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INTESTINAL PARASITE SPECIES DISTRIBUTION, ANAEMIC STATUS, AND GLYCAEMIC CONTROL AMONG DIABETES MELLITUS PATIENTS IN ONDO STATE, NIGERIA

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ABSTRACT

Background: The concurrent presence of intestinal parasitic infections (IPIs) and diabetes mellitus (DM) creates a compounding clinical and haematological burden that remains inadequately characterised in Nigeria. This study determined the distribution of intestinal parasite species and their relationship with anaemic status, body mass index (BMI), and glycaemic control among DM patients in Ondo State.

Methods: A cross-sectional study enrolled 284 confirmed DM patients across the three senatorial districts of Ondo State. Stool specimens were examined using formol-ether concentration and modified Ziehl-Neelsen methods; full blood count were obtained by automated haematology analyser; and glycated haemoglobin (HbA1c) was measured by fluorescence immunoassay. Glycaemic control was stratified as well-controlled (HbA1c ≤ 6.0%), moderately controlled (> 6.0–< 8.0%), and poorly controlled (≥ 8.0%). Chi-square tests were performed at $p < 0.05$.

Results: IPI overall prevalence was 27.5% (78/284); helminthic infections accounted for 58 cases (20.4%) and protozoan infections for 20 cases (7.1%). *Ascaris lumbricoides* was the most prevalent species (11.9%), followed by *Entamoeba histolytica* (7.1%), *Schistosoma mansoni* (4.2%), hookworm (2.5%), *Trichuris trichiura* (1.1%), and *Enterobius vermicularis* (0.7%). Anaemic subjects had a significantly higher IPI prevalence (51.9%) than non-anaemic participants (22.0%; $p < 0.001$). Mean haemoglobin concentration was significantly lower in IPI-positive patients (532.64 ± 40.82 g/L) than IPI-negative patients (697.23 ± 24.81 g/L; $p = 0.0001$). Overweight individuals (BMI 25–29.9 kg/m²) had a significantly higher infection rate (50.0%) compared with normal-weight counterparts (26.0%; $p = 0.04$). All 43 participants with HbA1c ≥ 8.0% were parasitologically positive (100.0%), compared with 16.5% and 14.2% among well- and moderately controlled patients respectively ($p < 0.001$). Diarrhoea and lipid profile parameters showed no statistically significant associations with IPI prevalence.

Conclusion: IPIs are strongly associated with both anaemia and poor glycaemic control in DM patients in Ondo State, underscoring the need for routine parasitological screening, integrated haematological monitoring, and context-sensitive anthelmintic therapy within comprehensive diabetes management protocols in endemic areas of Nigeria.

Keywords: Intestinal Parasites, Anaemia, Glycated Haemoglobin, Glycaemic Control, HbA1c, Diabetes Mellitus.

1 INTRODUCTION

Diabetes mellitus (DM) is among the most consequential non-communicable diseases of the twenty-first century, with the International Diabetes Federation (IDF) estimating 589 million affected adults globally in 2021, a figure projected to reach 853 million by 2050 [1]. Intestinal parasitic infections (IPIs) remain highly endemic across sub-Saharan Africa, with more than 1.5 billion people at risk from soil-transmitted helminths alone [2]. The concurrence of these two conditions creates a synergistic clinical burden that hospital and primary care systems in Nigeria are rarely equipped to manage in an integrated manner.

Diabetes mellitus exerts a wide-ranging suppressive effect on immunity, reducing functional capacity of polymorphonuclear leucocytes, decreasing T-cell activity, and compromising gastrointestinal mucosal integrity [3]–[4]. These defects render DM patients disproportionately susceptible to intestinal parasites [5]. IPIs contribute to anaemia through chronic intestinal blood loss (hookworm), impaired nutrient absorption (*Ascaris*), and dysentery with blood loss (*E. histolytica*) [6].

Glycated haemoglobin (HbA1c) provides an integrated measure of glycaemic control over two to three months. Poor glycaemic control is associated with heightened parasitic infection risk because hyperglycaemia impairs immune effector functions and creates a metabolic milieu favourable to parasite survival [7]–[8]. The bidirectional relationship between IPIs and glycaemic control has been proposed as a vicious clinical cycle [9]–[10].

