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Original paper

Intestinal parasitic infections among type-2 diabetics seeking healthcare in Sana'a city, Yemen

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ABSTRACT. Intestinal parasitic infections (IPIs) are common in developing countries, particularly in countries witnessing conflicts and humanitarian crises like Yemen. Type-2 diabetics are among the population categories most vulnerable to a variety of infections, including IPIs. Therefore, this study determined the prevalence and risk factors associated with IPIs among Yemeni type-2 diabetics in Sana'a city. This hospital-based, cross-sectional study recruited 389 type-2 diabetics seeking healthcare in Sana'a from December 2019 to February 2020. Sociodemographic data and risk factors were collected from interviewed participants using a structured questionnaire. Stool samples were collected and examined for parasites using standard techniques. The association of sociodemographic characteristics and risk factors with IPIs was tested using univariate analysis, and a multivariable logistic regression model was developed to identify the independent predictors of IPIs at a significance level of <0.05. The overall prevalence of IPIs among diabetics was 38.6%. *Entamoeba histolytica/dispar* (30.3%) was the most frequent parasite, followed by *Cryptosporidium* species (8.2%). The significant independent predictors of IPIs were duration of diabetes mellitus > 10 years (AOR = 1.6; 95% CI: 1.10–2.47, *P* = 0.029), eating unwashed vegetables/fruits (AOR = 3.2; 95% CI: 1.44–6.92, *P* = 0.004) and not practicing handwashing before meals (AOR = 2.4; 95% CI: 1.10–5.48, *P* = 0.035). Over one-third of type-2 diabetics seeking healthcare in Sana'a city are infected with one or more IPIs, predominantly with *E. histolytica/dispar*, followed by *Cryptosporidium* species. Such infections cannot be predicted from the sociodemographic characteristics of diabetics. Nevertheless, prolonged duration of diabetes mellitus, eating unwashed vegetables/fruits and not practicing handwashing before meals are independent predictors of IPIs among type-2 diabetics. Large-scale studies are recommended for IPIs among type-2 diabetics with and without gastrointestinal complaints, preferably in comparison to non-diabetics.

Keywords: intestinal parasitic infections, type-2 diabetes mellitus, prevalence, risk factors, Yemen

Introduction

Many types of intestinal parasitic infections (IPIs) represent an important category of neglected tropical diseases (NTDs) associated with morbidity and mortality in endemic developing countries. Among others, faecal contamination of the environment, poor sanitary infrastructure and poor hygienic practices are the factors most commonly associated with the prevalence of IPIs. In addition, behavioral, socio-economic and climatic conditions contribute to the burden of IPIs in endemic areas [1].

Soil-transmitted helminthoses and schistosomosis are associated with high morbidity and mortality in tropical and sub-tropical countries. Soil-transmitted

helminthoses, which are caused by nematodes collectively called soil-transmitted helminths (STHs); namely, *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms (*Ancylostoma duodenale*/*Necator americanus*), are the most prevalent IPIs, particularly among the poorest and most underserved communities with a global estimate of over 1.5 billion infected people [2]. Intestinal schistosomosis, mainly caused by the blood flukes *Schistosoma mansoni* and *S. japonicum*, can present as an acute and chronic disease with fatal complications. Schistosomosis is endemic in 78 countries, where over 230 million people needed preventive chemotherapy in 2019; out of whom, 105.4 million people received praziquantel [2]. Strongyloidosis and enterobiosis are the two common non-STH nematode infections that can be transmitted via contamination or autoinfection, primarily affecting the poorest communities living under unhygienic and unsanitary conditions. Strongyloidosis can cause fatal hyperinfection syndrome or disseminated disease in case of reduced immunity, with an estimate of over 600 million infected people worldwide [2]. Enterobiosis is one of the most common IPIs and is estimated to infect about 200 million people worldwide, particularly children aged 5–10 years old [3]. Hymenolepiosis and taeniosis are the two major cestode infections in several tropical and sub-tropical countries. *Hymenolepisis nana* is cosmopolitan, mostly asymptomatic and probably the most common type of infection with cestodes worldwide, particularly among children with an estimate of 50–75 million carriers [4]. Taeniosis, caused by *Taenia saginata* or *Taenia solium*, is prevalent where beef (for taeniosis saginata) or pork (for taeniosis solium) of infected animals is consumed raw or inadequately cooked. The prevalence of each type varies geographically within and across countries [4].

