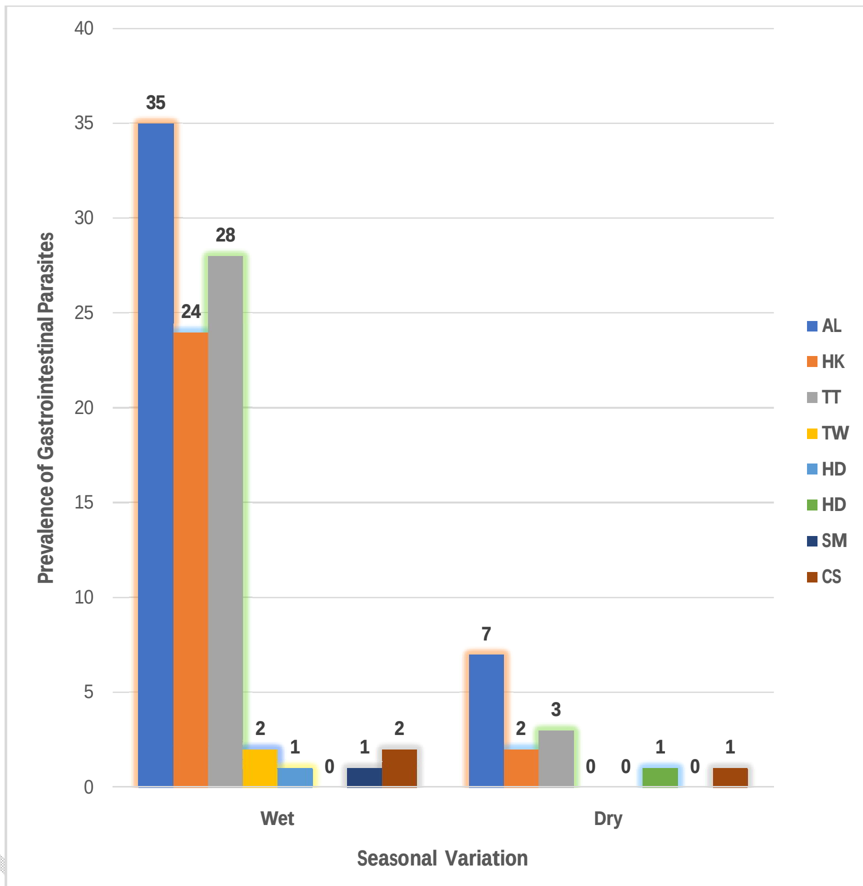

Fig 6: Prevalence of gastrointestinal parasites on the basis of season

Legends: AL: *Ascaris lumbricoides;* HK: Hookworm (*Ancylostoma duodenale/Necator americanus*); TT: *Trichuris trichiura;* TW: Tapeworm*;* HD: *Hymenolepis diminuta;* HN: *Hymenolepis nana;* SM: *Schistosoma mansoni;* CS: *Clonorchis sinensis*. *p*<0.05.

Table 2: Risk factors associated with transmission of gastrointestinal parasites in the study areas.

Variables	+ve cases N(%)	-ve cases N(%)	Total cases N(%)	*p*-value	Chi-square (X^2)
Use of drug in the last three months					
Yes	41(8.4)	445(91.6)	486(100)	0.618	0.2489
No	78(7.7)	936(92.3)	1014(100)		
Method of cooking vegetables					
Undercooked	36(7.6)	440(92.4)	476(100)	0.717	0.1309
Thoroughly	83(8.1)	941(91.9)	1024(100)		
Handwashing with soap					
Yes	72(9.1)	722(90.9)	794(100)	0.219	3.0344
No	47(6.7)	658(93.3)	705(100)		
Putting on shoes outside					
Yes	112(8.1)	1279(91.9)	1391(100)	0.544	0.3676
No	7(6.4)	102(93.6)	109(100)		
Contact with domestic animal					
Yes	13(5.1)	240(94.9)	253(100)	0.071	3.255
No	106(8.5)	1141(91.5)	1247(100)		
Washing hands after playing with soil					
Yes	101(7.7)	1204(92.3)	1305(100)	0.472	0.5166
No	18(9.2)	177(90.8)	195(100)		
Use of toilet paper					
Yes	46(17.6)	215(82.4)	261(100)	0.001	40.6309
No	73(5.9)	1166(94.1)	1239(100)		

Legend: +ve: Positive; -ve: Negative