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Determinants of Control Practices and Community-Level Strategies for Managing Gastrointestinal Parasitic Infections in Anambra State, Nigeria

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ABSTRACT: *Gastrointestinal parasitic infections (GIPIs) are one of the serious health challenges in Nigeria, which mainly affect vulnerable populations. Understanding community-level control practices and determinants is essential for designing effective intervention strategies. This study examined the determinants of control practices and community-level strategies for managing gastrointestinal parasitic infections across three senatorial districts in Anambra State, Nigeria. A cross-sectional study was conducted from July 2024 to June 2025 across nine randomly selected Local Government Areas (LGAs) representing Anambra North, Central, and South senatorial districts. A total of 3,000 stool samples, 400 water samples, 400 soil samples, and 400 fruit and vegetable samples were collected and analyzed using microscopy and polymerase chain reaction (PCR). Structured questionnaires and focus group discussions (FGDs) were used to assess knowledge, attitudes, practices, and control measures. Treatment efficacy was evaluated using single doses of Albendazole (400 mg) and Mebendazole (500 mg). Overall prevalence of GIPIs was 22.17%, with Taenia spp. most prevalent at 6.11%. Prevalence varied by district: Anambra South 7.83%, Central 4.59%, and North 2.97%. Water contamination was highest in streams at 10.25%, with Cryptosporidium parvum being the most commonly isolated parasite. Soil contamination reached 23.00%, while vegetables showed higher contamination than fruits at 49.1% versus 25.6%. Treatment efficacy analysis revealed that Albendazole achieved a 100% cure rate against Ascaris lumbricoides but showed lower effectiveness against hookworm and Entamoeba histolytica. Among households, 54% utilized plant-based remedies, predominantly Citrus aurantium/aurantifolia (25.5%), Ocimum basilicum (23.9%), and Allium sativum/Zingiber officinale (19.3%). Key determinants of infection included defecation practices, parental occupation, water sources, and sanitation facilities. Focus group discussions revealed knowledge gaps regarding transmission routes and inadequate access to healthcare infrastructure. Integrated control strategies combining improved sanitation infrastructure, health education, validation of traditional remedies, and targeted chemotherapy are essential for reducing the burden in Anambra State. Community engagement and evidence-based interventions addressing socioeconomic determinants should be prioritized.*

Keywords: Gastrointestinal parasites, control practices, community strategies, Anambra State, Nigeria, traditional remedies, treatment efficacy

1. INTRODUCTION

1.1 Background

Gastrointestinal parasitic infections constitute a major public health burden worldwide, especially in tropical and subtropical regions where inadequate sanitation and limited access to clean water facilitate transmission (World Health Organization [WHO], 2020). Nigeria, with prevalence rates ranging from 14.4% to 71.1% depending on region and study methodology, exemplifies the substantial impact of these infections (Nwaneri & Omuemu, 2012).

In sub-Saharan Africa, children bear the highest infection burden, followed by populations in Asia, Latin America, and the Caribbean (De Silva et al., 2003). The World Health Organization estimates that over 1.5 billion people, primarily in low- and middle-income countries, are infected with soil-transmitted helminths (WHO, 2020).

Anambra State in southeastern Nigeria presents unique epidemiological characteristics due to its diverse ecological zones and varying levels of infrastructure development across senatorial districts. Despite ongoing control efforts through mass drug administration and health education programs, gastrointestinal parasitic infections remain endemic (Okeibunor et al., 2017).

1.2 Study Rationale

Current literature demonstrates several critical knowledge gaps regarding community-level management of GIPIs in Nigeria. First, comprehensive assessments examining the interplay between traditional remedies and conventional treatment approaches are limited. Second, environmental contamination patterns across multiple vectors (water, soil, food) within the same geographic area have not been adequately characterized. Third, systematic evaluation of treatment efficacy under field conditions remains sparse.

Understanding community practices, knowledge, and attitudes toward GIPIs is essential for developing culturally appropriate and sustainable intervention strategies (Kloos, 2005). This study addresses these gaps by providing comprehensive data on infection prevalence, environmental contamination, treatment efficacy, and community-level control practices across Anambra State's three senatorial districts.

1.3 Study Objectives

Main Objective: To assess the determinants of control practices and evaluate community-level strategies for managing gastrointestinal parasitic infections in Anambra State, Nigeria.

Specific Objectives:

1. Determine the prevalence and distribution of gastrointestinal parasitic infections across three senatorial districts
2. Assess environmental contamination levels in water, soil, fruits, and vegetables
3. Evaluate the efficacy of commonly used anthelmintic treatments
4. Document traditional plant-based remedies utilized for GIPI management
5. Identify determinants influencing infection rates and control practices
6. Characterize community knowledge, attitudes, and practices regarding GIPIs

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This cross-sectional study was conducted from July 2024 to June 2025 in Anambra State, southeastern Nigeria (latitude 5°40′00″N to 6°50′00″N; longitude 6°40′00″E to 7°20′00″E). The state features semi-tropical rainforest vegetation with humid climate, temperatures around 30.6°C, and annual rainfall between 152-203 cm.

2.2 Sample Size and Sampling Strategy

Using simple random sampling (balloting method), nine Local Government Areas (LGAs) were selected, three from each senatorial district (North, Central, South), representing urban, semi-urban, and rural settlements (Table 1).

