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INTESTINAL PARASITIC INFECTIONS, NUTRITIONAL STATUS AND WASH PRACTICES AMONG PRIMARY SCHOOL PUPILS IN DEMSA LGA, ADAMAWA STATE, NIGERIA

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ABSTRACT

School-age children in northeastern Nigeria carry a disproportionate burden of undernutrition and intestinal parasitic infections (IPIs), conditions closely linked to inadequate water, sanitation and hygiene (WASH) practices. This cross-sectional study assessed nutritional status, WASH practices and facilities, and IPI prevalence among 300 pupils aged 5–15 years drawn from five primary schools in Demsa Local Government Area (LGA), Adamawa State, Nigeria, and examined the relationships among these three variables. Nutritional status was assessed using Body Mass Index (BMI); stool samples were examined by direct wet-mount and formol-ether concentration techniques; and WASH facilities were assessed using a structured observational checklist. Data were analysed using descriptive statistics, chi-square tests, and independent-samples t-tests ($\alpha = 0.05$). Overall, 84.3% of pupils fell below the normal BMI threshold, and only two of the five schools (40.0%) had adequate WASH facilities. Of 300 stool samples examined, 24 (8.0%) were positive for at least one intestinal parasite (Hymenolepis nana, 4.7%; Enterobius vermicularis, 3.3%). Infection prevalence was significantly associated with age ($\chi^2 = 10.83$, df = 3, $p = 0.013$), with younger pupils bearing the greatest burden, and infected pupils had significantly lower mean body weight than non-infected pupils (28.42 kg vs 31.40 kg; $t = -2.380$, df = 298, $p = 0.018$). Nutritional status did not differ significantly by school-level WASH status ($p = 0.898$) or infection status ($p = 0.086$). These findings suggest that undernutrition in Demsa LGA is a severe, community-wide problem that may be driven more by household food insecurity than by school-level WASH status alone, whereas IPI risk appears more directly linked to inadequate WASH infrastructure and is concentrated among younger pupils. Rehabilitation of school WASH infrastructure, integration of periodic deworming and hygiene education into school health programmes, and complementary household-level food security interventions are recommended.

Keywords: intestinal parasitic infections; nutritional status; WASH; primary school pupils; Demsa; Adamawa State; Nigeria

Introduction

Undernutrition and intestinal parasitic infections (IPIs) remain among the most persistent child health problems in low- and middle-income countries, and both are closely tied to inadequate water, sanitation and hygiene (WASH) provision (World Health Organization [WHO], 2023). The malnutrition–infection complex describes a bidirectional relationship in which undernutrition compromises immune function and increases susceptibility to infection, while infection particularly of the gastrointestinal tract accelerates nutrient loss and worsens nutritional status, creating a self-reinforcing cycle (Katona & Katona-Apte, 2022). Because intestinal parasites are transmitted predominantly through the faecal–oral route, WASH provision is a key upstream determinant of both infection risk and, indirectly, nutritional outcomes (Prüss-Ustün et al., 2022).

In Nigeria, the burden of child undernutrition and intestinal parasitic infection is markedly uneven, with the northern and north-eastern geopolitical zones consistently reporting poorer nutritional indicators than the south (Goson et al., 2022). Adamawa State, in Nigeria's North-East, lacks adequate WASH infrastructure in many rural communities, and prior surveys of nomadic and school-aged populations in the state have reported high helminth prevalence for example, preliminary unpublished data reported by Shitta and Akogun (2022) suggest a prevalence of approximately 72–76% among nomadic Fulani communities across two localities, including Demsa; as this source remains an unpublished manuscript, these figures should be regarded as indicative rather than verified. Despite this, WASH, nutrition and intestinal parasitic infection have typically been studied in isolation in this setting, and no prior study has examined the three variables concurrently within a single population of primary school pupils in Demsa Local Government Area (LGA).

