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Association of *Giardia duodenalis* Infection with Diabetes Mellitus and Chronic Gastrointestinal Diseases among Patients Attending Benghazi Medical Center Eastern Libya: A Cross-Sectional Study

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Abstract **Original Research Article**

Background: *Giardia duodenalis* is one of the most prevalent intestinal protozoan parasites worldwide and remains an important public health concern, particularly in low- and middle-income countries. Beyond its role in acute diarrhoeal disease, increasing evidence suggests that giardiasis may be associated with chronic gastrointestinal and metabolic disorders through alterations in intestinal barrier integrity, immune regulation, and gut microbiota. However, data regarding these associations remain limited in Libya. ***Objective:*** To investigate the distribution of *Giardia duodenalis* infection patterns and evaluate their associations with diabetes mellitus and chronic gastrointestinal diseases among patients attending Benghazi Medical Center, Eastern Libya. ***Methods:*** A hospital-based cross-sectional study was conducted among 94 patients attending Benghazi Medical Center. Stool specimens were examined using conventional parasitological techniques for the detection of intestinal parasites. Demographic and available clinical data were collected from study records. Associations between *Giardia*-associated infection patterns, diabetes mellitus, and chronic gastrointestinal diseases were assessed using appropriate statistical tests, with statistical significance defined as $P < 0.05$. ***Results:*** *Giardia duodenalis* was the predominant intestinal protozoan identified, with cysts detected in 65.9% (62/94) of participants. A statistically significant association was observed between *Giardia*-associated infection patterns and diabetes mellitus ($P = 0.033$). A significant association was also observed between intestinal parasitic infection patterns and chronic gastrointestinal diseases ($P = 0.016$). Among participants with available gastrointestinal clinical data, inflammatory bowel disease was the most frequently reported chronic gastrointestinal condition (57.8%), followed by *Helicobacter pylori* infection (23.3%). ***Conclusion:*** *Giardia duodenalis* was the predominant intestinal protozoan detected among patients attending Benghazi Medical Center. The observed associations between *Giardia*-associated infection patterns, diabetes mellitus, and chronic gastrointestinal diseases highlight the potential clinical relevance of giardiasis beyond acute intestinal infection. However, because of the cross-sectional design, these associations should not be interpreted as evidence of causality. Further longitudinal and mechanistic studies are warranted to clarify the nature of these relationships.

Keywords: *Giardia duodenalis*; Giardiasis; Diabetes mellitus; Inflammatory bowel disease; *Helicobacter pylori*.

INTRODUCTION

Intestinal parasitic infections (IPIs) continue to represent a major global public health challenge, particularly in low- and middle-income countries where inadequate sanitation, poor personal hygiene, contaminated food and water, and limited access to healthcare contribute to sustained transmission (Barasa *et al.,* 2025; Tawana *et al.,* 2023). It is estimated that billions of people worldwide are infected with intestinal parasites, with protozoan infections accounting for a substantial proportion of gastrointestinal morbidity and impaired quality of life. Beyond causing acute diarrhoeal illness, these infections are increasingly recognized for their association with chronic gastrointestinal disorders, malnutrition, impaired nutrient absorption, and reduced productivity.

Among intestinal protozoa, *Giardia duodenalis* (syn. *Giardia lamblia* or *Giardia intestinalis*) is one of the most frequently reported pathogens infecting humans worldwide. Transmission occurs primarily through the fecal–oral route via ingestion of infective cysts in

contaminated water or food or through direct person-to-person contact. Following ingestion, excystation occurs in the small intestine, where trophozoites colonize the intestinal mucosa, resulting in a wide spectrum of clinical manifestations ranging from asymptomatic carriage to chronic diarrhoea, abdominal pain, bloating, malabsorption, and weight loss (Lalle & Cacciò, 2023; Adam *et al.,* 2021).

The clinical expression of giardiasis is influenced by multiple factors, including parasite genotype, infective dose, nutritional status, gut microbiota composition, and host immune responses. Persistent infection has also been implicated in post-infectious irritable bowel syndrome, chronic intestinal inflammation, and prolonged gastrointestinal dysfunction, emphasizing the importance of early diagnosis and appropriate management (Halliez & Buret, 2013; Allain *et al.,* 2017).

