

## REINFECTION DYNAMICS OF GEOHELMINTHS AMONG INTERNALLY DISPLACED PERSONS IN A CAMP IN NORTH-CENTRAL NIGERIA.

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### **Author's contributions**

*This study was a collaborative effort of the author. The authors reviewed and approved the final version of the manuscript for publication.*

### **Article Information**

**DOI:** <https://doi.org/10.60787/fpj.vol3no5.121>

EISSN 1596-0501E



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**CITATION:** Ene Chidiebere Brown (2026). Reinfection dynamics of geohelminths among internally displaced persons in a camp in North-Central Nigeria. *Frontline Professionals Journal* 3(5), 123-129

### **ABSTRACT**

Geohelminths, also known as soil-transmitted helminths (STHs), remain a persistent public health challenge in internally displaced persons (IDP) settings, where overcrowding, poor sanitation, and environmental contamination sustain continuous transmission cycles. Although anthelmintic mass drug administration (MDA) is widely implemented as recommended by the World Health Organisation, persistence and/or early reinfection following treatment continues to undermine long-term control, particularly in high-transmission humanitarian contexts. This study assessed the short-term dynamics of geohelminth infection following anthelmintic MDA among school-aged children residing in an IDP camp in North-Central Nigeria. A prospective observational study was conducted among 112 school-aged children (5–14 years) with confirmed geohelminth infections. Each participant provided two stool samples: one at baseline before treatment and a second sample collected 21 days post-treatment. Samples were analyzed using the Kato-Katz technique to determine prevalence and infection intensity (eggs per gram of faeces, EPG). At baseline, 112 stool samples were collected from 112 children, all of whom had confirmed geohelminth infections. *Ascaris lumbricoides* was the most prevalent species (61.61%; 69/112), followed by hookworms (38.39%; 43/112), while *Trichuris trichiura* had the lowest prevalence (3.57%; 4/112). Following albendazole administration, a second assessment conducted 21 days post-treatment demonstrated marked reductions in prevalence: *A. lumbricoides* declined to 20.53% (23/112), and hookworms to 11.60% (13/112), while *T. trichiura* was not detected. Infection intensity also decreased substantially across all species. Despite these reductions, persistence and/or early reinfection of *A. lumbricoides* and hookworms was observed, indicating ongoing transmission within the study environment. Anthelmintic MDA significantly reduced geohelminth prevalence and infection intensity in the short term; however, persistence and/or early reinfection, particularly for *Ascaris lumbricoides* and hookworms, limit the sustainability of control in IDP camp environments. These findings highlight the need for integrated strategies combining repeated MDA, improved water, sanitation, and hygiene (WASH) interventions, and expanded population coverage to achieve sustained interruption of transmission.

**Keywords:** Reinfection, dynamics, geohelminths, Nigeria, transmission

## INTRODUCTION

Geohelminths, also known as soil-transmitted helminths (STHs), are intestinal nematode infections acquired through contact with contaminated environments. Transmission occurs either via ingestion of embryonated eggs present in contaminated soil, food, or water or through direct skin penetration by infective larvae. The major species of public health importance include *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms (*Necator americanus* and *Ancylostoma duodenale*), all of which are strongly associated with inadequate sanitation, poor hygiene practices, and limited access to safe water (World Health Organisation, 2022; Ca *et al.*, 2024). These infections remain among the most persistent neglected tropical diseases globally, disproportionately affecting populations living under conditions of poverty, overcrowding, and infrastructural deprivation (Sartorius *et al.*, 2021). The global burden of STH infection remains substantial, with an estimated 1.5 billion people infected worldwide, including nearly 800 million children. The health consequences extend beyond intestinal morbidity and include chronic iron-deficiency anaemia, protein-energy malnutrition, stunted growth, and impaired cognitive development. In school-aged children, these outcomes translate into reduced academic performance and long-term productivity losses, thereby reinforcing cycles of poverty in endemic settings. Children aged 5–14 years are particularly vulnerable due to frequent exposure to contaminated environments and inconsistent hygiene practices, especially where access to water and sanitation is limited (Oyeyemi & Okunlola, 2023; World Health Organization, 2022). In response to this persistent burden, the World Health Organization recommends periodic preventive chemotherapy through mass drug administration (MDA) in endemic regions. This strategy involves the administration of broad-spectrum anthelmintics such as albendazole without prior individual diagnosis, with the goal of reducing worm burden, preventing morbidity, and interrupting transmission. Albendazole remains the cornerstone of STH control programs due to its affordability, ease of administration, and favorable safety profile. Its mechanism of action involves inhibition of microtubule polymerization in helminths, leading to impaired glucose uptake, energy depletion, and parasite death (Montresor *et al.*, 2020). Despite its widespread use and documented short-term effectiveness, some studies suggest variable efficacy of albendazole against certain species, particularly *Trichuris trichiura*. This has raised concerns regarding possible reduced drug susceptibility in human populations. More importantly, reductions in prevalence and infection intensity observed after treatment are often transient in endemic environments where environmental contamination remains high, and re-exposure is continuous (Montresor *et al.*, 2020).