Of protozoan IPIs, amoebosis and giardiosis are prevalent in developing and, to a lesser extent, developed countries. *Entamoeba histolytica* is usually associated with asymptomatic amebosis in 90% of cases, which are attributed to the non-pathogenic but morphologically identical species *Entamoeba dispar* [5]. However, about 50 million people become symptomatic annually presenting with acute amebic dysentery or even complications of invasive amebosis, such as amebic liver abscess, with nearly 100,000 deaths per year [6]. *Giardia duodenalis* is one of the most common diarrhea-causing pathogens worldwide with the potential for zoonotic transmission, accounting for about 200 million cases annually [7]. The intestinal coccidia, *Cryptosporidium* species, *Cystoisospora belli* and *Cyclospora cayetanensis*, are opportunistic protozoa that infect the enteroepithelial cells and can cause protracted watery diarrhea in immuno-compromized patients. Cryptosporidiosis causes diarrhea, which is usually self-limiting in immunocompetent people but prolonged and life-threatening in young children and immuno-compromized patients, most commonly with *Cryptosporidium hominis* and *C. parvum* [8]. It is transmitted via the ingestion of oocysts or after contact with infected people or animals and is associated with foodborne and waterborne outbreaks [8]. Cystoisosporiosis and cyclosporiosis are emergent coccidian infections with global distribution, being associated with outbreaks following ingestion of water or produce contaminated with the infective mature oocysts [9].

In Yemen, a few reports have been published on IPIs, mainly focusing on the general population or apparently healthy workers [10–14], asymptomatic or symptomatic children/schoolchildren [15–31], or symptomatic patients seeking healthcare [32,33]. However, only a single study on IPIs among immunocompromized patients; namely, cancer patients undergoing chemotherapy in Sana'a [34], has been encountered by the time of drafting this paper. Therefore, there is a pressing need to unveil the burden of such IPIs among the untraced categories so far.

With the increasing incidence of diabetes mellitus (DM) and its consequences [35], it becomes imperative to determine the prevalence and identify the risk factors associated with various infectious diseases, including IPIs, among such an immunocompromized population category. DM is associated with immune dysfunction of both innate and acquired responses [36,37], increasing the risk of susceptibility to and severity of infections [38,39]. Concerning IPIs among diabetics, the findings of the few studies published elsewhere so far are conflicting. Some studies reported a higher prevalence of IPIs among diabetics compared to non-diabetic patients [40,41], while others did not find the prevalence of IPIs much higher, but even sometimes lower, among diabetics [42,43]. In Yemen, no reports have been published on IPIs among diabetics. Therefore, this study aimed to determine the prevalence and identify risk factors

associated with IPIs among type-2 diabetics in Sana'a city.

Materials and Methods

Study design, population and setting

A hospital-based, cross-sectional was conducted among laboratory-confirmed type-2 diabetics who were seeking healthcare in five major hospitals (three public and two private) in Sana'a city, the capital of Yemen, during the period from December 2019 to February 2020. Type-2 diabetics seeking healthcare in the hospitals were invited to participate voluntarily, irrespective of their gender or age. Diabetics were excluded from the study if they were pregnant women, had immuno-compromizing co-morbidities, were taking immunosuppressive drugs, reported the intake of anti-parasitic drugs two weeks before the study, or did not give written informed consent.

Sample size and sampling

A minimum sample size of 384 type-2 diabetics was calculated based on an expected prevalence of 50% for IPIs among type-2 diabetics because there was not any reported estimate, a confidence level of 95% and a precision of 5%. However, 389 cases were included in the study. The participants were consecutively recruited from the attendants seeking healthcare in the outpatient clinics of the study hospitals.

Data and sample collection

Data about sociodemographic characteristics and risk factors associated with IPIs were collected using a pre-designed, structured questionnaire via face-to-face interviews. Then, patients were asked to collect stool samples into pre-labeled, clean and leak-proof plastic containers after instructing them on the collection procedures. Because no diarrheic samples were observed, the stool samples were preserved in 10% formalin until processing and microscopic examination.

Parasitological examination

Stool sediments were examined systematically for protozoan cysts and helminthic ova and larvae after processing with the formal-ether concentration technique [44]. For the detection of coccidian oocysts, stool smears were prepared, fixed with absolute methanol and permanently stained with the modified Ziehl-Neelsen technique [45,46]. The parasite stages were identified and differentiated according to the criteria and bench aids of the World Health Organization (WHO) for the diagnosis of intestinal parasites [47].