Patients with chronic gastrointestinal diseases may be particularly susceptible to intestinal parasitic infections because alterations in intestinal barrier function, chronic mucosal inflammation, and dysbiosis facilitate colonization by enteric pathogens. Similarly, diabetes mellitus has emerged as an important risk factor for infectious diseases owing to impaired innate and adaptive immune responses, reduced neutrophil function, altered cytokine production, and defects in cell-mediated immunity.

Recent systematic reviews have suggested that intestinal parasitic infections occur more frequently among diabetic individuals than in the general population, although evidence remains limited in several regions, including North Africa (Tork *et al.,* 2023).

Despite the public health importance of intestinal parasitic infections, epidemiological data from Libya remain scarce, particularly regarding their relationship with diabetes mellitus and chronic gastrointestinal diseases. Most published studies from the region have focused on estimating prevalence, with limited evaluation of associated clinical and laboratory findings. Consequently, further investigations are needed to improve understanding of the epidemiology and clinical significance of intestinal parasitic infections among patients presenting with gastrointestinal disorders.

Previous studies have explored the relationship between infectious agents and diabetes, including experimental evidence demonstrating the detrimental effects of enteroviruses on human pancreatic islet cells (Elshebani *et al.,* 2007). However, evidence regarding the association between *Giardia duodenalis* infection, diabetes mellitus, and chronic gastrointestinal diseases remains limited, particularly in North Africa and Libya.

Therefore, the study aimed to determine the prevalence of intestinal parasitic infections among patients attending Benghazi Medical Center, Eastern Libya, and to investigate their associations with diabetes mellitus, chronic gastrointestinal diseases, gastrointestinal symptoms, and macroscopic and microscopic stool examination findings.

MATERIAL AND METHODS

Study Design and Setting

This hospital-based cross-sectional study was conducted at Benghazi Medical Center (BMC), Benghazi, Libya, one of the largest tertiary referral and teaching hospitals in the country. The study was conducted between 30 December 2022 and 30 March 2024 and included patients attending the gastroenterology outpatient clinics who underwent routine stool examination as part of their clinical evaluation.

Study Population

A total of 94 participants were enroled in the study. Patients of both sexes who had complete stool examination records and available clinical information were eligible for inclusion. Individuals with incomplete laboratory or clinical records were excluded from the analysis. Demographic information, including age and sex, together with clinical data on diabetes mellitus and chronic gastrointestinal diseases, was obtained from hospital medical records.

Stool Sample Collection

Fresh stool specimens were collected in sterile, wide-mouthed plastic containers without preservatives and transported immediately to the Parasitology Laboratory for examination. Each specimen was labeled with a unique identification code and processed on the day of collection according to routine laboratory procedures.

Laboratory Examination

Fresh stool specimens were examined immediately after collection using standard parasitological procedures.

Clinical Data Collection

Clinical information was extracted from hospital records and included demographic characteristics, diabetes mellitus status, and documented chronic gastrointestinal diseases, including inflammatory bowel disease (IBD), *Helicobacter pylori* Infection, celiac disease, Crohn's disease, colitis, diverticular disease, gastritis, autoimmune disorders, and oncology-related conditions. These variables were used to evaluate their association with *Giardia duodenalis* infection patterns.

Statistical Analysis

Data analysis was conducted using SPSS Statistics (Version 26). Categorical variables were summarized as frequencies and percentages. Associations between *Giardia duodenalis* infection patterns and demographic or clinical variables were evaluated using the Chi-square test or Fisher's exact test, as appropriate. A two-tailed P value < 0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the Local Research Ethics Committee of Benghazi Medical Center. Written informed consent was obtained from all participants before enrolment. All collected data were anonymized and handled confidentially throughout the study in accordance with the principles of the Declaration of Helsinki.

RESULTS

Characteristics of the Study Population

A total of 94 participants were enrolled in this hospital-based cross-sectional study. Females represented 57.4% (54/94) of the study population, while males accounted for 42.6% (40/94). Gender was not significantly associated with the distribution of intestinal parasitic infections
(P = 0.330) (Table 1).