In Nigeria and across sub-Saharan Africa, STH infections remain highly endemic, with *Ascaris lumbricoides* and hookworm species consistently reported as the dominant infections in affected populations (Alemu *et al.*, 2022; Tee *et al.*, 2022). Although MDA programs have contributed to reductions in overall worm burden, their long-term effectiveness is frequently undermined by rapid re-exposure to infective stages in the environment. This challenge is particularly pronounced in internally displaced persons (IDP) settings, where overcrowding, inadequate sanitation, unsafe water supply, and disrupted healthcare systems create ideal conditions for continuous transmission. Previous studies conducted in similar IDP settings in Benue State have reported high baseline prevalence of STH infections and demonstrated moderate short-term efficacy of albendazole MDA in reducing infection burden. However, these studies also highlighted concerns regarding sustained control, particularly in environments where transmission pressure remains high (Brown *et al.*, 2025). This underscores the need to move beyond short-term efficacy assessments and instead evaluate post-treatment infection dynamics as a more meaningful indicator of intervention impact in such settings. Understanding these dynamics is therefore essential for assessing the true effectiveness of MDA programs. Unlike conventional evaluations that focus primarily on immediate post-treatment cure rates and egg reduction, follow-up studies provide critical insight into ongoing transmission, environmental contamination, and the sustainability of control interventions. However, such evidence remains limited, particularly in humanitarian and displacement settings where transmission intensity is expected to be high and control measures are often fragmented. Against this backdrop, the present study investigates the short-term dynamics of geohelminth infections following anthelmintic mass drug administration among internally displaced persons residing in a camp in North Central Nigeria. Specifically, it examines baseline infection patterns, evaluates the short-term impact of albendazole treatment, and assesses patterns of persistence and/or early reinfection within 21 days post-treatment. The findings are expected to inform more integrated control strategies that combine periodic chemotherapy with strengthened water, sanitation, and hygiene (WASH) interventions for sustainable reduction of infection in vulnerable populations.

## METHODS

### Study Design, Setting, and Population

This study employed a prospective observational design conducted between April and May 2024 to evaluate the dynamics of geohelminth infection following anthelmintic mass drug administration (MDA). The study was carried out in the Ikyogen Internally Displaced Persons (IDP) Camp, located in Kwande Local Government Area, Benue State, North-Central Nigeria. The camp, originally established as the Ikyogen Cattle Ranch, currently hosts over 13,000 individuals, predominantly Cameroonian refugees. It is characterized by high population density, overcrowded living conditions, and limited water, sanitation, and hygiene (WASH) infrastructure, creating conditions conducive to sustained transmission of Soil-transmitted helminth infections (Omotola & Ofoezie, 2019). The study population comprised school-aged children (5–14 years), a group recognized as particularly vulnerable to infection due to increased environmental exposure and suboptimal hygiene practices. The diagnostic and treatment procedures used in this study followed previously established protocols in the same setting, including stool examination using the Kato-Katz technique and administration of a single 400 mg dose of albendazole under direct observation (Brown *et al.*, 2025).

### Sampling Technique

A simple random sampling technique was employed. A sampling frame was developed from the camp's community health register, from which eligible participants were selected. Only children with confirmed geohelminth infection at baseline were included in the follow-up component of the study.

### Inclusion and Exclusion Criteria

#### Inclusion Criteria

Children aged 5–14 years

Residency in the IDP camp for at least one year

Provision of informed consent by caregivers

#### Exclusion Criteria

Age below 5 years or above 14 years

Presence of comorbid conditions (e.g., lymphatic filariasis)

Active diarrhoea at the time of recruitment

Vomiting within four hours following drug administration

Inability to provide complete stool samples or attend follow-up

### Sample Size Determination

The minimum sample size was calculated using the standard formula:  $N = (Z^2 \times p \times q) / d^2$

Where:

Z = (95% confidence level)

P = estimated prevalence from previous Nigerian studies)

Q = 1-p

D = (margin of error)

After adjusting for a 10% non-response rate, the final sample size was 112 participants (Gebreyesus *et al.*, 2024).

### Anthelmintic Drug Administration

Each participant received a single 400 mg chewable dose of albendazole administered under direct observation. A light meal was provided before administration to minimize gastrointestinal discomfort. Participants were monitored for approximately four hours post-treatment, and any child who vomited within this period was excluded from analysis.

