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Prevalence of Soil-Transmitted Helminths and Protozoan Parasites' Infections Among Inmates in Nsukka Correctional Center, Enugu State, Nigeria

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Abstract

Intestinal parasitic infections, including protozoan and soil-transmitted helminths (STHs), are a major public health concern, especially in overcrowded correctional facilities with poor sanitation and limited access to clean water. However, data on their prevalence among inmates in Nigeria remain limited. This research investigated the prevalence of protozoan and STH infections among detainees at the Nsukka Correctional Center in Enugu State, Nigeria. A cross-sectional study involving 90 male inmates was conducted between March and August, 2023. Each participant provided feces in a well-labeled wide-mouthed sample collection bottles from which approximately 2g was analyzed using direct smear and formol-ether concentration techniques. Lugol's iodine was added to fresh specimens to improve visualization. Microscopy was performed at 10x and 40x magnifications. Overall, 66.7% of participants (60/90) were infected with at least one intestinal parasite. STH infections occurred in 23 inmates (25.6%), while 37 (41.1%) were infected with protozoa. Co-infections with STHs and protozoa were observed in six inmates (6.7%). The identified STHs were *Ascaris lumbricoides* (21.1%), *Strongyloides stercoralis* (5.6%), hookworms (2.2%), and *Trichuris trichiura* (1.1%), while the protozoans were *Entamoeba histolytica* (37.8%) and *Giardia lamblia* (8.9%). These findings highlight the substantial burden of parasitic infections in this correctional facility and underscore the urgent need for improved sanitation, hygiene practices, and health education to reduce transmission.

Keywords: Geohelminths, Prisoners, *Entamoeba histolytica*, *Giardia lamblia*, Hookworms, Roundworms, Threadworms, Whipworms.

Introduction

Soil-transmitted helminths (STHs), also known as geohelminths are cosmopolitan parasites found in developed and underdeveloped countries including sub-Saharan Africa (Mbuh et al., 2010; Frederick et al., 2021). Typical examples of these parasites are *Ascaris lumbricoides*, *Trichuris trichiura*, hookworms (*Necator americanus* and *Ancylostoma duodenale*), and *Strongyloides stercoralis* (Okwuonu et al., 2020). The life cycle of these parasitic nematodes is direct, requiring no intermediate hosts or vectors, thus contributing to their status as responsible for some of the most widespread chronic infections affecting humans globally (Ndenecho et al., 2002). More so, infection occurs when eggs or larvae present in warm, moist and contaminated soil are ingested by humans. Once ingested, these parasites inhabit the human intestine, where they compete for nutrients from the host to develop and reproduce, while leading to various health problems. It is estimated that nearly 25% of the global population (or approximately 2 billion people) in more than 100 countries are at risk of STH infection (Jourdan et al., 2017; Frederick et al., 2021). Alongside this, intestinal protozoan infections persist as major public health concerns, particularly in low- and middle-income countries within tropical and subtropical regions. The protozoan parasites, *Entamoeba histolytica* and *E. dispar* are estimated to infect roughly 10% of the global population, and potentially up to 50% in certain regions; while giardiasis, caused by the flagellated protozoa *Giardia lamblia*, affects about 20–30% of populations in many low- and middle-income countries (Bethony et al., 2006; Wale and Gedefaw, 2022). Such prevalence underscores the substantial geographic variability and high overall burden of intestinal protozoal and helminth infections (Chan et al., 1994; Bethony et al., 2006; Wale and Gedefaw, 2022). Nigeria, the most populous nation in sub-Saharan Africa, faces a high burden of STH infections, with estimates indicating 55 million cases of ascariasis, 34 million of trichuriasis, and 38 million of hookworm infections (De Silvas et al., 2003; Hotez et al., 2022). For example, previous studies have reported high infection prevalence in Nigerian correctional facilities, with 74.9% of inmates in Keffi Prison, Nasarawa State, Nigeria testing positive for parasitic infections (Amuga, 2006), 77.0% in Owerri Prison (Okolie, 2008) and 48.8% in Umuahia Prison (Lawrence et al., 2022). Prisoners are a particularly vulnerable population at an increased risk for STH and protozoan infections, primarily due to unsatisfactory sanitation and hygiene conditions in correctional facilities, overcrowding, restricted access to clean water, and inadequate personal hygiene practices, all of which enhance the transmission of these infections. The public health implications of STHs and intestinal protozoan infections are substantial, affecting millions of individuals, particularly those residing in economically-challenged nations (Turkeltaub et al., 2015). For incarcerated individuals, such infections can lead to significant acute and chronic health challenges, adversely affecting their overall well-being and quality of life. They may