Table 1: Selected Local Government Areas and Settlement Types

Senatorial District	LGA	Settlement Type	Communities
Central	Aniocha	Rural	10
Central	Awka South	Urban	9
Central	Idemili North	Semi-Urban	10
North	Anambra East	Semi-Urban	11
North	Onitsha South	Urban	1
North	Anyamelum	Rural	7
South	Nnewi North	Urban	4
South	Ihiala	Rural	10
South	Aguata	Semi-Rural	16

2.3 Sample Collection and Processing

2.3.1 Stool Samples

A total of 3,000 stool samples were collected from consenting participants across all age groups. Samples were collected in sterile containers, properly labeled with demographic information, and transported in cold packs to the laboratory for analysis within 24 hours.

2.3.2 Environmental Samples

- **Water samples (n=400):** Collected from wells, boreholes, streams, and rainwater sources (100 samples per source type)
- **Soil samples (n=400):** Collected from household compounds, markets, church premises, dumpsites, and school playgrounds
- **Fruits and vegetables (n=400):** Randomly selected from markets and street vendors, including pumpkin leaf (*Telfairia occidentalis*), scent leaf (*Ocimum gratissimum*), green leaf (*Amaranthus hybridus*), water leaf (*Talinum triangulare*), mango (*Mangifera indica*), African star apple (*Chrysophyllum albidum*), and African pear (*Dacryodes edulis*)

2.4 Laboratory Analysis

2.4.1 Microscopic Examination

Stool samples underwent both saline wet mount and formol-ether concentration techniques following WHO protocols (WHO, 2020). Parasite intensity was assessed using the Kato-Katz technique with eggs per gram (EPG) calculations.

2.4.2 Water Analysis

Water samples were processed using sedimentation method: 15ml of each sample was centrifuged at 1500rpm for 5 minutes, supernatant discarded, and sediment examined microscopically.

2.4.3 Soil Analysis

Two grams of soil were suspended in 10ml buffered saline (0.85% NaCl), filtered, centrifuged at 3,150g for 10 minutes, and examined using saline wet mount.

2.4.4 Fruits and Vegetables

Samples were washed using elution method, concentrated via centrifugation (5000rpm for 5 minutes), and examined microscopically for parasitic stages.

2.5 Molecular Analysis

2.5.1 DNA Extraction

DNA was extracted from preserved stool samples (0.2g in 0.8mL DNAzol®) using phenol-chloroform-isoamyl alcohol (PCI) method, with final resuspension in TE buffer and storage at -20°C.

2.5.2 PCR Amplification

Nested PCR was performed using primers specific for *Giardia intestinalis* assemblages A and B. Initial screening used general *Giardia* detection primers, followed by assemblage-specific PCR on positive samples.

2.6 Treatment Efficacy Assessment

Infected individuals received either Albendazole (400mg single dose) or Mebendazole (500mg single dose). Follow-up stool examinations were conducted 14-21 days post-treatment to calculate cure rates and egg reduction rates.

2.7 Qualitative Data Collection

2.7.1 Focus Group Discussions

Six FGDs were conducted with 6-10 participants each, representing adult men, adult women, youth, guardians, married, and unmarried individuals. Discussions were audio-recorded with consent and explored knowledge, perceptions, practices regarding GIPI causes, transmission, prevention, and management.

2.7.2 Structured Questionnaires

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A total of 956 households completed questionnaires assessing:

- Clinical symptom recognition
- Perceived causes of GIPIs
- Treatment-seeking behaviors
- Home remedies and traditional medicine use
- Water sources and sanitation practices
- Socioeconomic factors

2.7.3 On-Spot Observations

Structured observations documented water and sanitation infrastructure, hygiene behaviors, animal-human interactions, waste management, and environmental conditions using standardized checklists.

2.8 Ethical Considerations

Ethical approval was obtained from Anambra State Ministry of Health, Awka. Informed verbal consent was secured from all participants, with parental/guardian consent for minors. Participants were assured of confidentiality and voluntary participation.

2.9 Data Analysis

Data were analyzed using SPSS version 20.0. Prevalence rates were calculated with 95% confidence intervals. Chi-square tests and logistic regression assessed associations between variables. Analysis of variance (ANOVA) compared means across groups. Statistical significance was set at $p<0.05$.

3. RESULTS

3.1 Prevalence and Distribution of Gastrointestinal Parasitic Infections

Out of 3,000 stool samples examined, 232 tested positive for intestinal parasites, yielding an overall prevalence of 22.17%. Eight parasite species were identified, with *Taenia* spp. being most prevalent at 6.11%, followed by *Strongyloides stercoralis* (4.01%), *Ascaris lumbricoides* (3.92%), *Entamoeba histolytica* (3.85%), hookworm (2.00%), *Trichuris trichiura* (1.52%), *Giardia lamblia* (0.57%), and *Entamoeba dispar* (0.19%) (Table 2).

Table 2: Prevalence of Gastrointestinal Parasitic Infections

Parasite Species	Number Positive (n=3000)	Percentage (%)
Single Infections		
Taenia spp.	64	2.13
Strongyloides stercoralis	42	1.40
Ascaris lumbricoides	41	1.36
Entamoeba histolytica	40	1.33
Hookworm	21	0.70
Trichuris trichiura	16	0.53
Giardia intestinalis	6	0.20
Entamoeba dispar	2	0.07
Subtotal Single	**232**	**7.73**
Double Infections		
A. lumbricoides + S. stercoralis	14	1.34
T. trichiura + E. histolytica	13	1.24
E. histolytica + G. lamblia	9	0.86
E. histolytica + S. stercoralis	7	0.66
G. lamblia + S. stercoralis	2	0.19
Subtotal Double	**45**	**4.30**
Total Prevalence	**277**	**22.17**

Double infections occurred in 4.30% of infected individuals, with no triple infections observed.