This study therefore assessed the nutritional status, WASH practices and facilities, and prevalence of intestinal parasitic infections among primary school pupils in Demsa LGA, Adamawa State, and examined the relationships among these three variables. The specific objectives were to: (1) determine the nutritional status of pupils using anthropometric measurement (BMI); (2) assess the WASH practices and facilities available to pupils; (3) determine the prevalence and types of intestinal parasitic infection among pupils; (4) determine the association between WASH practices and IPI prevalence; (5) determine the relationship between nutritional status and IPI prevalence; (6) determine the relationship between WASH practices and nutritional status; (7) determine the association between pupil age and IPI prevalence; and (8) determine whether body weight differs between infected and non-infected pupils. Corresponding to these objectives, five null hypotheses were tested: that WASH practices are not significantly related to nutritional status (H_{01}, corresponding to objective 6); that WASH practices are not significantly associated with IPI prevalence (H_{02}, corresponding to objective 4); that nutritional status is not significantly related to IPI prevalence (H_{03}, corresponding to objective 5); that age does not significantly influence IPI prevalence (H_{04}, corresponding to objective 7); and that body weight does not differ significantly between infected and non-infected pupils (H_{05}, corresponding to objective 8).

Materials and Methods

1 Study Design and Area

A cross-sectional descriptive design was adopted, consistent with comparable school-based surveys of intestinal parasitic infection elsewhere in Nigeria and internationally (Dawaki et al., 2016; Ngui et al., 2012; Okyay et al., 2019). The study was conducted in Demsa LGA, Adamawa State, Nigeria (approximately 9°25′N, 12°8′E), an area of an estimated 180,251 people along the Benue River, characterised by a rural-to-semi-urban, agrarian setting with variable WASH infrastructure.

2 Study Population and Sampling

The study population comprised primary school pupils aged 5–15 years enrolled in Primary One (1) to Six (6) in five public primary schools in Demsa LGA: Demsa Central

Primary School, Girls Primary School Demsa, Farai Primary School, Gani-gaku Primary School, and Kawan Dowaya Primary School. The five schools were purposively selected to represent the range of WASH conditions present in the LGA. Minimum sample size was estimated using Cochran's (1977) formula for an infinite population ($Z = 1.96$, $p = 0.50$, $d = 0.05$), yielding a required minimum of 384 pupils; given the size of the Demsa LGA population (an estimated 180,251 people), a finite-population correction would not meaningfully reduce this minimum, and none was applied. For logistical and resource reasons, a stratified sampling procedure allocating 60 pupils to each of the five schools was instead adopted, giving an achieved sample of 300 pupils, equivalent to 78.1% of the calculated minimum. This shortfall is acknowledged as a limitation of the study (see Section 4.4) that may have reduced statistical power to detect smaller effects, particularly for associations involving the relatively small number of infected pupils ($n = 24$). Inclusion required current enrolment in a sampled school, age within 5–15 years, and parental/guardian consent together with pupil assent; acutely ill pupils and those without consent were excluded.

3 Data Collection

Weight was measured to the nearest 0.1 kg using a calibrated digital scale, and height to the nearest 0.1 cm using a portable stadiometer. Body Mass Index (BMI) was calculated as weight (kg)/height² (m²) and classified as Normal (BMI ≥ 18.5), Mild Underweight (16.0–18.4), Underweight (14.0–15.9), or Severely Underweight (< 14.0). Each pupil provided a single stool specimen in a labelled, leak-proof container; specimens were examined by direct wet-mount microscopy for motile protozoan trophozoites and by the formol-ether concentration technique for helminth eggs and protozoan cysts, following transport in a cool box at 4–8°C and processing by a qualified laboratory scientist. WASH practices and facilities water source, toilet/latrine facilities, handwashing provision, and waste disposal were assessed at each school using a structured observational checklist adapted from the WHO/UNICEF Joint Monitoring Programme school WASH guidelines, and each school was classified as having Adequate or Inadequate facilities based on availability, functionality and maintenance at the time of assessment. Basic demographic data (age, sex) were recorded from school enrolment records.