also facilitate the spread of other infectious diseases, such as HIV and tuberculosis, within prison populations. As these intestinal protozoa and STHs persist and pose significant public health concerns in low- and middle-income countries, there remains a notable scarcity of epidemiological data, particularly in Nigerian prisons, where high congestion, lack of access to adequate healthcare, limited access to clean water and poor hygiene contribute to such risks. For these reasons, the current study focused on inmates at Nsukka Correctional Center. This study aimed to assess the prevalence of protozoan and STH infections among inmates at Nsukka Correctional Center in Enugu State, Nigeria. The objectives were to determine the prevalence and intensity of soil-transmitted helminths and protozoan parasites.

Materials and methods

Study area

This study was conducted at the Nsukka Correctional Center, commonly known as Nsukka Prison, located within Nsukka town in Enugu State, Nigeria between March and August 2023. A correctional institution is dedicated in providing the detention and rehabilitation of offenders. The town is part of the Udi Hills region, with an approximate elevation of 1,300 feet (396 meters). Nsukka is geographically surrounded by Edem, Obimo, and Ede-Oballa, with an extension into the Opi community. Covering a substantial area, it is situated at coordinates 6°51'28.19" N latitude and 7°23'44.77" E longitude, with a population of 309,633 residents as per the 2006 national census, projected forward to 485,000 in 2025 using a 2.5% annual growth rate. The choice of this study area was motivated by the various challenges faced by inmates, including exposure to open defecation, walking barefoot in unsanitary environments, and residing in conditions susceptible to infections due to poor environmental management practices.

Study design and sample size determination

A cross-sectional study design was used to assess the prevalence and intensity of gastrointestinal parasite infections among male inmates in Nsukka Prison. The facility at the time of study accommodated approximately 300 male inmates. Based on a population size of 300, the sample size was estimated using Slovin's formula (Slovin, 1960): $n = N / (1 + N e^2)$, Where: n, required sample size; N, population size; e, acceptable margin of error (0.05 for 5%). The estimated sample size was 171. However, a total of 90 male prisoners who were randomly sampled, irrespective of their cell locations volunteered for the study. The age of the study participants ranged from 19 to 52 years.

Ethical considerations

The study was conducted per the ethical guidelines established by the Committee on Human Experiments and aligned with the Declaration of Helsinki (as revised in 2008). The Enugu State

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Ministry of Health granted ethical approval for this research, designated under the Ethical Number MH/MSD/REC21/397. Before sampling, relevant authorities, including the Nsukka Prison Service Department, were contacted and granted permission following a clear explanation of the study's objectives. Participants were thoroughly informed about the nature and purpose of the research and the type of information requested before sample collection. They were also assured of the confidentiality and anonymity of their responses, which would be solely used for research purposes. This approach was intended to protect participants' rights and well-being, thereby ensuring the study's ethical integrity and overall credibility.

Sample collection

Fecal specimens were obtained from the participants for parasitological analysis. Each inmate was provided a fresh, well-labeled wide-mouthed plastic container, equipped with a spatula, for the collection of early morning stool samples. Clear instructions were provided to the participants to ensure correct collection procedures and prevent contamination. Stool samples were collected from the 90 participants in the morning hours and transported to the laboratory for detailed examination. The samples were initially visually assessed to determine whether they were diarrheic (watery) or normal (well-formed). For samples that were not immediately analyzed, 10% formalin was added as a preservative to maintain sample integrity.