Table 1. Sociodemographic characteristics of diabetics in Sana'a city, Yemen (2019–2020)*

Characteristic		n	(%)
Gender			
	Male	247	(63.5)
	Female	142	(36.5
Age (years) [a]			
	≤40	68	(17.6)
	> 40	318	(82.4)
	Median (IQR): 55.0 (15.0)		
	Range: 20–90		
Marital status [b]			
	Single	11	(2.8)
	Married	326	(84.0)
	Divorced	10	(2.6)
	Widowed	41	(10.6)
Literacy status [b]			
	Illiterate	135	(34.8)
	Literate	253	(65.2)
Employment status [c]			
	Unemployed	206	(54.4)
	Employed	173	(45.6)
Household size (members) [d]			
	≤5	89	(23.1)
	> 5	297	(76.9)
Khat chewing			
	Yes	290	(74.6)
	No	99	(25.4)
Frequency of khat chewing [e]			
	Daily	150	(51.7)
	Irregular	140	(48.3)

Explanations: *The total number of type-2 diabetics included in the study was 389, IQR: interquartile range, [a] missing in three cases, [b] missing in one case, [c] missing in 10 cases, [d] missing in three cases, [e] calculated for khat chewers

Statistical analysis

Data were analyzed using the IBM SPSS Statistics, Version 21.0 (IBM Corp., Armonk, NY, USA). The association of sociodemographic and risk factors with IPIs was tested using the chi-square test in a univariate analysis, reporting the odds ratios

Table 2. Prevalence and multiplicity of IPIs among type-2 diabetics seeking healthcare in Sana'a city, Yemen (2019–2020)*

IPIs	n	(%)
Overall prevalence	150	(38.6)
Protozoan infections		
E. histolytica/dispar	118	(30.3)
Cryptosporidium species	32	(8.2)
G. duodenalis	9	(2.3)
B. hominis	3	(0.8)
Helminthic infections		
H. nana	3	(0.8)
T. trichiura	3	(0.8)
E. vermicularis	2	(0.5)
Multiplicity of infection [a]		
Single	131	(87.3)
Double	17	(11.3)
Triple	2	(1.3)

Explanations: *The total number of type-2 diabetics examined for IPIs was 389, n: number infected, [a] calculated for infected type-2 diabetics

(ORs) of the associations with their corresponding 95% CIs. A multivariable logistic regression analysis was then used to identify the independent predictors of IPIs together with their adjusted ORs (AORs) and 95% CIs. Statistical significance was set at *P*-values <0.05.

Results

Sociodemographic characteristics of the study population

The majority of diabetics seeking healthcare in Sana'a city were males (63.5%), aged 40 years or older (82.4%), with a median age of 55.5 (15.0) years (range: 20–90), married (84%), literate (65.5%) and unemployed (54.4%). The habit of khat chewing was reported by about three-fourths of patients. Of whom, 51.7% were daily khat chewers (Tab. 1).

Prevalence and multiplicity of IPIs among type-2 diabetics

Out of 389 type-2 diabetics, the overall prevalence of IPIs was 38.6% (95% CI: 33.9–43.5). *E. histolytica*/*dispar* (30.3%) was the most frequent protozoan species detected, followed by *Cryptospo-*

Table 3. Association of IPIs with sociodemographic characteristics of type-2 diabetics seeking healthcare in Sana'a city, Yemen (2019–2020)

	N	Presence of IPIs			*P*-value
		n	(%)	OR (95% CI)	
Gender					
Male	247	96	(38.9)	1.0 (0.63–1.48)	0.914
Female	142	54	(38.0)	Reference	
Age (years)					
>40	318	125	(39.3)	1.2 (0.69–2.05)	0.318
≤40	68	24	(35.3)	Reference	
Literacy status					
Illiterate	135	52	(38.5)	1.0 (0.66–1.55)	1.000
Literate	253	98	(38.7)	Reference	
Employment status					
Unemployed	173	67	(38.7)	1.0 (0.64–1.46)	0.916
Employed	206	78	(37.9)	Reference	
Household size (members)					
≤5	89	36	(40.4)	Reference	0.620
>5	297	111	(37.4)	1.2 (0.70–1.85)	