4 Data Analysis

Data were analysed in IBM SPSS Statistics version 25.0. Descriptive statistics (frequencies, percentages, means, standard deviations) summarised participant characteristics. The chi-square (χ^2) test of independence was used to test associations between categorical variables (WASH status, nutritional status category, infection status, sex, age group), and the independent-samples t-test compared mean anthropometric values between infected and non-infected pupils. Statistical significance was set at $p < 0.05$.

5 Ethical Considerations

Ethical approval for this study was obtained from the [name of institutional Health Research Ethics Committee] (approval number: [insert approval number]) prior to the commencement of data collection. Permission was also obtained from the Adamawa State Universal Basic Education Board and the head teacher of each participating school. Written informed consent was obtained from parents or guardians, and verbal assent was obtained from each pupil, before anthropometric measurement and stool sample collection. Stool specimens and personal data were coded and handled confidentially, and pupils found to be infected were referred, with parental consent, for free treatment through the school health programme.

Results

1 Demographic Characteristics

A total of 300 primary school pupils were examined across the five schools, comprising 165 females (55.0%) and 135 males (45.0%). Age ranged from 5 to 15 years (mean 9.47 ± 2.17 years). Each school contributed an equal 60 pupils (20.0% of the sample). Girls Primary School

Demsa had the youngest mean age (8.83 years) and Demsa Central Primary School the oldest (10.43 years).

Table 1. Distribution of Study Participants by School and Gender

School	Male	Female	Total (N)	% of Sample	Mean Age (yrs)
Demsa Central Primary School	16	44	60	20.0	10.43
Girls Primary School Demsa	18	42	60	20.0	8.83
Farai Primary School	37	23	60	20.0	9.53
Gani-gaku Primary School	32	28	60	20.0	9.50
Kawan Dowaya Primary School	32	28	60	20.0	9.07
Total	135	165	300	100.0	9.47

2 Nutritional Status

The mean BMI of participants was 16.87 kg/m² (SD = 1.90; range 10.50–23.91), within the mild-underweight range. Mean weight was 31.22 kg (SD = 5.78) and mean height 1.36 m (SD = 0.10). Male pupils had a marginally higher mean BMI (16.93 kg/m²) than females (16.83 kg/m²), a negligible difference. Overall, only 47 pupils (15.7%) had a normal BMI, meaning 84.3% of pupils fell below the normal nutritional threshold: 170 (56.7%) were mildly underweight, 61 (20.3%) underweight, and 22 (7.3%) severely underweight (Table 2). This pattern was consistent across all five schools (78.7–85.1% combined undernutrition), indicating a community-wide rather than school-specific problem. Kawan Dowaya Primary School had the highest proportion of severely underweight pupils (7/60, 11.7%). The distribution of nutritional status did not differ significantly by gender (χ^2(cal.) = 1.438, χ^2(tab.) = 7.815, df = 3, p = 0.697), indicating that gender was not a significant determinant of nutritional status in this population (Table 3).

Table 2. Nutritional Status Classification of Participants by School (N = 300)

Nutritional Status	DC-PS n(%)	GPS-D n(%)	Farai n(%)	Gani-g n(%)	K-Dow n(%)	Total	% of Total
Normal (BMI ≥ 18.5)	10 (16.7)	9 (15.0)	11 (18.3)	10 (16.7)	7 (11.7)	47	15.7
Mild Underweight (16.0–18.4)	35 (58.3)	33 (55.0)	36 (60.0)	32 (53.3)	34 (56.7)	170	56.7
Underweight (14.0–15.9)	12 (20.0)	13 (21.7)	10 (16.7)	14 (23.3)	12 (20.0)	61	20.3
Severely Underweight (< 14.0)	3 (5.0)	5 (8.3)	3 (5.0)	4 (6.7)	7 (11.7)	22	7.3
Total	60 (100)	60 (100)	60 (100)	60 (100)	60 (100)	300	100.0

Note: Percentages in each school column are row-wise share of that school's total (n = 60).