Table 1: Demographic characteristics of the Study Population

Gender	N	%
Male	40	42.55
Female	54	57.45
Total	94	100

Distribution of *Giardia duodenalis* Infection Patterns

The most frequently observed infection pattern was *Giardia duodenalis* cysts (GC), accounting for 65.9% (62/94) of participants. Other infection patterns included GC+EH (10.6%), GC+Charcot–Leyden crystals (7.4%), GC+GT (5.3%), GC+EH+Charcot–Leyden crystals (5.3%), GT (4.3%), and GCTCHA (1.1%) (Table 2).

Table 2: Distribution of *Giardia duodenalis* Infection Patterns

		GC	GC+GT	GC+EH	GC+Charcol	GC+EH+ Charcol	GT	GCTCHA	Total
Male	Count	**27**	**2**	**6**	**2**	**2**	**0**	**1**	**40**
	% within gender	67.5%	5.0%	15.0%	5.0%	5.0%	0.0%	2.5%	%100
Female	Count	35	3	4	5	3	4	0	54
	% within gender	64.8%	5.6%	7.4%	9.3%	5.6%	7.4%	0.0%	100.0%
	Count	62	5	10	7	5	4	1	94
	% within gender	65.9%	5.3%	10.6%	7.4%	5.3%	4.3%	1.1%	100.0%

Association Between *Giardia duodenalis* Infection and Diabetes Mellitus (DM)

Diabetes status was available for 85 participants, including 25 (29.4%) individuals with diabetes mellitus and 60 (70.6%) without diabetes. The prevalence of diabetes did not differ significantly between males and females (P = 0.814) (Table 3).

Table 3: Distribution DM according to gender

			DM		Total
			Non-diabetic	DM	
Gender	Male	Count	26	10	36
		% within Gender	72.2%	27.8%	100.0%
	Female	Count	34	15	49
		% within Gender	69.4%	30.6%	100.0%
Total		Count	60	25	85
		% within Gender	70.6%	29.4%	100.0%

A statistically significant association between diabetes mellitus and intestinal parasitic infectin (P = 0.033) (Table 4). *Giardia duodenalis* cysts were the most frequently observed infection pattern among both diabetic and non-diabetic participants

Table 4: Relation between DM and Parasitic Infection

Count			
	DM		**Total**
	Non-diabetic	**DM**	
GC	44	12	56
GC+GT	3	2	5
GC+E.H	2	5	7
GC+Charcol	3	4	7
GC+E.H+Charcol	4	1	5
GT	3	1	4
GCTCHA	1	0	1
Total	60	25	85

Association Between *Giardia duodenalis* Infection and Chronic Gastrointestinal Diseases

Clinical information regarding chronic gastrointestinal diseases was available for 90 participants. Inflammatory bowel disease (IBD) represented the most common diagnosis (57.8%, 52/90), followed by *Helicobacter pylori* infection (23.3%, 21/90) and celiac disease (6.7%, 6/90). Other gastrointestinal disorders were observed less frequently (Table 5).

Table 5: Distribution of gender and chronic gastrointestinal diseases

		Chronic Disease									
			h.pylori infection	**IBD**	**Celiac DIS**	**AID**	**Oncology**	**Crons disease**	**DIVERTICULUM DIS**	**Colitis**	**GASTRITIS**	**Total**
Gender	Male	Count	9	27	2	0	0	0	0	0	0	38
		%within Gender	23.7%	71.1%	5.3%	0%	0%	0%	0%	0%	0%	100%
	Female	Count	12	25	4	1	1	4	1	3	1	52
		%within Gender	23.1%	48.1%	7.7%	1.9%	1.9%	7.7%	1.9%	5.8%	1.9%	100%
	Total	Count	21	52	6	1	1	4	1	3	1	90
		%within Gender	23.3%	57.8%	6.7%	1.1%	1.1%	4.4%	1.1%	3.3%	1.1%	100.0%

A statistically significant association was identified between chronic gastrointestinal diseases and intestinal parasitic infection (P = 0.016) (Table 6). Patients diagnosed with IBD constituted the largest proportion of participants infected with *Giardia duodenalis*, followed by those with *H. pylori* infection.

