



Current status of intestinal parasitosis among patients attending teaching hospitals in Zagazig district, Northeastern Egypt

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Received: 21 September 2021 / Accepted: 21 March 2022 / Published online: 1 April 2022
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Abstract

Almost 80% of health problems in the developing world are due to malnutrition and infectious diseases, which are mainly parasitic. Updated records on the prevalence of parasitic infections and the potential risk factors are essential to enhancing control strategies. Therefore, this study was conducted to evaluate the current situation of intestinal parasitism among patients attending teaching hospitals in Zagazig district, Northeastern Egypt. The study involved five hundred cases. They were all subjected to faecal examination using direct smear measure and two commercial faecal concentrators: Mini-Parasep® solvent-free and Mini-FLOTAC procedures. Mini-FLOTAC was performed with two solutions (FS2: saturated sodium chloride and FS7: zinc sulphate). The overall prevalence of intestinal parasitic infections was 56%. Different species were identified, like *Giardia lamblia* (12.6%), *Entamoeba histolytica/dispar* (10%), *Ascaris lumbricoides* (8.8%) and *Hymenolepis nana* (8.6%). Data analyses revealed a significant association of intestinal parasitism with different socio-demographic features of the participants. Our results showed a better diagnostic performance of Mini-Parasep® in the overall recovery of intestinal parasites. It was more accurate than Mini-FLOTAC in diagnosing both helminths and protozoan infections. Mini-FLOTAC (FS2) exhibited a higher sensitivity than FS7 for helminth recovery (74.6% vs 53.4%), while FS7 was more sensitive for protozoan infections (50.6% vs 43.8%). Intestinal parasitosis remains a challenging health problem in Zagazig city, wherever reliable diagnostic approaches are limited. Thus, our study has proposed the value of the commercial concentrators (Mini-Parasep® and Mini-FLOTAC) as alternative techniques for diagnosing a large variety of parasite species in resource-constrained settings.

Keywords Parasites · Egypt · Mini-FLOTAC · Prevalence · Mini-Parasep®

Introduction

Intestinal parasitic infections (IPIs) are recognized as one of the neglected tropical diseases which constitute a global health concern, especially in developing countries (Taghipour et al. 2021). Over 3 billion people worldwide are infected with different intestinal parasites, causing

morbidity in 450 million individuals (Hailegebriel 2017). The prevalence of these infections is governed by geographical, behavioural, biological and socioeconomic factors. They are closely associated with the humid tropical climate, limited access to clean water, poor environmental sanitation, overcrowding and low family income. All these conditions favour and facilitate the growth, transmission and exposure to intestinal parasites (Amer et al. 2018).

Ingestion of contaminated food and water is the commonest route for transmitting different intestinal parasites. Infection can also be acquired after active skin penetration by infective larval stages in polluted soil (Moses et al. 2013). Intestinal parasites are key aetiological agents of different gastrointestinal troubles such as dysentery, diarrhoea, abdominal distension, vomiting and lack of appetite. They can also cause iron deficiency anaemia, growth retardation and mentally related disorders. Such clinical complications commonly affect high-risk populations like pregnant

Section Editor: Peter Fischer

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females, immunocompromised individuals and children (Mahmud et al. 2020). Furthermore, intestinal parasitic diseases account for nearly 39 million disability-adjusted life years (DALYs) globally (Stephenson et al. 2000).

Despite the notable improvement in sanitation infrastructure and hygienic status, intestinal parasitism remains a significant health challenge in Egypt (Monib et al. 2016). Owing to the broad diversity in cultural, educational, geographic and socioeconomic status, reports on prevalence rates of intestinal parasites vary in different localities in Egypt. In the Greater Cairo region, about 51% of the patients complaining of gastrointestinal symptoms were positive for different intestinal parasitic infections (Hussein et al. 2017). In Sohag Governorate, Southern Egypt, El-Nadi et al. (2017) reported a higher infection rate (63.5%) among elementary school children. Thus, studies on the prevalence of IPIs and associated risk factors are essential to identify high-risk communities and improve different control measures (Abera et al. 2013).