Table 3. Nutritional Status by Gender (N = 300)

Nutritional Status	Female n(%)	Male n(%)	Total	% of Total
Normal (BMI ≥ 18.5)	23 (13.9)	24 (17.8)	47	15.7
Mild Underweight	95 (57.6)	75 (55.6)	170	56.7
Underweight	36 (21.8)	25 (18.5)	61	20.3
Severely Underweight	11 (6.7)	11 (8.1)	22	7.3
Total	165 (100)	135 (100)	300	100.0

χ^2(cal.) = 1.438; χ^2(tab.) = 7.815; df = 3; p = 0.697 (NS). NS = Not Significant (p > 0.05).

3 WASH Practices and Facilities

Two of the five schools; Demsa Central Primary School and Kawan Dowaya Primary School had adequate, properly and regularly maintained WASH facilities, served by a borehole or pipe-borne water supply, functional Ventilated Improved Pit (VIP) latrines, handwashing facilities with soap, and a structured waste-disposal bin system. The remaining three schools Girls Primary School Demsa, Farai Primary School, and Gani-gaku Primary School had inadequate WASH conditions, characterised by reliance on open wells or surface water, dilapidated or non-functional pit latrines, absence of handwashing facilities with soap, and open waste dumping (Table 4). Overall, only 2 of 5 schools (40.0%) had adequate WASH facilities.

Table 4. WASH Facilities and Conditions in Sampled Schools, Demsa LGA

School	Water Source	Toilet/Latrine	Handwashing (Soap)	Waste Disposal	WASH Status
Demsa Central Primary School	Borehole/Pipe-borne	Functional VIP latrines	Yes	Structured bin system	Adequate
Girls Primary School Demsa	Open well/Surface water	Pit latrine (dilapidated)	No	Open dumping	Inadequate
Farai Primary School	Open well/Surface water	Pit latrine (non-functional)	No	Open dumping	Inadequate
Gani-gaku Primary School	Open well	Pit latrine (limited)	No	Open dumping	Inadequate
Kawan Dowaya Primary School	Borehole/Pipe-borne	Functional VIP latrines	Yes	Structured bin system	Adequate

Key: VIP = Ventilated Improved Pit latrine. Two of the five schools had facilities that were available and properly maintained at the time of assessment.

4 Prevalence and Types of Intestinal Parasitic Infection

Of the 300 stool samples examined, 24 (8.0%) were positive for at least one intestinal parasite. Two species were identified: Hymenolepis nana, the predominant species, in 14 pupils (4.7% of the sample; 58.3% of infected cases), and Enterobius vermicularis in 10 pupils (3.3% of the sample; 41.7% of infected cases). No co-infections were recorded (Table 5).

Girls Primary School Demsa recorded the highest school-level prevalence (11.7%, 7/60), followed by Farai Primary School (10.0%, 6/60); the two schools with adequate WASH facilities Demsa Central Primary School and Kawan Dowaya Primary School recorded the lowest prevalence, at 6.7% and 5.0% respectively.

Females had a higher infection prevalence (9.7%, 16/165) than males (5.9%, 8/135), but this difference was not statistically significant (χ^2(cal.) = 0.968, χ^2(tab.) = 3.841, df = 1, p = 0.325). Infection prevalence varied significantly by age group (χ^2(cal.) = 10.83, χ^2(tab.) = 7.815, df = 3, p = 0.013): prevalence was 11.8% (9/76) among 5–7-year-olds, peaked at 12.4% (13/105) among 8–10-year-olds, dropped to 2.1% (2/96) among 11–12-year-olds, and no infections were recorded among 13–15-year-olds (0/23), indicating a significantly higher infection burden among younger pupils.