Table 6: Distribution of Chronic Disease and Parasitic Infection

	GC	**GC+GT**	**GC+E.H**	**GC+Charcol**	**GC+E.H+Charcol**	**GT**	**GCTCHA**	**Total**
H.pylori infection	10	2	5	2	0	2	0	21
IBD	37	3	3	3	5	0	1	52
Celiac disease	3	0	1	0	0	2	0	6
AID	0	0	0	1	0	0	0	1
Oncology	0	1	0	0	0	0	0	1
Crohns disease	3	0	1	0	0	0	0	4
Diverticular disease	0	0	0	1	0	0	0	1
Colitis	4	0	3	0	0	0	0	7
GASTRITIS	1	0	0	0	0	0	0	1
missing								2
Total	57	5	9	7	5	4	1	88

Summary of the Main Findings

Overall, *Giardia duodenalis* was the predominant intestinal parasite, accounting for approximately two-thirds of all detected parasitic infections. Significant associations were identified between *Giardia* infection patterns and both diabetes mellitus (P = 0.033) and chronic gastrointestinal diseases (P = 0.016), whereas no significant associations were observed with gender.

DISCUSSION

The present study investigated the association between *Giardia duodenalis* infection patterns, diabetes mellitus, and chronic gastrointestinal diseases among patients attending Benghazi Medical Center in Eastern Libya. The principal findings demonstrated that *Giardia duodenalis* was the predominant intestinal parasite identified in the study population and that significant associations existed between *Giardia* infection patterns and both diabetes mellitus and chronic gastrointestinal diseases, particularly inflammatory bowel disease (IBD). These findings extend the growing body of evidence suggesting that giardiasis should not be regarded solely as an acute self-limiting intestinal infection but rather as a condition with potential implications for chronic gastrointestinal and metabolic health (Halliez & Buret, 2013; Allain *et al.,* 2017; Cacciò & Ryan, 2024).

The predominance of *Giardia duodenalis* observed in the present study is consistent with numerous epidemiological investigations identifying *Giardia* as one of the most prevalent intestinal protozoan parasites worldwide, (Garcia, 2020; Einarsson *et al.,* 2016). Hospital-based studies have similarly reported a relatively high frequency of giardiasis among patients with chronic medical conditions, suggesting that underlying diseases may influence susceptibility to persistent intestinal parasitic infections (Halliez & Buret, 2013).

One of the most important findings of this study was the significant association between *Giardia duodenalis* infection and diabetes mellitus. Although the cross-sectional design precludes establishing a causal relationship, several biological mechanisms may explain this observation. Diabetes mellitus is characterized by impaired innate and adaptive immune responses, including reduced neutrophil chemotaxis, impaired macrophage activity, altered cytokine production, and defects in cell-mediated immunity, all of which increase susceptibility to infectious diseases (Casqueiro *et al.,* 2012; American Diabetes Association Professional Practice Committee, 2025). Chronic hyperglycaemia also disrupts intestinal epithelial barrier function, alters gut microbial composition, and promotes persistent low-grade inflammation, thereby creating a favorable environment for enteric pathogens, including *Giardia duodenalis* (Tilg *et al.,* 2020; Allain *et al.,* 2017).

Experimental studies have further demonstrated that *Giardia* infection can induce epithelial barrier dysfunction, increase intestinal permeability, disrupt tight junction proteins, and modulate both innate and adaptive immune responses (Halliez & Buret, 2013; Beatty *et al.,* 2017). These alterations may contribute to prolonged intestinal colonization and persistent inflammatory responses, particularly in individuals with impaired immune regulation such as patients with diabetes mellitus.

The present findings should also be interpreted within the broader context of research investigating infectious agents as potential contributors to metabolic diseases. In an experimental study, (Elshebani *et al.,* 2007) demonstrated that enterovirus isolates obtained from patients at the clinical onset of type 1 diabetes were capable of infecting isolated human pancreatic islet cells, resulting in cellular injury and impaired insulin secretion. Although the current study investigated an intestinal protozoan rather than viral pathogens, both studies support the broader hypothesis that infectious agents may contribute to metabolic dysfunction through different biological pathways. Whereas enteroviruses appear to exert direct cytopathic effects on pancreatic β-cells, *Giardia duodenalis* is more likely to influence glucose metabolism indirectly through chronic intestinal inflammation, immune dysregulation, epithelial barrier disruption, and alterations of the intestinal microbiota. Consequently, the present findings expand the concept of infection-associated metabolic disease by suggesting that chronic intestinal parasitic infections may also be relevant in patients with diabetes mellitus.