Helminths drive a Th2-polarised immune response involving IL-4, IL-5, and IL-13 and expansion of regulatory T cells. These shifts have been shown to modulate insulin sensitivity in experimental models, suggesting that helminth-induced immunomodulation may alter the metabolic trajectory of type 2 DM [11]. In clinical populations with poorly controlled DM, concurrent helminthic infection accelerates glycaemic instability and increases the risk of hypoglycaemic episodes secondary to impaired nutrient absorption [12].

Anaemia in DM patients carries additional prognostic weight: Ramirez-Manent et al. [13] found it was independently associated with chronic kidney disease progression, diabetic retinopathy, and all-cause mortality. A 2025 African meta-analysis by Debash et al. [14], pooling sixteen studies, reported a pooled IPI prevalence of 31% in diabetic patients, with poor glycaemic control consistently identified as a significant risk factor, consistent with findings from Nigeria [15]. Despite this, data from Ondo State linking parasite species distribution to anaemic status, BMI, lipid profile, diarrhoeal presentation, and HbA1c values in DM patients remain absent. This study addresses that gap.

2 MATERIALS AND METHODS

2.1 Study Design and Population

This cross-sectional study enrolled 284 DM patients (54.3% male, 45.7% female), aged 30–70 years, at Out-Patient clinics across three senatorial districts of Ondo State, with 60 non-diabetic controls. The protocol for this study was approved by the Ethics and Research Committee of the Ministry of Health in Ondo State (Reference No: OSHREC/04/10/2024/761). Informed consent was also obtained from the participants before collecting specimens.

2.2 Laboratory Methods

Stool specimens were examined using the formol-ether concentration method [16] and the modified Ziehl-Neelsen staining method [17] and observed microscopically using $\times 10$ and $\times 40$ objective lenses. Full blood count was obtained using the XN-330 Sysmex automated analyser. HbA1c was measured using the Finecare FIA Meter (fluorescence immunoassay; 5-minute result). Body mass index (BMI) was calculated as weight (kilograms) divided by height squared (metres) for the participants. Serum total cholesterol, high-density lipoprotein (HDL) cholesterol, and triglycerides were quantified by standard enzymatic colorimetric methods using a calibrated semi-automated spectrophotometer. Low-density lipoprotein (LDL) cholesterol was estimated using the Friedewald equation, where LDL equals total cholesterol minus HDL minus the quotient of triglycerides divided by five, a formula validated for fasting samples with triglyceride concentrations below 400 mg/dL [18]. Glycaemic control was classified as well-controlled ($\text{HbA1c} \leq 6.0\%$), moderately controlled ($> 6.0 - < 8.0\%$), poorly controlled ($\geq 8.0\%$) [19]. Chi-square tests were performed using Statistical Package for the Social Sciences (SPSS) version 27, and the level of statistical significance was set at $p < 0.05$.

3 RESULTS

3.1 Parasite Species Distribution

Out of 284 DM patients, 78 (27.5%) were positive for intestinal parasitic infections (IPIs): 58 helminthic (20.4%) and 20 protozoan infections (7.1%). The intestinal parasites identified among DM patients were *Ascaris lumbricoides* (11.9%), the most predominant parasite, followed by *Entamoeba histolytica* (7.1%), *Schistosoma mansoni* (4.2%), Hookworm (2.5%), *Trichuris trichiura* (1.1%), and *Enterobius vermicularis* (0.7%) (Table 1).

Table 1: Distribution of intestinal parasite species among DM patients.

Parasites	Number Tested	Prevalence (%)
Protozoa	20	7.1
<i>Entamoeba histolytica</i>	20	7.1
Helminths	58	20.4
<i>Ascaris species</i>	34	11.9
<i>Schistosoma mansoni</i>	12	4.2
Hookworm	7	2.5
<i>Trichuris trichiura</i>	3	1.1
<i>Enterobius vermicularis</i>	2	0.7

3.2 The relationship between IPIs, Haemoglobin values, Anaemic Status and Body mass index (BMI)

Haemoglobin (Hb, g/L) significantly affected the prevalence of intestinal parasitic infections ($p = 0.0001$). DM patients infected with intestinal parasites had a lower mean Hb value of 532.64 g/L (± 40.82 SEM) compared with DM patients without parasitic infection, who had a mean Hb value of 697.23 g/L (± 24.81 SEM) (Table 2). This finding suggests that parasitic infection was associated with reduced haemoglobin levels among diabetic patients. Anaemia status significantly affected the prevalence of intestinal parasitic infections. Anaemic subjects had the highest prevalence of 27 (51.9%) compared with non-anaemic subjects who had a prevalence rate of 51 (22.0%) (Table 3).