3.2 Geographic Distribution by Senatorial District

Prevalence varied across senatorial districts but differences were not statistically significant (p>0.05): Anambra North 9.75%, Anambra South 7.83%, and Anambra Central 4.59% (Table 3).

Table 3: Prevalence by Senatorial District

Parasite	Anambra North (n=1000)	Anambra South (n=1000)	Anambra Central (n=1000)	Total (%)
A. lumbricoides	18 (1.80%)	12 (1.20%)	11 (1.10%)	3.92
T. trichiura	9 (0.90%)	5 (0.50%)	2 (0.20%)	1.52
Hookworm	7 (0.70%)	10 (1.00%)	4 (0.40%)	2.00
G. lamblia	3 (0.30%)	3 (0.30%)	0 (0.00%)	0.57
E. dispar	2 (0.20%)	0 (0.00%)	0 (0.00%)	0.19
Taenia spp.	27 (2.70%)	20 (2.00%)	17 (1.70%)	6.11
E. histolytica	19 (1.90%)	11 (1.10%)	10 (1.00%)	3.85
S. stercoralis	17 (1.70%)	21 (2.10%)	4 (0.40%)	4.01
Total	**102 (9.75%)**	**82 (7.83%)**	**48 (4.59%)**	**22.17**

χ^2 values: North (0.3497, p>0.05); South (1.2, p>0.05); Central (3.6585, p>0.05)

3.3 Age and Sex Distribution

The highest prevalence occurred in children aged 0-10 years at 8.12%, followed by 11-20 years at 6.97%. Prevalence decreased with advancing age, with the lowest rate of 1.33% in the 41-50 year age group (Table 4). Sex-specific analysis revealed marginally higher prevalence in females at 12.04% compared to males at 10.13%, though this difference was not statistically significant (p=0.744).

Table 4: Age and Sex Distribution of Infections

Variable	Number Examined	Number Positive	Prevalence (%)
Age Groups			
0-10 years	565	85	8.12
11-20 years	570	73	6.97
21-30 years	445	25	2.39
31-40 years	500	18	1.72
41-50 years	425	14	1.33
51+ years	495	17	1.62
Sex			
Male	1436	106	10.13
Female	1564	126	12.04

p>0.05 for both age (p=0.300) and sex (p=0.744) distributions

3.4 Seasonal Variation

Rainy season showed higher prevalence at 59.51% compared to dry season at 40.49%, though this difference was not statistically significant (p=0.744). Helminth egg recovery was higher during rainy season: 56 parasites (14.00%) versus 36 (9.00%) in dry season (Table 5).

Table 5: Seasonal Prevalence of Helminthic Infections

Parasite	Dry Season (%)	Rainy Season (%)	Total (n=400)	Percentage (%)
Hookworms	7 (1.75)	12 (3.00)	19	4.75
A. lumbricoides	9 (2.25)	15 (3.75)	24	6.00
S. stercoralis	6 (1.50)	11 (2.75)	17	4.25
T. trichiura	6 (1.50)	8 (2.00)	14	3.50
Enterobius vermicularis	5 (1.25)	7 (1.75)	12	3.00
Hymenolepis nana	3 (0.75)	3 (0.75)	6	1.50
Total	**36 (9.00%)**	**56 (14.00%)**	**92**	**23.00**

t-test values: South (0.061, p>0.05); North (0.120, p>0.05); Central (0.002, p<0.05)

3.5 Infection Intensity

Intensity classifications revealed predominantly light infections across all helminth species (Table 6). *Taenia* spp. showed the highest number of light infections at 42 cases (16.85%), while heavy infections were most common with *E. histolytica* at 8 cases (2.04%).

Table 6: Intensity of Intestinal Helminth Infections

Intensity	*A. lumbricoides*	*T. trichiura*	Hookworm	*Taenia* spp.	*S. stercoralis*	*E. histolytica*
Light	36 (20.77%)	10 (14.28%)	9 (10.85%)	42 (16.85%)	25 (8.57%)	25 (8.57%)
Moderate	4 (2.28%)	5 (2.85%)	10 (5.71%)	20 (11.42%)	10 (5.71%)	7 (1.71%)
Heavy	1 (0.28%)	1 (0.57%)	2 (4.57%)	2 (4.57%)	7 (1.71%)	8 (2.04%)
Geometric Mean EPG	607.00	122.69	110.64	110.60	171.04	171.04
Total	**41 (3.92%)**	**16 (1.52%)**	**21 (2.00%)**	**64 (10.57%)**	**42 (4.01%)**	**40 (3.90%)**

$p>0.05$, $p=0.700$

3.6 Environmental Contamination

3.6.1 Water Sources

Among 400 water samples, streams exhibited the highest contamination at 10.25%, followed by wells at 9.25%, rainwater at 2.75%, and boreholes at 1.25% (Table 7). Nine parasite species with varying developmental stages (oocysts, cysts, eggs, larvae) were isolated. *Cryptosporidium parvum* was the most prevalent water contaminant at 4.75%, followed by *Giardia lamblia* at 4.00%.