Table 5. Prevalence and Types of Intestinal Parasitic Infection by School, Gender and Age Group (N = 300)

Category	No. Exam.	No. +ve	%	H. nana n	E. vermicularis n
Demsa Central Primary School	60	4	6.7	3	1
Girls Primary School Demsa	60	7	11.7	4	3
Farai Primary School	60	6	10.0	2	4
Gani-gaku Primary School	60	4	6.7	3	1
Kawan Dowaya Primary School	60	3	5.0	2	1
Female	165	16	9.7	9	7
Male	135	8	5.9	5	3
Age 5–7 yrs	76	9	11.8	5	4
Age 8–10 yrs	105	13	12.4	7	6
Age 11–12 yrs	96	2	2.1	2	0
Age 13–15 yrs	23	0	0.0	0	0
Total (all pupils)	300	24	8.0	14	10

Sex: χ^2(cal.) = 0.968, χ^2(tab.) = 3.841, df = 1, p = 0.325 (NS). Age group: χ^2(cal.) = 10.83, χ^2(tab.) = 7.815, df = 3, p = 0.013 (significant). H. nana = Hymenolepis nana; E. vermicularis = Enterobius vermicularis; NS = Not Significant.

5 Association Between WASH Status and Infection, and Anthropometric Comparison

Infection prevalence tracked school-level WASH status closely: the two schools with adequate WASH facilities recorded the lowest prevalence (5.0–6.7%), while the three schools with inadequate WASH facilities recorded consistently higher prevalence (6.7–11.7%), peaking at Girls Primary School Demsa. Because only five school-level units were available, this association was examined descriptively (ecologically) rather than through formal inferential testing; the pattern nonetheless supports the qualitative rejection of H_{02}, indicating that poor WASH conditions are an important determinant of infection risk in Demsa LGA.

Infected pupils had a significantly lower mean weight (28.42 kg, SD = 5.14) than non-infected pupils (31.40 kg, SD = 5.81; t = −2.380, df = 298, p = 0.018). Mean BMI was also lower among infected pupils (16.17 kg/m²) than non-infected pupils, though this difference did not reach significance (t = −1.910, df = 298, p = 0.057), nor did mean height (t = −1.483, df = 298, p = 0.139) (Table 6).

Table 6. Comparison of Anthropometric Indices Between Infected and Non-Infected Pupils

Parameter	Infected Mean (SD)	Non-Infected Mean (SD)	t-statistic	df	p-value
Weight (kg)	28.42 (5.14)	31.40 (5.81)	−2.380	298	0.018*
Height (m)	1.324 (0.11)	1.362 (0.10)	−1.483	298	0.139 (NS)
BMI (kg/m²)	16.17 (2.09)	16.90 (1.89)	−1.910	298	0.057 (NS)

** Significant at p < 0.05 (independent-samples t-test). NS = Not Significant.*

6 Relationship Between Nutritional Status and Infection Prevalence

Infection prevalence rose with worsening nutritional status: 6.4% among normal-weight pupils, falling to 5.3% among mildly underweight pupils, then rising to 14.8% among underweight pupils and 13.6% among severely underweight pupils (Table 7). Although this

pattern is biologically coherent with the malnutrition–infection cycle, it did not reach statistical significance (χ^2(cal.) = 6.589, χ^2(tab.) = 7.815, df = 3, p = 0.086); H_{03} was therefore not rejected.

Table 7. Cross-tabulation of Nutritional Status Against Infection Status (N = 300)

Nutritional Status	No. Exam.	No. +ve (%)
Normal (BMI ≥ 18.5)	47	3 (6.4)
Mild Underweight (16.0–18.4)	170	9 (5.3)
Underweight (14.0–15.9)	61	9 (14.8)
Severely Underweight (< 14.0)	22	3 (13.6)
Total	300	24 (8.0)

χ^2(cal.) = 6.589; χ^2(tab.) = 7.815; df = 3; p = 0.086 (NS).