Laboratory examination of fecal samples

The laboratory analysis of fresh fecal samples encompassed both macroscopic and microscopic evaluations. The macroscopic examination aimed to identify visible indicators such as blood, mucus, adult helminths, and segmented tapeworms. A microscopic examination was conducted to detect parasitic eggs, larvae, unembryonated eggs, and cysts (Gardner, 1996). Two parasitological techniques were employed: the direct fecal smear method and the formol-ether sedimentation procedure.

Direct smear method

Slides were prepared by adding a small amount of water to create a moist environment, facilitating the visualization of helminth eggs or larvae. A portion of the fecal sample was carefully applied to the slide, ensuring the transfer of any parasitic forms present. The slides were then examined microscopically at both low ($\times 10$) and high ($\times 40$) magnifications. Key morphological features, such as size, shape, and coloration of helminth eggs, larvae, and protozoan cysts were assessed to identify and differentiate among parasite species.

Formol-ether concentration technique

The formol-ether concentration method was used to detect parasite eggs and cysts in the stool samples. Approximately 1 gram of stool was thoroughly emulsified with an applicator in 3 ml of 10% formol saline solution contained in a 15 ml test tube. An additional 3 ml of the same solution was then added to the mixture. The contents were subsequently mixed vigorously to ensure effective emulsification, facilitating the subsequent concentration of parasitic stages for microscopic examination.

Data analysis

Data were analyzed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Prevalence and intensity of infection were estimated using chi-square tests.

Results

Overall prevalence

A total of 90 inmates with mean age 32.01 years (SD \pm 8.31), with ages ranging from 19 to 52 years was sampled. Out of the total 90 participants, 60 (66.7%) individuals, were found to be infected with at least one STH or protozoan parasite. Statistical analysis indicated that there were no significant differences in infection prevalence across the different age groups ($\chi^2 = 1.035$, df = 2, $p = 0.596$) (Table 1). A notably higher prevalence of *A. lumbricoides* infection was observed among prisoners aged 25 years or younger, with an infection prevalence of 58.3%, which was significant compared to other age groups ($\chi^2 = 27.954$, df = 2, $p < 0.001$). Only two people had hookworm infection, one inmate from each of the age groups 26–40 years and >40 years. Additionally, the prevalence of *Entamoeba histolytica* was approximately twice as high in prisoners >40 years of age compared to the other age groups ($\chi^2 = 5.894$, df = 2, $p = 0.052$) (Table 1). The parasite isolates consisted primarily of ova from various helminth species, with the exception of *Strongyloides stercoralis*, which was identified by larvae. Protozoan isolates were characterized by the presence of cysts. A summary of infection intensity is presented in Table 2. The majority of helminth infections were categorized as mild or low in intensity.

Parasite species prevalence

The parasitic infections identified encompassed both helminths and protozoan. Helminth infections were present in 23 individuals (25.6%), while protozoan infections were detected in 37 individuals (41.1%) (Figures 1A and 1B). Co-infections, reflecting simultaneous infections with both helminths and protozoans, were observed in six individuals, accounting for 6.7% of the study population. *Ascaris lumbricoides*, with a prevalence of 21.1%, was the most frequently detected helminth, while *Entamoeba histolytica*, at 37.8%, was the most common protozoan infection (Table 2). Plates 1–6 are representative images of the isolated parasites