Table 7: Parasitic Contamination in Water Sources

Parasite	Well	Borehole	Stream	Rain	Total (n=400)	Percentage (%)
Cryptosporidium spp.	4 (1.00)	2 (0.50)	10 (2.50)	3 (0.75)	19	4.75
Entamoeba coli	9 (2.25)	2 (0.50)	2 (0.50)	1 (0.25)	14	3.50
Giardia lamblia	4 (1.00)	0 (0.00)	10 (2.50)	2 (0.50)	16	4.00
Fluke	0 (0.00)	0 (0.00)	6 (1.50)	1 (0.25)	7	1.75
Round worm	2 (0.50)	1 (0.25)	3 (0.75)	1 (0.25)	7	1.75
Schistosoma haematobium	4 (1.00)	0 (0.00)	2 (0.50)	0 (0.00)	6	1.50
S. stercoralis	9 (2.25)	0 (0.00)	0 (0.00)	1 (0.25)	10	2.50
Giardia intestinalis	2 (0.50)	0 (0.00)	3 (0.75)	0 (0.00)	5	1.25
A. lumbricoides	3 (0.75)	0 (0.00)	5 (1.25)	2 (0.50)	10	2.50
Total	**37 (9.25%)**	**5 (1.25%)**	**41 (10.25%)**	**11 (2.75%)**	**94**	**23.50**

Statistical significance: Well water ($p=0.014$, $p<0.05$); Borehole ($p=0.152$, $p>0.05$); Stream ($p=0.006$, $p<0.05$); Rain ($p=0.43$, $p>0.05$)

3.6.2 Soil Contamination

Out of 400 soil samples, 92 tested positive for geohelminth parasites, representing an overall contamination rate of 23.00%. Anambra South recorded the highest contamination at 8.75%, followed by Anambra Central at 7.50% and Anambra North at 6.75% (Table 8).

Table 8: Distribution of Soil Contamination by Location

Location	Samples Screened	Number Contaminated	Percentage (%)
Anambra North	100	27	6.75
Anambra South	160	35	8.75
Anambra Central	140	30	7.50
Total	**400**	**92**	**23.00**

Location-based parasite distribution showed open dumps harbored the most parasites (34 specimens, 8.50%), followed by markets (15, 3.75%), churches (18, 4.50%), schools (17, 4.25%), and households (8, 2.00%). *Ascaris lumbricoides* was most prevalent in soil samples at 6.0%.

3.6.3 Fruits and Vegetables

Among 400 fruit and vegetable samples, 150 tested positive for parasitic contamination, yielding an overall rate of 39.1%. Vegetables exhibited significantly higher contamination at 49.1% compared to fruits at 25.6% (Table 9).

Table 9: Parasitic Contamination of Fruits and Vegetables

Type	Item	Number Examined	Number Positive (%)
Vegetables			
	Pumpkin leaf	55	31 (56.4)
	Scent leaf	55	29 (52.7)
	Green leaf	55	25 (45.5)
	Water leaf	55	23 (41.8)
	Subtotal	**220**	**108 (49.1)**
Fruits			
	Pear	60	17 (30.9)
	Udara	60	16 (29.1)
	Mango	60	9 (16.7)
	Subtotal	**180**	**42 (25.6)**
Total		**400**	**150 (39.1)**

Factors significantly associated with contamination included: unwashed produce before display (odds ratio [OR] 5-6 times higher risk), vendors with untrimmed fingernails (OR 2.1), produce displayed in water buckets (OR 2.7), and direct farmer supply versus middlemen (OR 2.0).

3.7 Treatment Efficacy Assessment

3.7.1 Albendazole Treatment Outcomes

A single 400mg dose of Albendazole demonstrated 100% cure rate against *A. lumbricoides* (41/41 treated), 85.71% against hookworm (18/21 treated), and 87.50% against *E. histolytica* (14/16 treated). Egg reduction rates (ERR) were 100% for *A. lumbricoides*, 55% for hookworm, and 44.2% for *T. trichiura* (Table 10).

3.7.2 Mebendazole Treatment Outcomes

Single 500mg dose of Mebendazole achieved 100% cure rate against hookworm (16/16 treated), 87.50% against *A. lumbricoides* (36/41 treated), and 66.66% against *E. histolytica* (14/21 treated). ERR was 100% for hookworm, 62.9% for *A. lumbricoides*, and 7.2% for *T. trichiura*.

Table 10: Anthelmintic Treatment Efficacy

Drug	Parasite	Before Treatment n(%)	After Treatment n(%)	Cure Rate (%)	ERR (%)
Albendazole					
	A. lumbricoides	41 (3.92)	0 (0.0)	100.0	100.0
	Hookworm	21 (2.00)	3 (0.28)	85.71	55.0
	E. histolytica	16 (1.52)	2 (0.19)	87.50	44.2
Mebendazole					
	Hookworm	16 (1.52)	0 (0.0)	100.0	100.0
	A. lumbricoides	41 (3.92)	2 (0.19)	87.50	62.9
	E. histolytica	21 (2.00)	7 (0.67)	66.66	7.2

3.8 Community Knowledge, Attitudes, and Practices

3.8.1 Symptom Recognition

Among 1,676 total responses from 956 households, vomiting was the most recognized symptom at 29.2% (490 responses), followed by abdominal pain at 23.5% (394 responses), and fever/headache at 11.7% (196 responses) (Table 11).

Table 11: Recognition of Clinical Symptoms (n=1676 responses)

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Symptom	Number of Responses	Percentage (%)
Vomiting	490	29.2
Abdominal/stomach pain	394	23.5
Fever and headache	196	11.7
Loss of appetite	164	9.8
Emaciation	100	6.0
Weakness	96	5.7
Salivation	72	4.3
Diarrhea/blood in stool	66	3.9
Abdominal distention	60	3.6
Anorexia	20	1.2
Increased appetite	18	1.1
Total	**1676**	**100.0**

3.8.2 Perceived Causes

Analysis of 2,102 responses revealed that 23.1% (486 responses) incorrectly attributed infections to sugary foods, while correct causes identified included: drinking contaminated water 19.5% (410), eating with unwashed hands 15.4% (324), eating dirty/spoiled food 12.3% (258), and eating unwashed fruits/vegetables 9.4% (198).