7 Relationship Between WASH Status and Nutritional Status

Table 8 disaggregates nutritional status by school-level WASH status, combining the two adequate-WASH schools (Demsa Central and Kawan Dowaya, n = 120) and the three inadequate-WASH schools (Girls Primary School Demsa, Farai, and Gani-gaku, n = 180). Undernutrition was almost equally severe in both groups: 84.2% (101/120) of pupils in adequate-WASH schools and 84.4% (150/180) of pupils in inadequate-WASH schools fell below the normal BMI threshold. The chi-square test confirmed that this distribution did not differ significantly by school-level WASH status (χ^2(cal.) = 0.595, χ^2(tab.) = 7.815, df = 3, p = 0.898); H_{01} was therefore not rejected. This near-identical undernutrition burden across WASH strata, set against the near-universal 84.3% undernutrition rate recorded overall, indicates that household- and community-level food insecurity rather than school-level WASH provision is the principal driver of the nutritional crisis in Demsa LGA.

Table 8. Nutritional Status by School-Level WASH Status (N = 300)

WASH Status	Normal n(%)	Mild Underweight n(%)	Underweight n(%)	Severely Underweight n(%)	Total
Adequate (n = 120)	17 (14.2)	69 (57.5)	24 (20.0)	10 (8.3)	120
Inadequate (n = 180)	30 (16.7)	101 (56.1)	37 (20.6)	12 (6.7)	180
Total (N = 300)	47 (15.7)	170 (56.7)	61 (20.3)	22 (7.3)	300

χ^2(cal.) = 0.595; χ^2(tab.) = 7.815; df = 3; p = 0.898 (NS). Adequate = Demsa Central + Kawan Dowaya Primary Schools; Inadequate = Girls Primary School Demsa + Farai + Gani-gaku Primary Schools.

8 Summary of Hypothesis Testing

Table 9 summarises the outcome of all five hypothesis tests. Of the five null hypotheses tested, two were rejected — the association between WASH status and infection prevalence (qualitatively, H_{02}) and the influence of age on infection prevalence (H_{04}) — together with the closely related finding of a significant weight deficit among infected pupils supporting H_{05}. The remaining hypotheses, concerning WASH status and nutritional status (H_{01}) and nutritional status and infection prevalence (H_{03}), were not rejected at the conventional $p < 0.05$ threshold, although both showed directionally coherent trends consistent with the malnutrition–infection and WASH–health frameworks.

Table 9. Summary of Hypothesis Testing Outcomes

Hypothesis	Statistical Test	Test Statistic	p-value	Decision
H_{01}: WASH status not related to nutritional status	Chi-square	χ^2(cal.)=0.595; χ^2(tab.)=7.815	0.898 (NS)	Not Rejected
H_{02}: WASH status not associated with IPI prevalence	Ecological/descriptive comparison	Prevalence 5.0–6.7% (adequate) vs 6.7–11.7% (inadequate)	Qualitative	Rejected (qualitatively)
H_{03}: Nutritional status not related to IPI prevalence	Chi-square	χ^2(cal.)=6.589; χ^2(tab.)=7.815	0.086 (NS)	Not Rejected
H_{04}: Age does not influence IPI prevalence	Chi-square	χ^2(cal.)=10.83; χ^2(tab.)=7.815	0.013*	Rejected
H_{05}: No difference in weight between infected/non-infected	Independent t-test	t = −2.380 (weight); t = −1.910 (BMI)	0.018* (wt); 0.057 (BMI)	Rejected (weight)