Explanations: N: number examined, n: number infected, IPIs: intestinal parasitic infections, OR: odds ratio, CI: confidence interval

Table 4. Risk factors associated with IPIs among type-2 diabetics seeking healthcare in Sana'a city, Yemen (2019–2020)

	N	Presence of IPIs			*P*-value
		n	(%)	OR (95% CI)	
Duration since DM diagnosis (years)					
≤10	217	73	(33.6)	Reference	0.027
>10	169	74	(43.8)	1.5 (1.02–2.33)	
Source of drinking water					
Bottled	217	79	(36.4)	Reference	0.346
Unbottled	172	71	(41.3)	1.2 (0.81–1.85)	
Khat chewing					
Yes	290	107	(36.9)	0.8 (0.48–1.21)	0.282
No	99	43	(43.4)	Reference	
Frequency of khat chewing					
Daily	150	58	(38.7)	1.2 (0.73–1.89)	0.544
Non-daily	140	49	(35.0)	Reference	
Washing khat before chewing					
Yes	203	74	(36.5)	Reference	0.894
No	85	32	(37.6)	1.0 (0.56–1.60)	
Contact with soil					
Yes	129	49	(38.0)	1.0 (0.63–1.49)	0.912
No	260	101	(38.8)	Reference	
Wearing gloves during contact with soil					
Yes	20	4	(20.0)	Reference	0.130
No	108	44	(40.7)	2.8 (0.86–8.78)	
Washing hands before meals					
Yes	360	132	(36.7)	Reference	0.009
No	29	18	(62.1)	2.8 (1.30–6.17)	
Washing hands after using the toilets					
Yes	251	88	(35.1)	Reference	0.064
No	138	62	(44.9)	1.5 (1.00–2.31)	
Eating unwashed vegetables/fruits					
Yes	32	21	(65.6)	3.4 (1.58–7.22)	0.002
No	357	129	(36.1)	Reference	
Eating street-vended foods					
Yes	137	53	(38.7)	1.0 (0.65–1.53)	1.000
No	251	97	(38.6)	Reference	

Explanations: N: number examined, n: number infected, IPIs: intestinal parasitic infections, OR: odds ratio, CI: confidence interval

ridium species (8.2%). Only nine diabetics were infected with *G. duodenalis*, three diabetics with *B. hominis*, *H. nana* and *T. trichiura* each, and two diabetics with *E. vermicularis*. The majority of infected diabetics had a single infection (87.4%), while double and triple infections were observed among 11.3% and 1.3% of infected diabetics, respectively (Tab. 2).

Association of sociodemographic characteristics of type-2 diabetics with IPIs

No statistically significant association was found between the gender, age, literacy status, employment status, or household size of patients and IPIs among diabetics in Sana'a city (Tab. 3).

Table 5. Independent predictors of IPIs among type-2 diabetics seeking healthcare in Sana'a city, Yemen (2019–2020)

Independent predictor	AOR	95% CI	*P*-value
Duration longer than 10 years since DM diagnosis	1.6	1.10–2.47	0.029
Eating unwashed vegetables/fruits	3.2	1.44–6.92	0.004
Not washing hands before meals	2.4	1.10–5.48	0.035

Explanations: IPIs: intestinal parasitic infections, AOR: adjusted odds ratio, CI: confidence interval, DM: diabetes mellitus

Risk factors associated with IPIs among type-2 diabetics

Univariate analysis showed that the duration longer than 10 years since DM diagnosis (OR = 1.5; 95% CI: 1.02–2.33, $P = 0.027$), not practicing handwashing before meals (OR = 2.8; 95% CI: 1.30–6.17, $P = 0.009$) and eating unwashed vegetables/fruits (OR = 3.4; 95% CI: 1.58–7.22, $P = 0.002$) were significantly associated with IPIs among type-2 diabetics seeking healthcare in Sana'a. In contrast, source of drinking water, chewing khat, not washing khat before chewing, contact with soil, not wearing gloves during contact with soil, not washing hands after using the toilets and eating street-vended foods were not significantly associated with IPIs among type-2 diabetics (Tab. 4).

Independent predictors of IPIs among type-2 diabetics

Multivariable logistic regression analysis showed that the duration longer than 10 years since DM diagnosis (AOR = 1.6; 95% CI: 1.10–2.47, $P = 0.029$), eating unwashed vegetables/fruits (AOR = 3.2; 95% CI: 1.44–6.92, $P = 0.004$) and not practicing handwashing before meals (AOR = 2.4; 95% CI: 1.10–5.48, $P = 0.035$) were the significant independent predictors of IPIs among type-2 diabetics in Sana'a (Tab. 5).