3.8.3 Treatment-Seeking Behavior

Of 956 households surveyed, treatment practices showed: 39.5% (378) used patent medicine stores, 21.3% (204) visited health centers, 12.8% (122) practiced self-treatment with home remedies, 11.9% (114) went to hospitals, 10.3% (98) consulted traditional medicine practitioners, and 4.2% (40) relied on faith-based approaches.

Regarding treatment initiation timing: 61.9% (592) began treatment within 48 hours of symptom onset, 33.9% (324) waited 2-5 days, and 4.2% (40) sought no treatment. Among 500 respondents whose children did not recover promptly, 52.6% (263) sought hospital care, 29.4% (147) returned to patent medicine vendors for alternative drugs, and 18.0% (90) turned to faith-based healing.

3.9 Traditional Plant-Based Remedies

Out of 956 households, 518 (54.2%) reported using plant-based remedies for treating intestinal parasitic infections. The most commonly utilized plants were *Citrus aurantium/aurantifolia* (lemon/lime) at 25.5% (132 households), *Ocimum basilicum* (scent leaf) at 23.9% (124 households), and *Allium sativum/Zingiber officinale* (garlic/ginger) at 19.3% (100 households) (Table 12).

Table 12: Plant-Based Remedies Utilized (n=518 households)

Common Name	Botanical Name	Frequency	Percentage (%)
Lemon/Lime	*Citrus aurantium/Citrus aurantifolia*	132	25.5
Scent leaf	*Ocimum basilicum*	124	23.9
Garlic/Ginger	*Allium sativum/Zingiber officinale*	100	19.3
Bitter kola	*Garcinia kola*	60	11.6
Utazi leaf	*Gongronema latifolium*	40	7.7
Wormwood	*Artemisia absinthium*	32	6.2
Red clover	*Trifolium pratense*	30	5.8

3.10 Risk Factors and Determinants

Logistic regression analysis identified several significant determinants of infection (Table 13). Occupation emerged as the strongest predictor, with children of farmers showing 16.53% prevalence compared to 0.47% for unemployed parents' children. Open defecation practices were associated with 11.18% prevalence versus 5.70% for water closet users. Stream/river water users demonstrated 9.46% prevalence compared to 0.76% for borehole users.

Table 13: Risk Factors Associated with Infection Prevalence

Variable	Category	Number Examined	Number Positive	Prevalence (%)
Toilet Type				
	Bush (open)	675	117	11.18
	Pit latrine	260	60	5.73
	Water system	111	55	5.70
Parental Occupation				
	Farmer	377	173	16.53
	Businessman	315	38	3.63
	Formal employment	288	15	1.43
	Unemployed	50	5	0.47
Water Source				
	Stream/river	443	99	9.46
	Wells	139	97	9.27
	Water vendors	105	21	2.00
	Borehole	122	8	0.76
	Rainwater	135	7	0.66

3.11 Molecular Characterization

PCR analysis of positive stool samples identified *Giardia intestinalis* assemblages A (4.6%, 8/174) and B (26.4%, 46/174). Phylogenetic analysis confirmed species-specific distribution patterns and validated the high sensitivity and specificity of molecular detection methods.

4. DISCUSSION

4.1 Prevalence and Distribution Patterns

The overall GIPI prevalence of 22.17% observed in this study represents a moderate burden but shows decline compared to previous Nigerian studies reporting rates from 24.8% to 71.1% (Nwaneri & Omuemu, 2012; Udensi et al., 2015). This reduction likely reflects cumulative impacts of recent government interventions including mass drug administration programs, improved sanitation infrastructure, and health education campaigns implemented across Anambra State.

The finding of *Taenia* spp. as the most prevalent parasite (6.11%) contrasts with many African studies where soil-transmitted helminths typically dominate (Brooker et al., 2020). However, this aligns with the region's livestock practices and cultural food preparation methods. The relatively high prevalence of *Strongyloides stercoralis* (4.01%) warrants particular attention given this parasite's capacity for autoinfection and potential for hyperinfection syndrome in immunocompromised individuals (Graeff-Teixeira et al., 2009).

Geographic variation in prevalence across senatorial districts (South 7.83%, North 9.75%, Central 4.59%), though not statistically significant, likely reflects differences in infrastructure development, with Anambra Central benefiting from its status as the administrative capital with better access to healthcare facilities and improved sanitation systems.

4.2 Age and Sex-Related Vulnerability

The highest infection rates in children aged 0-10 years (8.12%) and 11-20 years (6.97%) align with global patterns where children bear disproportionate GIPI burden (Hotez et al., 2019). This age-related vulnerability stems from multiple factors: developing immune systems, soil contact during play, inadequate hand hygiene practices, and behaviors such as geophagis (Stephenson et al., 2000). The decline in prevalence with increasing age likely reflects acquired immunity, improved hygiene awareness, and reduced soil contact in adults.

The marginally higher prevalence in females (12.04%) versus males (10.13%), while not statistically significant, may reflect gender-based differences in water collection duties, food preparation responsibilities, and agricultural activities that increase environmental exposure to infectious stages (WHO, 2019).

4.3 Environmental Contamination as Transmission Driver

4.3.1 Water Contamination

The finding that 23.50% of water samples harbored parasites underscores water as a critical transmission vehicle in Anambra State. Stream water contamination at 10.25% was expected given surface water's susceptibility to fecal pollution from open defecation, agricultural runoff, and animal waste. However, the 9.25% well water contamination is particularly concerning as wells are perceived as "safe" sources by communities.