Table 2: Haemoglobin values in DM patients with and without IPIs.

Patients	N	Mean Hb (g/L)	$\pm$ SEM	P-value
With parasites	78	532.64	± 40.82	0.0001
Without parasites	206	697.23	± 24.81	

SEM=Standard Error of the Mean.

Table 3: Relationship between anaemia status and IPIs.

Anaemia Status	Number Tested	Number Infected (%)	χ^2	P-value
Anaemic	52	27 (51.9)	19.11	<0.001
Non-anaemic	232	51 (22.0)		
BMI (kg/m ²)				
Normal (18.5 – 24.9)	269	70 (26.0)	6.49	0.04
Overweight (25 – 29.9)	14	7 (50.0)		
Obese (≥ 30)	1	1 (100.0)		
Total	284	78 (27.5)		

HbA1c = Glycated Haemoglobin; BMI = Body Mass Index; $p < 0.05$.

The finding showed that the BMI significantly influenced the prevalence of intestinal parasitic infections in DM patients ($p=0.04$), with normal weight individuals having a prevalence rate of 26.0% (70/269), overweight participants at 50.0%

(7/14), while only one obese individual was affected. Income status was not significantly associated with intestinal parasitosis among diabetic patients ($p=0.29$) (Table 3).

3.3 Effect of Diabetes Mellitus (DM) on Intestinal Parasitic Infections.

The duration of DM was not significantly associated with intestinal parasitic infections ($p=0.46$) (Table 4). When evaluated in terms of risk factors, a statistically significant association was observed between intestinal parasite positivity and HbA1c level ($p<0.001$) in the diabetic patient group. All patients with HbA1c ≥ 8 were infected with intestinal parasites (100.0%), compared with 16.5% of those with ≤ 6.0 and 14.2% with values between >6.0 and <8 (Table 4).

Table 4: Effect of Diabetes Mellitus (DM) and control status on Intestinal Parasitic Infections.

DM Characteristic	Number Tested	Number Infected (%)	χ^2	P-value
Duration				
1 year	18	4 (22.2)	1.56	0.46
2 years	63	14 (22.2)		
≥ 3 years	203	60 (29.6)		
HbA1c				
$\leq 6.0\%$ (well-controlled)	58	9 (16.5)	16.69	<0.001
> 6.0 – $< 8.0\%$ (moderate)	183	26 (14.2)		
$\geq 8.0\%$ (poor control)	43	43 (100.0)		

3.4 Relationship between Diarrhoea presentation, Lipid Profile and Intestinal Parasitic Infections among Diabetic Patients in Ondo State.

Clinical manifestation of diarrhoea did not significantly affect the prevalence of IPIs ($p=0.44$) among the DM subjects in the study community. Participants presenting with diarrhoea had a higher prevalence of infection (31.0%) than those without diarrhoea (26.3%), although the difference was not statistically significant (Table 5). Serum cholesterol, HDL, and LDL levels were not significantly associated with intestinal parasitic infections in this study ($p > 0.05$) (Table 6).

Table 5: Relationship between Diarrhoea and Intestinal Parasitic Infections among Diabetic Patients.

Variable	Number Tested	Number Infected (%)	χ^2	P-value
Diarrhoea	71	22 (31.0)	0.59	0.44
Without Diarrhoea	213	56 (26.3)		

DM = Diabetes Mellitus; $p<0.05$.

Table 6: Effect of Lipid Profile on Intestinal Parasitic Infections among Diabetic Patients in Ondo State.

Lipid Parameter	Number Tested	Number Infected (%)	χ^2	P-value
Total Cholesterol				
< 200 mg/dL	198	43 (21.7)	10.84	0.065
≥ 200 mg/dL	86	35 (40.7)		
LDL				
< 160 mg/dL	260	71 (27.3)	0.04	0.85
≥ 160 mg/dL	24	7 (29.2)		
HDL				
< 50 mg/dL	214	62 (29.0)	0.99	0.32
≥ 50 mg/dL	70	16 (22.9)		

LDL=Low-Density Lipoprotein. HDL=High-Density Lipoprotein.