Discussion

Yemen, one of the poorest and least-developed countries in the world, had been ranked 179 out of 189 countries and territories according to the 2020 Human Development Index (HDI) of the World Bank [48]. Out of approximately 30 million people in the country, 17.8 million people lack access to safe water and sanitary services and 19.7 million have no access to adequate healthcare [49]. Such situations negatively affect the health of people and deteriorate the already fragile municipal and sanitary services, favoring the transmission and spread of infectious diseases, including IPIs. On the other hand, hyperglycemia in uncontrolled DM renders patients immunocompromized and increases their susceptibility to infections [50]. Against the above background, the present study is the first to report on the prevalence and risk factors associated with IPIs among type-2 diabetics in Yemen.

In the present study, just over one-third of type-2 diabetics seeking healthcare in Sana'a had one or more IPIs caused by four protozoan and three helminthic species. Almost one-third of diabetics were infected with *E. histolytica*/*dispar,* followed by *Cryptosporidium* species among 8.2% of diabetics. However, low proportions of diabetics harbored *G. duodenalis* (2.3%), *B. hominis* (0.8%) and helminths (<1.0% each). One scenario behind the almost absence of STHs and *S. mansoni* among diabetics could be the impact of preventive chemotherapy with praziquantel and albendazole through mass drug administration campaigns targeting school-age children and high-risk populations since 2010 [51].

The overall prevalence of IPIs among diabetics in the present study is lower than that (63.1%) reported among cancer patients undergoing chemotherapy [34]. Among other factors, the more severe immunosuppression and the inclusion of children could partially explain the higher prevalence of IPIs among cancer patients. Unlike the pattern of parasite species among diabetics in the present study, *Cryptosporidium* species (30.1%) and *G. duodenalis* (18.0%) were the most prevalent while *E. histolytica/dispar* (2.4%) was the least prevalent among cancer patients [34]. However, the low prevalence (1.5%) of helminths reported among cancer patients is consistent with the finding of the present study. The pattern of the most common species causing IPIs among diabetics differs across countries. For instance, the most prevalent species

among type-2 diabetics were *G. duodenalis* in Ghana, Sohag governorate of Upper Egypt and Alborz Province of Iran [40,52,53], *E. histolytica* in Gharbia governorate of Egypt and Cameroon [42,43], *B. hominis* in Isfahan province of Iran and Beni-Suef governorate of Egypt [41,54], and *Cryptosporidium* species in southern Ethiopia [55]. On the other hand, one or more species of STHs were reported as the most prevalent parasite species among diabetics from Turkey, Nigeria and Ethiopia [56–59]. The discordance in the prevalence and types of IPIs among diabetics across various countries could be attributed, among other reasons, to the heterogeneous endemicity and burden of different parasite species across countries besides the differences in environmental, climatic and behavioral factors favoring parasite transmission and epidemiology.

The prevalence of *Cryptosporidium* species and *B. hominis* among diabetics seeking healthcare in Sana'a is lower than that reported among cancer patients undergoing chemotherapy in the city [34], where the two parasite species were detected among 30.1% and 4.9% of cancer patients, respectively. *B. hominis* was found to be the most common opportunistic species causing gastrointestinal symptoms among Iranian diabetics [41]. The higher prevalence of opportunistic protozoa among cancer patients undergoing chemotherapy could be explained by the lower clearance of such parasites because of the severity of immunosuppression. *Cryptosporidium* species and/or *B. hominis* were frequently reported among diabetics elsewhere [40,41,43,50,53]. The presence of these species among diabetics in the present study shows the inability of their immune systems to clear such opportunistic protozoa. *Cryptosporidium* is one of the most common coccidian species infecting immunocompromized patients [60]. There is some evidence on its role in causing chronic diarrhea in diabetics with normal lymphocyte subpopulations, suggesting the role of other immune defects in such patients as a cause of diarrhea [61]. In the present study, however, the association between cryptosporidiosis and diarrhea among diabetics could not be tested because the studied patients were not diarrheic but were seeking healthcare for DM rather than gastrointestinal complaints. Therefore, it is imperative to include diabetics seeking healthcare for diarrhea and other gastrointestinal symptoms in future studies. *B. hominis* has emerged as a potential pathogen among diabetics despite controversy over its pathogenesis in immunocompromized patients [60]. It is noteworthy that neither DM nor the length of its duration was found to be significantly associated with *Blastocystis* infection among Thai diabetics [62]. Likewise, no association was found between *Blastocystis* infection and DM among Brazilian patients [63]. The trivial prevalence of helminthic infections among diabetics in the present study is consistent with that (<1.0%) reported among diabetics elsewhere [40,43]. A link between non-exposure to helminthic infections and the marked increase in the prevalence of type-2 DM has been postulated, suggesting a protective role of helminths against this metabolic syndrome [64–67].