Another important finding of the present study was the significant association between *Giardia duodenalis* infection and chronic gastrointestinal diseases, particularly inflammatory bowel disease and *Helicobacter pylori* infection. Increasing evidence indicates that *Giardia* infection is capable of inducing persistent alterations in intestinal physiology even after apparent parasite clearance. These include disruption of epithelial barrier integrity, prolonged immune activation, changes in intestinal permeability, and intestinal dysbiosis, all of which have been implicated in the pathogenesis of chronic gastrointestinal disorders (Halliez & Buret, 2013; Allain *et al.,* 2017; Lalle & Hanevik, 2018).

The predominance of inflammatory bowel disease among participants with chronic gastrointestinal disorders is particularly noteworthy. Experimental and clinical investigations have suggested that disturbances in mucosal immunity and gut microbial homeostasis play central roles in the development and progression of IBD (Kaplan & Windsor, 2021; Ungaro *et al.,* 2017). Since *Giardia duodenalis* has been shown to modify both intestinal microbial composition and mucosal immune responses, persistent or recurrent giardiasis may represent an additional environmental factor capable of

exacerbating gastrointestinal inflammation in susceptible individuals (Beatty *et al.,* 2017; Halliez & Buret, 2013). Nevertheless, the cross-sectional nature of the present study does not allow determination of whether *Giardia* infection preceded gastrointestinal disease or occurred as a consequence of altered host susceptibility.

The observed coexistence of *Giardia* infection and *Helicobacter pylori* is also clinically relevant. Both pathogens colonize the upper gastrointestinal tract and are frequently associated with poor sanitation and shared environmental risk factors. Furthermore, chronic *H. pylori* infection has been associated with alterations in gastric acidity and gastrointestinal microbial ecology, factors that may influence intestinal colonization by enteric parasites (Malfertheiner *et al.,* 2022). However, additional studies are required to clarify whether this coexistence reflects shared epidemiological determinants or biologically relevant host–pathogen interactions.

The present study has several strengths. It represents one of the few investigations from Libya examining the relationship between *Giardia duodenalis*, diabetes mellitus, and chronic gastrointestinal diseases within the same patient population. In addition, the study moves beyond simple prevalence estimates by exploring clinically relevant associations between parasitic infection and chronic diseases. Nevertheless, several limitations should be acknowledged. The cross-sectional design precludes causal inference, the sample size was relatively modest, molecular characterization of *Giardia* assemblages was not performed, and host inflammatory biomarkers and gut microbiome profiles were not evaluated. These limitations should be addressed in future multicentre prospective studies.

Overall, the present findings provide important epidemiological evidence supporting an association between *Giardia duodenalis* infection, diabetes mellitus, and chronic gastrointestinal diseases in Eastern Libya. Together with previous experimental evidence demonstrating that infectious agents can contribute to metabolic dysfunction through diverse mechanisms (Elshebani *et al.,* 2007), the current study highlights the need for further multidisciplinary research integrating parasitology, immunology, microbiology, and metabolic medicine to better understand the complex interactions between intestinal pathogens and chronic human diseases.

CONCLUSION

This study demonstrated that *Giardia duodenalis* was the predominant intestinal parasite among patients attending Benghazi Medical Center in Eastern Libya. Significant associations were observed between *Giardia* infection patterns and both diabetes mellitus and chronic gastrointestinal diseases, particularly inflammatory bowel disease (IBD), highlighting the potential clinical relevance of giardiasis beyond acute intestinal infection.

Although the cross-sectional design does not permit causal inference, the findings suggest that *Giardia duodenalis* infection should be considered during the clinical evaluation of patients with diabetes mellitus and chronic gastrointestinal disorders, particularly in endemic regions. The observed associations may reflect complex interactions involving intestinal inflammation, immune dysregulation, epithelial barrier dysfunction, and alterations in the gut microbiota.

Further multicenter prospective studies incorporating molecular characterization of *Giardia* assemblages and investigations of host immune responses are needed to clarify the biological mechanisms underlying these associations. Overall, this study provides important epidemiological evidence from Libya and contributes to the growing understanding of the relationship between *Giardia duodenalis*, chronic gastrointestinal diseases, and diabetes mellitus.

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