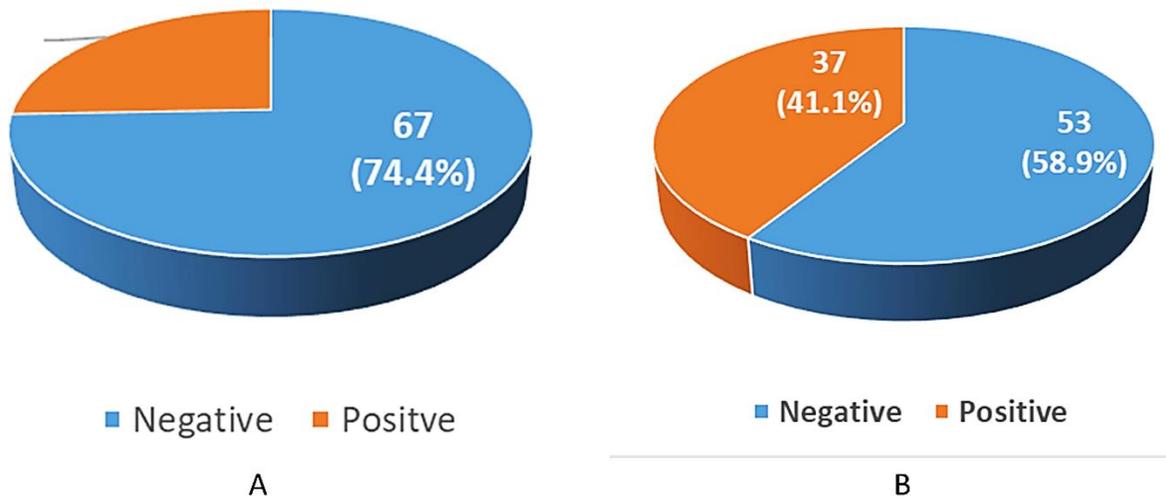


Figure 1: Prevalence of gastrointestinal (A) helminths, and (B) protozoan parasites among prisoners in Nsukka Correctional Facility, Nsukka, Enugu State



Plate 1: Fertilized eggs of *Ascaris lumbricoides*



Plate 3: Hookworm larva



Plate 5: *Entamoeba histolytica* cyst



Plate 2: Larva of *Strongyloides stercoralis*



Plate 4: *Trichuris trichuria* ova

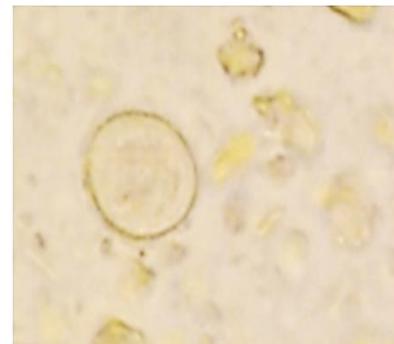


Plate 6: *Giardia lamblia*

Figure 2: Gastrointestinal helminth and protozoan species

Table 2: Prevalence and intensity of gastrointestinal helminth and protozoan species among prisoners in Nsukka Correctional Facility, Nsukka, Enugu State

Parasite	Number infected (%)	Intensity		
		+	++	+++
Helminth	23 (25.6)			
<i>Ascaris lumbricoides</i>	19 (21.1)	18 (20.0)	1 (1.1)	0 (0.0)
Hookworm	2 (2.2)	2 (2.2)	0 (0.0)	0 (0.0)
<i>Trichuris trichuria</i>	1 (1.1)	1 (1.1)	0 (0.0)	0 (0.0)
<i>Strongyloides stercoralis</i>	5 (5.6)	5 (5.6)	0 (0.0)	0 (0.0)
Protozoa	37 (41.1)			
<i>Entamoeba histolytica</i>	34 (37.8)	17 (18.9)	11 (12.2)	6 (6.7)
<i>Giardia lamblia</i>	8 (8.9)	8 (8.9)	0 (0.0)	0 (0.0)