The lack of a significant association between the sociodemographic characteristics of diabetics and their infection status in the present study is consistent with that reported among cancer patients undergoing chemotherapy in Sana'a city [34], where gender and age of patients were not significantly associated with IPIs. This finding is consistent with the absence of a significant association between the prevalence of IPIs among diabetics and the age of diabetics from Iran, Ghana and Libya [41,52,68], the gender of diabetics from Egypt, Ghana, Nigeria, Ethiopia, Turkey and Libya [52–57,68], the household size of Iranian diabetics [41], the educational level of diabetics from Egypt and Sudan [54,69], and the occupation of diabetics from Egypt [54]. In contrast, the prevalence of IPIs was significantly associated with the female gender of Iranian and Sudanese diabetics [41,69], older age of diabetics from Sohag of Egypt and Nigeria [53,54,57], low or poor education of diabetics from Iran, Ghana and Ethiopia [41,52,55,58], being farmers or laborers for Ethiopian diabetics [55], and unemployment status of Sudanese diabetics [69].

The duration of DM was an independent predictor of IPIs among diabetics in Sana'a city, where the longer the duration of DM, the more likely the IPIs. This finding agrees with that reported for IPIs among diabetics from Ghana and Libya [52,68]. Therefore, particular attention needs to be given to diabetics with prolonged duration of the disease by raising their awareness of the importance of follow-up and control of DM in the prevention and control of IPIs. In contrast to the present study, no significant association was found between IPIs and the duration of DM among diabetics from Nigeria, northwest Ethiopia and Sudan [57,58,69].

Eating unwashed vegetables/fruits and not

practicing handwashing before meals were independent predictors of IPIs among diabetics in the present study, significantly increasing the likelihood of contracting the infection by approximately threefold and 2.5-fold, respectively. Therefore, diabetics should be educated about the importance of food and hand hygiene in the prevention and control of IPIs. In contrast, eating unwashed raw vegetables was not significantly associated with IPIs among Ethiopian diabetics [55]. Although contaminated water and food sources are major contributors to the transmission and spread of IPIs, no significant association was found between the source of drinking water or eating street-vended foods and IPIs among diabetics from Sana'a. This finding is consistent with the absence of association between the type of water source or supply and IPIs among diabetics from Egypt, Ethiopia and Nigeria [54,55,57] as well as with the absence of association between the food source and IPIs among Ethiopian diabetics [55]. In line with the present study, not washing hands after using the toilets was not significantly associated with IPIs among Ethiopian diabetics [55].

The present study is limited by being hospital-based conducting among type-2 diabetics seeking healthcare, making its findings not necessarily generalizable to all diabetics at the community level. DM in patients seeking healthcare may be more controlled than that of diabetics in the community. However, it is the first study in the country to provide preliminary information about the prevalence and predictors of IPIs among type-2 diabetics and to address this neglected gap among this vulnerable group. The findings of the present study can help inform physicians about the common IPIs and associated risk factors among diabetics. Another limitation might be introduced by the collection of a single stool sample from each patient because it was difficult to collect more than one from the same patient, and this entails conducting further studies based on the collection of three samples on alternate days to increase the sensitivity of detection.

In conclusion, over one-third of type-2 diabetics seeking healthcare in Sana'a city are infected with one or more IPIs, predominantly with *E. histolytica/dispar* and *Cryptosporidium* species. Such infections cannot be predicted from the sociodemographic characteristics of diabetics. Nevertheless, prolonged duration of DM, eating unwashed vegetables/fruits and practicing handwashing before meals are independent predictors of IPIs among type-2 diabetics. Large-scale studies are recommended for IPIs among type-2 diabetics with and without gastrointestinal complaints, preferably in comparison to non-diabetics.

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