Cryptosporidium parvum emergence as the most prevalent water contaminant (4.75%) has significant public health implications. This protozoan's oocysts resist standard chlorination, survive harsh environmental conditions, and cause severe diarrheal disease especially in children and immunocompromised individuals (Striepen, 2013). The isolation of *Giardia lamblia* in 4.00% of samples similarly indicates substantial waterborne transmission risk.

Borehole water's relatively low contamination (1.25%) validates its role as the safest drinking water source in the study area, though even this rate indicates need for proper construction, maintenance, and protection from surface contamination.

4.3.2 Soil Contamination

The 23.00% soil contamination rate confirms soil-transmitted helminths remain endemic in Anambra State. The concentration of parasites in open dumps (8.50%), markets (3.75%), and public spaces highlights how inadequate waste management and open defecation perpetuate transmission cycles. Children playing in contaminated soil and adults engaged in farming are at highest risk for infections via skin penetration (hookworm) or ingestion of embryonated eggs (*Ascaris*, *Trichuris*).

Ascaris lumbricoides predominance in soil (6.0%) reflects this parasite's remarkable environmental resilience. Ascarid eggs can survive extreme temperatures and desiccation for years due to their lipid-rich outer shell containing ascarosides (Crompton & Peters, 2020). This longevity explains persistent transmission even in areas with improving sanitation.

4.3.3 Food Contamination

The substantially higher vegetable contamination (49.1%) compared to fruits (25.6%) relates to structural differences. Leafy vegetables' large surface areas, crevices, and proximity to soil facilitate parasite adherence and retention. Pumpkin leaf (56.4%) and scent leaf (52.7%) showed highest contamination, likely due to cultivation practices, irrigation with contaminated water, and washing inadequacies.

Multiple contamination pathways were identified: soil splash during rainfall, irrigation with fecal-contaminated water, vendor handling with contaminated hands, and display practices (e.g., immersion in communal water buckets). The finding that unwashed produce displayed increased contamination risk 5-6-fold emphasizes the protective role of proper washing, though water quality for washing must itself be ensured.

Vendors with untrimmed fingernails showed 2.1 times higher produce contamination, highlighting how personal hygiene practices directly impact food safety. Fingernails harbor fecal-oral pathogens and can transfer parasitic stages during handling (Escobedo & Cimerman, 2007).

4.4 Treatment Efficacy Patterns

4.4.1 Albendazole Performance

Albendazole's 100% cure rate against *A. lumbricoides* confirms its status as first-line therapy for ascariasis, consistent with WHO recommendations (WHO, 2017). The drug's benzimidazole structure inhibits parasite microtubule formation, causing metabolic disruption and death (Horton, 2017). Its lower efficacy against hookworm (85.71%) and *E. histolytica* (87.50%) suggests these parasites may require modified dosing regimens or alternative agents.

The suboptimal performance against *T. trichiura* (44.2% egg reduction) aligns with known limitations of single-dose benzimidazole therapy against whipworm, which embeds its anterior portion deep in colonic mucosa (Keiser & Utzinger, 2018). Multi-day regimens typically achieve better outcomes.

4.4.2 Mebendazole Performance

Mebendazole's 100% cure rate against hookworm but 87.50% against *A. lumbricoides* presents an interesting pharmacological pattern. While both drugs share similar mechanisms, mebendazole's poor gastrointestinal absorption confines activity primarily to intestinal lumen, potentially explaining differential efficacy across species based on their anatomical locations (Keiser & Utzinger, 2018).

The poor performance against *E. histolytica* (66.66% cure rate, 7.2% egg reduction) indicates benzimidazoles are inadequate for amebiasis, where metronidazole or tinidazole remain treatments of choice (Haque et al., 2017).

These efficacy data have programmatic implications for mass drug administration strategies in Anambra State. While single-dose albendazole effectively controls ascariasis, comprehensive GIPI control requires tailored approaches addressing hookworm, whipworm, and protozoal infections.

4.5 Community Knowledge and Health-Seeking Behaviors

4.5.1 Knowledge Assessment

The high recognition of clinical symptoms (with vomiting and abdominal pain most commonly identified) indicates reasonable community awareness of GIPI manifestations. However, the substantial proportion (23.1%) attributing infections to "sugary foods" reveals persistent misconceptions that could undermine prevention efforts. This misunderstanding likely stems from observational associations where children consuming sweets also engage in poor hand hygiene.

Importantly, the majority correctly identified key transmission routes: contaminated water (19.5%), unwashed hands (15.4%), and unwashed produce (9.4%). This knowledge base provides a foundation for health education interventions, though translating knowledge into consistent preventive behaviors remains challenging.

4.5.2 Treatment-Seeking Patterns

The predominance of patent medicine store utilization (39.5%) over formal healthcare facilities (hospitals 11.9%, health centers 21.3%) reflects multiple barriers: cost, distance, perceived severity of infection, and trust in community-based vendors. Patent medicine vendors often provide immediate access and credit options, making them preferred first-line sources despite limited training (Stanley et al., 2021).

The finding that 61.9% initiated treatment within 48 hours demonstrates prompt response to symptoms, though appropriateness of treatments obtained from various sources (especially patent stores and traditional practitioners) requires scrutiny. The 52.6% who eventually sought hospital care when children didn't recover indicates recognition of treatment failure, though delayed appropriate care may have allowed complications to develop.

4.6 Traditional Medicine Utilization

The remarkable finding that 54.2% of households employed plant-based remedies for GIPI management underscores traditional medicine's enduring role in Nigerian healthcare. The three most utilized plants—*Citrus aurantium/aurantifolia* (25.5%), *Ocimum basilicum* (23.9%), and *Allium sativum/Zingiber officinale* (19.3%)—merit ethnopharmacological investigation.