4 DISCUSSION

4.1 Species Distribution of Intestinal Parasites

The prevalence of *Ascaris lumbricoides* in this study was 11.9%. This outcome is lower than the previous study conducted by Banjo et al. [20], who reported the high prevalence of 37.1% *Ascaris lumbricoides* in DM individuals attending hospitals in Kaduna Metropolis, Nigeria. These variations may be attributed to differences in environmental sanitation, personal hygiene practices, and behavioural risk factors such as consumption of unwashed vegetables, walking barefoot, inadequate handwashing, agricultural soil exposure, unsafe water sources, and improper waste disposal. Additionally, intestinal helminth infections, including ascariasis, are known to adversely affect nutritional status, particularly among individuals with chronic conditions such as diabetes mellitus, thereby compounding health risks in affected populations [21].

The prevalence of *Entamoeba histolytica* in this study was 7.1%. These variations may be attributed to differences in water quality, sanitation, consumption of raw vegetables, and handwashing practices [22].

The prevalence of hookworm infection was 2.5%, which is lower than findings from Kano State, Nigeria [23], and Lake Tana, Northwest Ethiopia [24]. Conversely, it is higher than the very low prevalence observed in Limbe and Buea, Cameroon (0.6%) [25]. Differences across studies are likely related to environmental sanitation, access to deworming programs, and behavioral factors such as barefoot walking and occupational exposure to contaminated soil [26]. Hookworm infection contributes to anaemia and protein deficiency due to chronic intestinal blood loss, and although intestinal helminths rarely cause mortality, they impose significant long-term effects on nutritional status and overall health [6].

The prevalence of *Schistosoma mansoni* in the study area was 4.2%. The observed prevalence may be explained by the riverine nature of the study area, where frequent human contact with natural water bodies during bathing, fishing, irrigation, and farming facilitates transmission [27]. Such ecological and occupational exposures are well recognized as key determinants of schistosomiasis distribution in endemic communities.

The prevalence of *Trichuris trichiura* in the study area was 1.1%. These differences may reflect variations in sanitation practices, use of human feces as fertilizer, barefoot farming, and contamination of food and water sources [28]. The prevalence of *Enterobius vermicularis* was 0.7%, the lowest among the identified parasites. These variations may be associated with hygiene practices, consumption of unwashed fruits and vegetables, and the use of unsafe water sources [29].

Overall, the predominant intestinal parasitic infections across the three senatorial districts were *Ascaris lumbricoides* (11.9%), *Entamoeba histolytica* (7.1%), and hookworm (2.5%), consistent with patterns reported in other endemic settings [24].

4.2 Relationship between IPIs, Haemoglobin values, Anaemic Status and Body mass index (BMI)

The significant association between anaemia and IPI association ($p < 0.001$) aligns with the well-established haematological impact of intestinal helminthic infections. The mean haemoglobin concentration in IPI-positive patients (532.64 ± 40.82 g/L) was 164.59 g/L lower than that in IPI-negative counterparts (697.23 ± 24.81 g/L; $p = 0.0001$), demonstrating additive haematological burden when DM and IPIs coexist [30].

Glycated haemoglobin (HbA1c) showed a strong association with intestinal parasitosis ($p < 0.001$). Poor glycaemic control may impair parasite clearance due to defects in both innate and adaptive immunity, including reduced neutrophil function and compromised mucosal integrity [7]–[8]. Similar results were reported in Van, where higher HbA1c levels were associated with markedly increased parasite prevalence [10].

Body mass index (BMI) was also significantly associated with infection ($p = 0.04$). Intestinal parasites can impair nutrient absorption and cause gastrointestinal symptoms that influence body weight and metabolic control [31]. The observed positive relationship between BMI and HbA1c supports evidence that overweight and obesity worsen insulin resistance and glycaemic regulation [32]–[34]. Lifestyle-based weight management, including diet, physical activity, and behavioral interventions, has been shown to improve glycaemic outcomes, as demonstrated in the Look AHEAD trial [35]–[36]. These findings underscore the importance of integrating weight management into diabetes care to improve metabolic control and reduce susceptibility to infections.