Key: + mild; ++ moderate; +++ severe

Discussion

The research conducted revealed a high prevalence of 66.7% for intestinal parasite infections among the study population. This is notably higher than the 49% reported in Omdurman Prison, Sudan (Rasha *et al.*, 2011), and the 48.8% documented by Lawrence *et al.* (2022) in Umuahia, Abia State, Nigeria. Additionally, it surpasses the 42.6% prevalence found among inmates in Mekelle Prison, North Ethiopia (Mardio *et al.*, 2019), the 33.5% observed in the Central Prison of Conakry, Guinea (Kadio *et al.*, 2021), and the 32.8% reported among Malaysian prison inmates (Colman *et al.*, 2013). However, this study's prevalence is lower than the 72.7% noted in a North Central Ethiopian prison (Mamo, 2014), 74.9% in Keffi Prison, Nassarawa State, Nigeria (Amuga, 2006), and 77.0% in Owerri Prison (Okolie, 2008). Variations in the prevalence of gastrointestinal parasites across different prison settings may stem from factors such as participant numbers, sanitary conditions, laboratory methodologies, climate, and environmental variables (Mardu *et al.*, 2019). Generalizability of these findings is limited. Prison environments differ widely by country and facility in crowding, sanitation, and inmate behavior, so the observed prevalence may not reflect other populations. Study design, sample size, diagnostic methods, and the age and sex distribution of participants also constrain extrapolation. Accordingly, interpretation should be contextual and cautious, with replication across varied detention settings using standardized methods to support broader conclusions. Broad patterns—such as protozoan predominance and age-related trends—could inform similar settings with poor hygiene, but applying exact prevalence figures to different groups risks misestimation. Variation in site prevalence may stem from factors like recent mass deworming campaigns, sanitation improvements, or shorter incarceration durations that reduce exposure. Differences in sampling and diagnostics, as well as seasonal effects, can yield divergent results. Inmate health-seeking behavior, prior deworming, and healthcare access can bias findings. Geographic, climatic, and ecological contexts shape parasite distribution; some prisons may show lower prevalence due to effective public health measures or

intake practices. Beyond overall prevalence, we encountered a higher burden of intestinal protozoa (41.1%) compared to helminth infections (25.6%). This finding aligns with research conducted among inmates at Ouagadougou Prison in Burkina Faso (Zida *et al.*, 2014). The distinct transmission modes of intestinal protozoa and helminths may elucidate these differences; for instance, hookworm and *Strongyloides stercoralis* infections necessitate skin contact with contaminated soil. Given the limited physical activities of inmates, the likelihood of contracting intestinal helminthic infections is reduced. In contrast, intestinal protozoa typically spread through the fecal-oral route, and some helminths (such as *Trichuris trichiura* and *Ascaris lumbricoides*) require environmental maturation. Thus, auto-infections of protozoa among inmates may occur more frequently. Furthermore, intestinal protozoa replicate within their human hosts, unlike helminths, which may lead to instances where the latter is undetectable when present in low numbers. In the present investigation, *Entamoeba histolytica* emerged as the most frequently detected intestinal protozoan, accounting for 37.8% of cases, with *Giardia lamblia* ranking second at 8.9%. The prominence of *E. histolytica* aligns with findings from other studies involving gastrointestinal parasites in the prison population of Omdurman (Rasha *et al.*, 2011) and general intestinal parasitic infections in Northern Ethiopia (Feleke *et al.*, 2017). The presence of these parasites, including *G. lamblia*, indicates poor hygiene conditions within the prison environment. A high rate of *A. lumbricoides* was observed among prisoners who are 25 years old or younger, at 58.3%. This age-related gap in *A. lumbricoides* prevalence aligns with prior findings that identify the parasite as particularly common in Nigeria (Amuga, 2006, Okolie, 2008, Lawrence *et al.*, 2022). Transmission generally occurs by ingesting infective eggs, which can happen when contaminated hands touch the mouth or via unwashed fruit. *A. lumbricoides*, a soil-transmitted helminth, thrives in areas with poor sanitation. Younger inmates may originate from communities with higher childhood transmission, leading to either latent, patent, or recently acquired infections at intake. In some places, transmission remains active in households or neighborhoods, and younger