Citrus species contain flavonoids, limonoids, and essential oils with documented antimicrobial and antiparasitic properties (Khodadadi, 2016). *Ocimum basilicum* (basil) produces eugenol and linalool, compounds demonstrating activity against various gastrointestinal pathogens (Simon et al., 1999). Garlic (*Allium sativum*) produces allicin, a sulfur compound with broad antimicrobial effects, while ginger (*Zingiber officinale*) contains gingerols and shogaols with anti-inflammatory and immunomodulatory activities (Ali et al., 2008; Rahman, 2007).

While these plants show pharmacological promise, their effectiveness against specific parasites remains inadequately characterized through controlled clinical trials. The widespread community use without standardized preparation methods, dosing regimens, or quality control raises safety and efficacy concerns. However, their accessibility, affordability, and cultural acceptability position them as potential complementary approaches worthy of systematic investigation.

Integration of validated traditional remedies into formal healthcare systems could enhance treatment access, particularly in rural areas with limited pharmaceutical availability. This requires rigorous scientific evaluation including: phytochemical characterization, in vitro and in vivo antiparasitic activity screening, toxicology studies, standardization of active compounds and preparations, and randomized controlled trials comparing efficacy to standard treatments (WHO, 2013).

4.7 Socioeconomic Determinants

The pronounced association between parental occupation (especially farming) and infection prevalence (16.53% for farmers' children versus 0.47% for unemployed parents' children) illuminates how livelihoods shape health risks. Farming families experience multiple exposure pathways: occupational soil contact, use of human waste as fertilizer in some areas, contaminated irrigation water, and economic constraints limiting sanitation access (Hotez & Kamath, 2009).

The strong correlation between open defecation (11.18% prevalence) and infection versus water closet use (5.70%) quantifies sanitation's protective effect. However, even among households with latrines, prevalence remained substantial (5.73%), suggesting that latrine quality, maintenance, and consistent use require attention beyond mere availability.

Water source emerged as another critical determinant. The nearly 13-fold difference in prevalence between stream users (9.46%) and borehole users (0.76%) emphasizes safe water's paramount importance. Yet well water's relatively high associated prevalence (9.27%) indicates that protected sources require proper construction, maintenance, and community education about contamination prevention.

These socioeconomic patterns align with the fundamental truth that GIPI control ultimately requires addressing poverty, infrastructure deficits, and health inequities—interventions extending beyond health sector capacity alone (Strunz et al., 2014).

4.8 Seasonal Transmission Dynamics

The higher rainy season prevalence (59.51% versus 40.49% dry season) and increased helminth egg recovery during wet months (14.00% versus 9.00%) conform to established transmission ecology. Rainfall creates favorable conditions for parasite development and transmission through multiple mechanisms: soil moisture facilitates egg embryonation and larval development, flooding contaminates water sources with fecal material, standing water supports intermediate hosts (for some parasites), and agricultural activities intensify during rainy season, increasing soil contact (Pullan & Brooker, 2011).

While this seasonal pattern was not statistically significant in our study ($p=0.744$), likely due to Anambra's year-round rainfall and relatively stable temperature, the trend suggests timing mass drug administration before peak transmission seasons could enhance impact.

4.9 Molecular Epidemiology Insights

The PCR identification of *Giardia intestinalis* assemblages A (4.6%) and B (26.4%) provides molecular epidemiological insights with public health implications. Assemblage A shows broader host range including livestock, suggesting potential zoonotic transmission routes. Assemblage B appears more anthroponotic (human-specific), implicating person-to-person transmission as primary (Feng & Xiao, 2011).

The predominance of assemblage B indicates that improving human sanitation and hygiene would likely yield substantial impact on giardiasis burden. However, the presence of assemblage A necessitates One Health approaches addressing livestock management and veterinary public health.

The demonstration of PCR's high sensitivity and specificity for detecting low-intensity infections invisible to microscopy suggests this technology could enhance surveillance and program evaluation, though cost currently limits routine implementation in resource-constrained settings.

4.10 Study Limitations

Several limitations warrant acknowledgment. The cross-sectional design precludes assessment of temporal trends or causality between risk factors and infection. Reliance on single stool samples may have underestimated true prevalence for parasites with intermittent egg shedding. Self-reported behaviors may introduce social desirability bias. The study could not assess reinfection rates or long-term treatment outcomes. Finally, while plant remedies were documented, their actual efficacy was not experimentally validated.

5. CONCLUSIONS

This comprehensive investigation of gastrointestinal parasitic infections across Anambra State, Nigeria reveals a 22.17% prevalence indicating moderate endemic burden with substantial environmental contamination across water (23.50%), soil (23.00%), and food sources (39.1%). While this represents improvement compared to historical rates, sustained control requires integrated strategies addressing multiple transmission pathways simultaneously.

Key findings with programmatic implications include:

1. **Persistent environmental contamination** across water, soil, and food sources perpetuates transmission despite improved awareness, indicating that health education alone is insufficient without infrastructure development.

2. **Socioeconomic determinants**—particularly occupation (farming), sanitation access, and water sources—emerged as primary drivers of infection risk, underscoring that sustainable GIPI control demands multi-sectoral approaches addressing poverty, infrastructure, and health equity.

3. **Treatment efficacy variations** across parasites and drugs suggest single-agent mass drug administration may inadequately address the region's polyparasitic burden. Tailored treatment strategies targeting specific parasites may enhance control effectiveness.