** Significant at $p < 0.05$. χ^2(tab.) = 7.815 at df = 3. NS = Not Significant; IPI = Intestinal Parasitic Infection.*

Discussion

The finding that 84.3% of pupils fell below the normal BMI threshold represents an alarmingly high undernutrition burden, considerably exceeding rates reported in most recent Nigerian school-based studies, including Sanni et al. (2024) in Ekiti State and Adeomi, Fatusi and Klipstein-Grobusch (2022) across two Nigerian states. This disparity is consistent with well-documented geographic gradients in Nigerian child nutrition, whereby the North-East where Adamawa State and Demsa LGA are located records some of the poorest nutritional indicators nationally (Goson et al., 2022). The near-uniform undernutrition across all five schools (78.7–85.1%), irrespective of WASH status, together with the absence of any recorded overnutrition, points to chronic household food insecurity rather than school-level or infection-related factors as the dominant proximate cause, echoing the multi-level analysis of Adeomi et al. (2022), which found household- and community-level factors to be the strongest predictors of both under- and over-nutrition among Nigerian schoolchildren. The absence of a significant gender difference in nutritional status ($\chi^2 = 1.438$, $p = 0.697$) is likewise consistent with recent Nigerian evidence (Sanni et al., 2024), suggesting gender is not a strong independent determinant of nutritional status at the primary-school level, prior to pubertal growth divergence. The severity of undernutrition observed here is broadly consistent with the wide range of anthropometric deficits reported across African child populations over the past two decades (Modjadji et al., 2023), and with systematic-review evidence that intestinal parasitic infection and child nutritional status are closely, bidirectionally linked (Fauziah et al., 2022).

Only 40.0% of sampled schools had adequate WASH facilities, and both parasite species identified Hymenolepis nana and Enterobius vermicularis are transmitted exclusively via the faecal–oral route, reinforcing the WASH–infection nexus described in the literature (Prüss-Ustün et al., 2022; Hajissa et al., 2022). The overall prevalence of 8.0% is lower than several recently reported Nigerian and West African figures (Gbonhinbor et al., 2022; Amisu et al., 2023) but follows a WASH-linked school-level gradient consistent with expectation: prevalence was lowest (5.0–6.7%) in the two schools with adequate, properly maintained facilities and highest (6.7–11.7%) in the three schools with inadequate facilities. The notable absence of soil-transmitted helminths such as Ascaris lumbricoides, Trichuris trichiura, or hookworm, which dominate in many comparable Nigerian surveys (Dawaki et al., 2016), may

reflect genuine local epidemiology, seasonal timing of sample collection, or the sensitivity limits of direct wet-mount and formol-ether concentration microscopy relative to more sensitive techniques such as Kato-Katz or PCR-based methods; this warrants further investigation, particularly given that soil-transmitted helminths remain a substantial treatment target in national deworming programmes (World Health Organization [WHO], 2020). The significantly higher infection prevalence among younger pupils (11.8–12.4% in the 5–10-year age band versus 0–2.1% among pupils aged 11 years and above; $\chi^2 = 10.83$, $p = 0.013$) mirrors a consistent finding in the regional literature that younger children's play, hygiene, and hand-to-mouth behaviours increase exposure to infective parasite stages (Chelkeba et al., 2020). The significantly lower mean body weight among infected pupils (28.42 kg vs 31.40 kg; $t = -2.380$, $p = 0.018$) provides direct, Demsa-specific quantitative support for the malnutrition–infection cycle, in which parasitic infection contributes to nutrient loss and growth deficits (Humphrey, 2009).

The non-significant but biologically coherent gradient linking worsening nutritional status to higher infection prevalence (6.4% among normal-weight pupils rising to 14.8% among underweight pupils; $\chi^2 = 6.589$, $p = 0.086$) is consistent with a real but modest-effect-size relationship that a sample of 24 infected cases may be underpowered to detect at conventional significance thresholds, particularly given that the related, continuous-measure comparison (weight) did reach significance. Likewise, the absence of a significant relationship between school-level WASH status and nutritional status ($\chi^2 = 0.595$, $p = 0.898$) should not be read as evidence that WASH is unimportant for child health in Demsa LGA; rather, it indicates that WASH functions primarily as a determinant of infectious disease risk rather than as an independent driver of chronic undernutrition once household-level food insecurity is severe and widespread across the community, a pattern consistent with Adeomi et al. (2022) and Goson et al. (2022), and with meta-analytic evidence that WASH interventions alone tend to have only modest, inconsistent effects on child nutritional-status outcomes unless combined with direct nutrition-specific interventions (Gizaw et al., 2020). Taken together, the findings suggest that improving school WASH infrastructure in Demsa LGA would be expected to reduce IPI prevalence and its associated weight deficits, but that a substantial reduction in the community's 84.3% undernutrition burden will additionally require direct household food-security interventions.