individuals might return to riskier routines (shared latrines, outdoor activities) more often than older inmates who may have altered living conditions or safer practices. Younger prisoners may have more contact with contaminated hands or objects because hygiene facilities are limited or crowded; differences may also stem from greater participation by younger inmates in unsanctioned activities that raise exposure or varying health literacy. Younger inmates might depend more on communal meals or informal sharing networks where contamination can spread. Partial immunity and nutritional status, which can influence susceptibility and worm burden, may also differ by age. *Entamoeba histolytica* showed a higher prevalence in prisoners between 26 and 40 years old, roughly double that of younger groups, though the result did not reach statistical significance ($\chi^2 = 5.894$, $df = 2$, $p = 0.052$). Several factors could explain this pattern. Older inmates might have accumulated exposure over time or reflected sustained transmission in their communities prior to incarceration, leading to persistent infections. Alternatively, age-related differences in immunity or gut microbiota could modulate susceptibility and parasite establishment. Within-prison dynamics, such as differential healthcare access, prior deworming, or coexisting conditions, may also influence detection. The near-significant p-value suggests a potential trend worth exploring with larger samples to account for confounders like hygiene, housing conditions, and duration of incarceration. The high rates of intestinal parasites observed among inmates in this study underscore the urgent need for enhanced sanitation and hygiene practices within prison facilities. Improving these conditions could alleviate the prevalence of parasitic infections among prisoners and potentially diminish the risk of transmission to the broader community, as these infections impact not only the incarcerated population but also public health at large. For instance, infections by helminths can lead to nutritional deficiencies and hinder growth in children, while protozoan parasites like *Giardia* may contribute to diarrhea outbreaks within the community. There is a crucial requirement for increased surveillance and monitoring of parasitic infections within prison settings, enabling timely and appropriate interventions. Such a strategy could facilitate the identification of changes in infection prevalence over time and evaluate the effectiveness of implemented measures. Additionally, regular laboratory testing coupled with prompt treatment, along with educational initiatives focused on the transmission and prevention of intestinal parasitic infections, would greatly enhance the health outcomes for inmates.

Conclusion

In conclusion, the study reveals a high parasite burden among prisoners, with intestinal protozoa (41.1%) and helminths (25.6%), implying fecal-oral transmission tied to prison hygiene. The younger inmates (≤ 25) bore a heaviest load of *Ascaris lumbricoides* (58.3%), signaling age-related

vulnerability linked to living conditions and sanitation. To address these challenges posed by this high burden of STHs and intestinal protozoan infection among the prison inmates there is need for implementation of sanitation upgrades, routine quarterly stool screening with prompt treatment guidelines, and an integrated targeted parasite-control program. Hygiene education should be emphasized, environmental risk mitigated (water quality, waste management), and overcrowding reduced at the facilities.

Conflict of interest

The authors declare that they have no conflicts of interest.

Author contribution

EJC and NCC conceived the study; AION conducted data analysis and interpretation, while NCC and AEC gathered and organized the data. NCC drafted the initial version of the manuscript. OES, NGI, NIA, and AJM participated in reviewing and commenting on the draft. All authors approved the manuscript for publication after review.

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Table 1: Prevalence of parasite species by age groups of prisoners in Nsukka Correctional Facility, Nsukka, Enugu State

	Age group (years)	Number examined	Number infected (%)
Overall prevalence of gastrointestinal parasite	≤ 25	24	18 (75.0)
	26 – 40	50	32 (64.0)
	> 40	16	10 (62.5)
		90	60 (66.7)
			$\chi^2 = 1.035, df = 2, p = 0.596$
Helminth			
<i>Ascaris lumbricoides</i>	≤ 25	24	14 (58.3)
	26 – 40	50	5 (10.0)
	> 40	16	0 (0.0)
			$\chi^2 = 27.954, df = 2, p < 0.001$
Hookworm	≤ 25	24	0 (0.0)
	26 – 40	50	1 (2.0)
	> 40	16	1 (6.3)
			$\chi^2 = 1.751, df = 2, p = 0.417$
<i>Trichuris trichuria</i>	≤ 25	24	0 (0.0)
	26 – 40	50	1 (2.0)
	> 40	16	0 (0.0)
			$\chi^2 = 0.809, df = 2, p = 0.667$
<i>Stroglyoia stercoralis</i>	≤ 25	24	1 (4.2)
	26 – 40	50	3 (6.0)
	> 40	16	1 (6.3)
			$\chi^2 = 0.122, df = 2, p = 0.941$
Protozoa			
<i>Entamoeba histolytica</i>	≤ 25	24	6 (25.0)
	26 – 40	50	18 (36.0)
	> 40	16	10 (62.5)
			$\chi^2 = 5.894, df = 2, p = 0.052$
<i>Giardia lamblia</i>	≤ 25	24	1 (4.2)
	26 – 40	50	7 (14.0)
	> 40	16	0 (0.0)
			$\chi^2 = 3.835, df = 2, p = 0.147$

Significance at $p \leq 0.05$