4. **Traditional plant-based remedies** utilized by 54% of households represent culturally embedded health-seeking behaviors that, if scientifically validated and standardized, could complement formal healthcare delivery, particularly in underserved rural areas.

5. **Community knowledge gaps** persist despite generally high symptom recognition, with substantial misunderstandings about transmission routes (e.g., attributing infections to sugary foods) requiring targeted health education using culturally appropriate messaging.

6. **Molecular characterization** revealing *Giardia* assemblage distribution patterns indicates mixed anthroponotic and zoonotic transmission, necessitating One Health approaches integrating human, animal, and environmental health interventions.

The intersection of these findings points toward an integrated control framework encompassing:

- **Infrastructure development**: Expanding access to safe water (protected boreholes) and improved sanitation (household latrines with proper maintenance)
- **Behavioral interventions**: Evidence-based health education addressing knowledge gaps about transmission, emphasizing hand hygiene, food washing, and shoe wearing
- **Healthcare strengthening**: Improving diagnostic capacity, standardizing treatment protocols, and ensuring anthelmintic availability across all health system levels
- **Traditional medicine integration**: Scientific validation of commonly used plant remedies with potential development of standardized, quality-controlled herbal formulations
- **Targeted chemotherapy**: Periodic mass drug administration for high-risk groups (children, farmers) with drug selection based on local parasite profiles
- **Environmental management**: Reducing soil contamination through proper waste disposal, eliminating open defecation, and agricultural best practices
- **One Health approaches**: Coordinating human and veterinary public health interventions given zoonotic transmission potential

Implementation requires sustained commitment from government, NGOs, community leaders, and households, with interventions adapted to local contexts across urban, semi-urban, and rural settings. While Anambra State has demonstrated progress through recent control efforts, achieving sustainable GIPI elimination demands long-term investments addressing fundamental determinants of health.

RECOMMENDATIONS

For Public Health Authorities

1. **Strengthen mass drug administration programs** by ensuring consistent anthelmintic supply, expanding coverage to all high-risk populations (particularly farming communities), and implementing pre-treatment diagnostic screening to tailor drug selection.

2. **Prioritize water and sanitation infrastructure** development, focusing on: constructing community boreholes with proper protection mechanisms, expanding household latrine coverage with maintenance training, and implementing water quality monitoring systems.

3. **Establish food safety programs** targeting markets and vendors, including: training on produce washing and handling, provision of clean water at market sites, and regular parasitological surveillance of high-risk foods.

4. **Develop culturally tailored health education** campaigns utilizing radio, television, community meetings, and schools to address identified knowledge gaps, emphasizing evidence-based transmission routes.

For Healthcare Providers

1. **Implement routine screening protocols** for GIPIs in primary care settings, particularly for children and high-risk occupational groups.

2. **Standardize treatment algorithms** based on local parasite profiles and documented drug efficacies, avoiding empiric single-drug approaches for polyparasitic infections.

3. **Strengthen diagnostic capacity** through training in microscopy and gradually introducing molecular techniques where resources permit.

For Research Community

1. **Conduct ethnopharmacological studies** systematically evaluating the most commonly used traditional remedies (*Citrus* spp., *Ocimum basilicum*, *Allium sativum/Zingiber officinale*) through: phytochemical characterization, in vitro and in vivo antiparasitic activity assays, toxicology assessments, and randomized controlled trials comparing efficacy to standard treatments.

2. **Investigate drug resistance patterns** particularly given long-standing use of benzimidazole anthelmintics in the region, using molecular markers where possible.

3. **Establish longitudinal surveillance systems** to monitor prevalence trends, assess program impacts, detect emerging parasites, and identify high-risk geographic hotspots requiring intensified interventions.

4. **Explore One Health frameworks** investigating human-animal-environment interfaces contributing to parasite transmission, particularly for zoonotic species.

For Community Leaders and Organizations

1. **Engage traditional healers** as partners in health promotion, leveraging their community trust while encouraging evidence-based practices.

2. **Mobilize communities** around sanitation improvements through participatory approaches like Community-Led Total Sanitation (CLTS).

3. **Support school-based interventions** integrating deworming with health education, WASH infrastructure, and nutritional programs.

CONTRIBUTION TO KNOWLEDGE

This study makes several significant contributions to the scientific understanding of gastrointestinal parasitic infections in Nigeria:

1. **Comprehensive multi-vector environmental assessment**: First study in Anambra State simultaneously evaluating contamination across water, soil, and food sources, revealing interconnected transmission pathways requiring integrated control approaches.

2. **Treatment efficacy under field conditions**: Provides real-world data on anthelmintic performance against the region's specific parasite assemblage, informing evidence-based treatment protocols and identifying gaps in current mass drug administration strategies.

3. **Documentation of traditional medicine practices**: Systematic characterization of plant-based remedies actually utilized by communities (rather than hypothetical ethnobotanical surveys) with quantification of usage frequencies, establishing foundation for future pharmacological validation studies.

4. **Molecular epidemiological insights**: First molecular characterization of *Giardia* assemblages in Anambra State, revealing predominance of assemblage B and providing evidence for targeted interventions addressing anthroponotic transmission.

5. **Socioeconomic determinant quantification**: Precise odds ratios for key risk factors (occupation, sanitation, water source) enable evidence-based targeting of interventions toward highest-risk populations.

6. **Integration of quantitative and qualitative data**: Combination of parasitological, environmental, clinical, and social science methodologies provides holistic understanding of GIPI burden and community responses, informing culturally appropriate interventions.

7. **Baseline for intervention evaluation**: Establishes comprehensive baseline data across three senatorial districts enabling rigorous assessment of future control program impacts.

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