Limitations

Several limitations should be considered when interpreting these findings. First, the achieved sample of 300 fell short of the calculated minimum of 384, and only 24 pupils were positive for an intestinal parasite; this small number of infected cases limits statistical power for chi-square comparisons and may explain why some biologically plausible associations (e.g., nutritional status and infection status) did not reach conventional significance. Second, the cross-sectional design captures a single point in time and cannot establish the direction of causality between WASH status, nutritional status and infection; longitudinal designs are needed to confirm temporal and causal relationships. Third, the five schools were purposively, rather than randomly, selected to represent a range of WASH conditions, which may limit the generalisability of the findings to other schools in Demsa LGA and beyond, and restricts the WASH–infection association at school level to a descriptive, ecological comparison across only five units rather than a formally tested inferential association. Fourth, only a single stool sample was collected per pupil; because parasite egg or cyst shedding can be intermittent, single-sample microscopy may have underestimated true infection prevalence and could account for the absence of soil-transmitted helminths detected in comparable surveys. Finally, direct wet-mount and formol-ether concentration microscopy are less sensitive than techniques such as Kato-Katz or PCR-based methods, and household-level socioeconomic and food-security data were not collected, limiting the ability to directly test explanations for the undernutrition pattern observed.

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Conclusion

Primary school pupils in Demsa LGA face two distinct but partially interacting public health challenges. Undernutrition is severe and widespread, affecting more than four in every five pupils sampled, and is distributed almost uniformly across schools and WASH strata, which may point to household food insecurity and broader socioeconomic constraints as more plausible principal drivers than school-level WASH provision, although this study did not directly measure household food security and so cannot confirm this explanation. Intestinal parasitic infection, by contrast, though comparatively low in overall prevalence (8.0%) and narrow in the range of species detected, appears to be patterned by WASH infrastructure adequacy and pupil age, with younger pupils and pupils in schools with inadequate WASH facilities bearing the greater burden; because the school-level WASH comparison involved only five units and was examined descriptively rather than through formal inferential testing (Section 3.5), this pattern should be read as suggestive rather than statistically proven. Although nutritional status and infection status were not statistically significantly related in this sample, the significantly lower body weight among infected pupils, together with the WASH–infection and age–infection associations, is consistent with the malnutrition–infection complex and suggests the two problems are biologically and programmatically connected, warranting coordinated rather than isolated intervention.

6. Recommendations

1. Government and relevant stakeholders, including the Universal Basic Education Board and Local Government Education Authority, should prioritise rehabilitation and construction of adequate WASH infrastructure reliable water sources, functional sanitary latrines, and handwashing facilities with soap in the three schools identified with inadequate facilities, and extend similar assessment and investment to other schools across Demsa LGA.
2. School health authorities should integrate periodic mass deworming and structured hygiene education into routine school health programmes in Demsa LGA, with particular attention to younger pupils, who bear a disproportionate share of intestinal parasitic infection.
3. Because undernutrition was severe and largely independent of school-level WASH status, the Adamawa State Ministry of Health, in partnership with the State Universal Basic Education Board and nutrition-focused NGOs (e.g., UNICEF-supported community nutrition programmes active in the state), should lead the roll-out of complementary household- and community-level food security and nutrition interventions such as school feeding programmes, caregiver nutrition education, and support for household food production in Demsa LGA, with a phased implementation beginning within the next 12 months and an initial impact assessment at 24 months, rather than relying on WASH improvement alone.
4. School authorities and parent-teacher associations should institute routine, at least annual, anthropometric and parasitological screening of pupils to enable early identification and referral of undernourished or infected children.
5. Health education programmes targeting parents and caregivers should emphasise the link between household WASH practices, hygiene behaviour, and both nutritional and infection outcomes, to complement school-based interventions.
6. Policy makers at state and local government levels should use the school-specific WASH and health findings generated by this study as baseline evidence for targeted resource allocation, monitoring, and evaluation of future school health and WASH interventions in Demsa LGA.

Conflict of Interest

The authors declare no conflict of interest.

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