### Parasitological Examination

Each participant provided two stool samples: one at baseline before treatment and a second sample collected 21 days post-treatment. Samples were analyzed using the Kato-Katz thick smear technique for quantitative determination of eggs per gram (EPG) of faeces in accordance with WHO guidelines (World Health Organization, 2017). All hookworm slides were examined within 60 minutes of preparation to prevent egg degeneration and ensure accurate quantification.

### Quality Control

To ensure diagnostic reliability, a subset of slides was randomly selected and re-examined independently by an experienced parasitologist. Any discrepancies in egg counts were resolved through consensus review.

### Follow-Up and Assessment of Persistence and/or Early Reinfection

A structured follow-up assessment was conducted 21 days post-treatment. Only participants who were positive at baseline were included in this analysis. Given the short follow-up period, outcomes were interpreted as persistence and/or early reinfection, defined as the detection of parasite eggs following treatment. Comparisons between baseline and follow-up parasitological indices were conducted in accordance with WHO recommendations for monitoring STH control programs (World Health Organization, 2014).

### Follow-Up and Reinfection Assessment

A structured follow-up was conducted 21 days post-treatment to evaluate reinfection dynamics. Only participants who were positive at baseline were included in the reinfection analysis. Those absent during scheduled follow-up were revisited within 48 hours to minimize loss to follow-up bias. Reinfection was defined based on the reappearance of parasite eggs following documented clearance after treatment. Reinfection prevalence and intensity were assessed in accordance with World Health Organization recommendations for post-treatment evaluation of STH control programs (WHO, 2014), with comparisons made between baseline and follow-up parasitological indices.

## RESULTS

A total of 289 stool samples were collected during the study, reflecting repeated sampling of the same cohort of 112 school-aged children at two time points (baseline and 21 days post-treatment). At baseline, all 112 children (39%) were positive for at least one soil-transmitted helminth (STH) infection.

### Baseline Prevalence of Soil-Transmitted Helminths

At baseline, *Ascaris lumbricoides* was the most prevalent infection, accounting for 61.61% (69/112) of cases. Hookworm infection was observed in 38.39% (43/112), while *Trichuris trichiura* had the lowest prevalence at 3.57% (4/112).

**Table 1: Baseline Prevalence of Soil-Transmitted Helminths**

Parasite Species	Prevalence (%)	Number Infected (n = 112)
<i>Ascaris lumbricoides</i>	61.61	69
Hookworm	38.39	43
<i>Trichuris trichiura</i>	3.57	4

### Post-Treatment Changes (21-Day Follow-Up)

Following albendazole administration, a marked reduction in the prevalence of all geohelminth species was observed.

- *Ascaris lumbricoides* decreased from 61.61% to 20.53% (23/112)
- Hookworm infections reduced from 38.39% to 11.60% (13/112)
- *Trichuris trichiura* was eliminated (0.00%)

However, persistence and/or early reinfection of *A. lumbricoides* and hookworm infections were observed, indicating continued transmission within the study environment.

**Table 2: Prevalence Before and After Treatment**

Parasite Species	Baseline (%) (n/112)	21 Days Post-Treatment (%) (n/112)
<i>Ascaris lumbricoides</i>	61.61 (69/112)	20.53 (23/112)
Hookworm	38.39 (43/112)	11.60 (13/112)
<i>Trichuris trichiura</i>	3.57 (4/112)	0.00 (0/112)

### Intensity of Infection (Eggs per Gram of Faeces)

A substantial reduction in infection intensity was recorded across all parasite species following treatment.

- *Ascaris lumbricoides*: 429,349 → 106,032 EPG
- Hookworm: 29,973 → 4,485 EPG
- *Trichuris trichiura*: 854 → 0 EPG

**Table 3: Intensity of Infection (EPG)**

Parasite Species	Baseline (EPG)	21 Days Post-Treatment (EPG)
<i>Ascaris lumbricoides</i>	429,349	106,032
Hookworm	29,973	4,485
<i>Trichuris trichiura</i>	854	0

### Summary of Findings

Albendazole mass drug administration resulted in substantial reductions in both prevalence and infection intensity of soil-transmitted helminths within the short follow-up period. The greatest reduction was observed for *Trichuris trichiura*, which was completely cleared. Despite these reductions, *A. lumbricoides* and hookworm infections persisted at 21 days post-treatment, suggesting either incomplete parasite clearance or early reinfection in a high-transmission environment.

Overall, these findings indicate that while chemotherapy significantly reduces infection burden in the short term, sustained transmission continues in the study setting.