4.3 Diabetes Type, Duration and Glycated Haemoglobin

The duration of DM did not significantly associate with intestinal parasitic infections ($p=0.46$). Among diabetic patients, intestinal parasitic infections were most commonly observed in the age group of 41–60 years however, no statistically significant difference was observed compared with other age groups. Tangi et al. [25] reported a higher prevalence of parasitic infections in the middle age (13.3%). Akinbo et al. [30] reported a female preponderance of 78.57%, which is consistent with our study where a male preponderance of 69.9% was observed. This inconsistency in gender distribution may be attributed to variations in the sex-dependent distribution of the disease, which is influenced by socioeconomic and environmental factors [37].

4.4 Intestinal Parasitic Infections and the Clinical Manifestation of Diarrhoea and Lipid profile

Participants with diarrhoea recorded a higher IPI prevalence than those without, though the difference was not statistically significant. Waly et al. [9], working among diabetic patients at Beni-Suef University Hospital, Egypt, observed an association between IPI and diarrhoea ($p<0.001$), suggesting the relationship may be genuine but context-dependent. The non-significant result in the present study likely reflects two intersecting factors. First, the infections detected were predominantly helminthic, and soil-transmitted helminths at low to moderate infection intensities are more frequently subclinical than protozoa such as *Entamoeba histolytica* and *Giardia lamblia*, which more directly provoke acute mucosal symptoms [37]. Second, diarrhoea among diabetic patients is frequently non-infectious in origin, arising from autonomic neuropathy and small intestinal bacterial overgrowth [38]. Sommers et al. [39] reported that 11.2% of United States diabetic adults had chronic diarrhoea independent of any enteric infection. These overlapping aetiologies dilute the diagnostic value of diarrhoea as a clinical indicator for parasitic infection in this population, reinforcing the need for routine stool examination regardless of gastrointestinal symptom status [40].

No lipid parameter was significantly associated with IPI prevalence ($p>0.05$). Nevertheless, a biologically important trend emerged for total cholesterol: participants with values ≥ 200 mg/dL had a higher infection rate (40.7%) than those below this threshold (21.7%), with a more pronounced pattern at ≥ 300 mg/dL (87.5% vs 25.7%), though the higher stratum comprised only eight individuals, and this finding warrants cautious interpretation. This trend is plausible, since protozoan parasites, including *Entamoeba histolytica* and *Giardia lamblia*, exploit cholesterol-rich membrane lipid rafts for host cell entry, while *Schistosoma* species exchange cholesterol with the host environment during reproduction [41]. Elevated total cholesterol is simultaneously a recognized feature of poorly controlled type 2 diabetes, with a pooled prevalence of 38.6% reported across 60 African studies [42], suggesting a shared metabolic substrate favouring both conditions. There were no significant associations observed for LDL or HDL, consistent with evidence that active helminthic infection itself suppresses these fractions, a bidirectionality that cross-sectional designs cannot fully elucidate [43]. These findings provide preliminary grounds for incorporating lipid management into parasitological risk assessment among diabetic patients [40].

5 CONCLUSION

This study provides the first integrated, laboratory-confirmed characterisation of intestinal parasite species distribution, anaemic status, and glycaemic control among DM patients across all three senatorial districts of Ondo State. The findings establish three clinically significant patterns. First, helminths accounted for the majority of infections, with *Ascaris lumbricoides* predominating (11.9%), highlight persistent environmental and sanitation risk factors that deworming programmes must address. Second, the haematological burden is substantial: IPI-positive patients exhibited a mean haemoglobin deficit of 164.59 g/L compared with uninfected counterparts, and anaemic participants had more than twice the prevalence of IPI observed among non-anaemic patients (51.9% vs 22.0%; $p < 0.001$). Third, glycaemic control was the strongest correlate of infection status, with every patient in the poor glycaemic control category ($HbA1c \geq 8.0\%$) parasitologically positive. Taken together, these findings support the routine integration of parasitological and haematological screening into DM management protocols in endemic areas of Nigeria, particularly for patients with suboptimal glycaemic control, and reinforce the case for context-specific anthelmintic therapy as a component of comprehensive diabetic care in sub-Saharan Africa.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

Statement of Ethical approval

Ethical clearance was obtained from the Ondo State Ministry of Health (Reference No: OSHREC/04/10/2024/761).

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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