### DISCUSSION

The present study provides a detailed evaluation of the short-term reinfection dynamics of soil-transmitted helminths (STHs) following anthelmintic mass drug administration (MDA) in a highly vulnerable internally displaced population. While earlier findings from the same setting demonstrated significant reductions in infection intensity following albendazole MDA (Brown *et al.*, 2025), the current study extends this evidence by showing that such gains are not sustained over time in a persistently high-transmission environment. Although marked reductions in both prevalence and infection intensity were achieved following treatment, the reappearance of infections within 21 days highlights the complex interplay between drug efficacy, environmental contamination, and continuous exposure in IDP settings.

A key observation is the reduction in prevalence of *Ascaris lumbricoides* and hookworm infections shortly after treatment. However, the persistence of positive cases at follow-up suggests ongoing transmission dynamics. These findings may reflect either incomplete parasite clearance or early reinfection, particularly given the short 21-day observation period, which limits definitive separation of these two processes. In settings with high environmental contamination, both mechanisms are biologically plausible and may occur concurrently (Jia *et al.*, 2012; Sartorius *et al.*, 2021). The observed cure rates for *A. lumbricoides* (66.7%) and hookworm (53.5%) are below the World Health Organisation-recommended efficacy thresholds of  $\geq 95\%$  and  $\geq 90\%$ , respectively (World Health Organisation, 2017). This discrepancy should be interpreted cautiously, as reduced post-treatment positivity may not necessarily indicate primary drug failure. Still, it may also reflect rapid re-exposure and reinfection in highly contaminated environments. Previous studies have similarly reported variable efficacy of albendazole in endemic settings, particularly where transmission intensity remains high (Montresor *et al.*, 2020; Bekele *et al.*, 2024).

In contrast, the complete clearance of *Trichuris trichiura* (100%) aligns with WHO expectations, although WHO guidelines indicate a lower efficacy threshold of  $\geq 50\%$  for this species (World Health Organisation, 2017). This result may be influenced by the low baseline prevalence and low infection intensity, as lighter worm burdens are generally more responsive to treatment (Tee *et al.*, 2022). Therefore, interpretation should consider baseline epidemiological conditions rather than the treatment effect alone. Species-specific patterns observed in this study are consistent with known biological characteristics of STHs. *Ascaris lumbricoides* remained the most persistent infection post-treatment, likely due to the high environmental resilience of its eggs, which can survive for extended periods under adverse conditions (Sartorius *et al.*, 2021). Hookworm persistence may be attributed to continued exposure through skin contact with contaminated soil, particularly in settings where footwear use is inconsistent (Ca *et al.*, 2024). These findings reinforce the role of environmental contamination as a major driver of ongoing transmission.

From a programmatic perspective, the results suggest that current MDA schedules may not be sufficient in high-transmission humanitarian settings. However, it is important to note that chemotherapy alone may be insufficient in such high-transmission settings, particularly where environmental sanitation is severely compromised. Evidence from longitudinal studies suggests that more frequent treatment cycles may be required to maintain reductions in infection burden (Jia *et al.*, 2012; Montresor *et al.*, 2020). Furthermore, restricting treatment to school-aged children may limit overall program impact, as untreated populations can serve as reservoirs of infection (Gyorkos *et al.*, 2018). Integrated control approaches are therefore essential. Improvements in water, sanitation, and hygiene (WASH) infrastructure have been shown to reduce reinfection rates when combined with chemotherapy significantly (World Health Organisation, 2022; Sartorius *et al.*, 2021). In IDP settings, where infrastructure is often inadequate or temporary, such interventions are particularly critical for sustained control.

Another important consideration is the potential for reduced anthelmintic effectiveness with repeated MDA implementation. Although confirmed resistance in human helminths remains limited, concerns exist due to established resistance patterns in veterinary settings (Montresor *et al.*, 2020). The observed reduced post-treatment effectiveness may therefore warrant further surveillance, although it cannot be conclusively attributed to drug resistance in this study. This study has limitations. The short follow-up period of 21 days limits the ability to clearly distinguish between reinfection and incomplete parasite clearance. A longer follow-up period (3–6 months) would provide more robust insight into reinfection dynamics (Jia *et al.*, 2012). Additionally, the absence of environmental and behavioural risk factor assessment limits the interpretation of transmission drivers.

## CONCLUSION

This study demonstrates that while albendazole-based MDA significantly reduces STH burden in the short term, these gains are not sustained in high-transmission IDP environments. The findings suggest that chemotherapy alone may be insufficient in such high-transmission settings and highlight the need for integrated strategies combining repeated MDA, expanded coverage, and WASH interventions to achieve sustained control. These findings are consistent with previous evidence from the same population, reinforcing the need for integrated control strategies beyond mass drug administration alone (Brown *et al.*, 2025).

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