In the field studies, the search for an optimal applicable diagnostic tool is a bit challenging. The choice of a specific technique is determined by its sensitivity, simplicity, affordability and cost (Garcia 2001). Thus, different commercial faecal parasite concentrators have been developed recently to replace the traditional concentration methods, particularly in low transmission settings (Saez et al. 2011). Mini-Parasep® solvent-free (SF) concentrator is a closed single-use device that removes the debris and fat from faecal samples through a two-stage filtration matrix without using chemical agents. Besides, it is a cost-effective tool that could be used in large-scale epidemiological surveys (Mohram et al. 2020). The Mini-FLOTAC method has also been recently introduced to provide laboratories in resource-limited facilities with a reliable measure for both diagnostic and epidemiological purposes. The main advantage of this technique is that it does not require any centrifugation steps, and so, it is practical in processing large numbers of samples that require a rapid diagnosis (Barda et al. 2013).

Several studies were conducted to evaluate the situation of intestinal parasitism in the city of Zagazig, Northeastern Egypt. Yet, most of these studies have focused on the distribution of specific parasites among specific populations, particularly children. For example, Farghly et al. (2016) denoted a prevalence rate of 21.07% for soil-transmitted helminths among school children. Also, Mohammad et al. (2021) reported a molecular prevalence of 25.5% for *Cryptosporidium* species among children suffering from malignancy. Unfortunately, there is limited data about the extent of different human intestinal parasites among different population segments in Zagazig city. Besides, the numerous risk factors which might aggravate the transmission of intestinal parasites are still overlooked. In line with this, our study aims to provide an updated report on the current profile

of intestinal parasites and the potential risk factors among patients attending two principal teaching hospitals (Zagazig University Hospital and Al-Ahrar Teaching Hospital) in Zagazig district. Moreover, to the best of our knowledge, this is the first study that combined two commercial faecal concentrators (Mini-Parasep® SF and Mini-FLOTAC) as innovative diagnostic measures to assess the current situation of human intestinal parasitism in the city of Zagazig.

Subjects and methods

Study type and area

This cross-sectional prevalence study was carried out in the city of Zagazig, Sharqia Province, Northeastern Egypt, during the period from November 2019 to early April 2021. Zagazig is the capital of Sharqia Governorate which is situated about 80 km from Cairo to the Northeast. It is located at latitude 30.57° N and longitude 31.50° E. The total area of the urban boundary of Zagazig is 4275 acres, with a population of 481,500 in the year 2027 (El-Barmelgy and El-Khateb 2020). Participants in this study were selected from two main teaching hospitals in Zagazig district: Zagazig University Hospital, which is located 3.6 km from the centre of the city, and Al-Ahrar Teaching Hospital (2.0 km from the city centre).

Study population and design

The participants in the present study aged between 11 and 60 years old. They were recruited from Pediatrics and Internal Medicine in- and outpatient Clinics of both Zagazig University and Al-Ahrar Teaching Hospitals. A simple random sampling method was employed to select the participants in the study. The cases consisted of 290 males (58%) and 210 females (42%), with symptoms suggestive of intestinal parasitic infections. Patients on anti-parasitic agents were excluded from the study. A semi-structured questionnaire was established to gather information on age, sex, hospitalized or non-hospitalized status, socioeconomic profile (family monthly income), type of residence, number of house rooms and number of individuals in the household of all studied cases. The questionnaires were accurately checked for completeness. In the current study, socioeconomic status (SES) was graded as low, medium and high according to Fahmy et al. (2015) grading scale. The household crowding index (HCI) was described as the total number of co-residents per household divided by the total number of rooms. It was grouped into three distinct categories as follows: the first category < 1; the second category, 1–2; and the third category, > 2 residents per room (Melki et al. 2004).

Sample collection and examination

Faecal samples were collected in sterile, dry and labelled plastic containers. About 2–5 g of solid or 10 ml of liquid stool specimens was obtained from each patient. All parasitological procedures were conducted at the Medical Parasitology Department (Post-Graduate Research Laboratory), Faculty of Medicine, Zagazig University. Stool samples were examined promptly after collection. Each sample was processed as follows.

Macroscopic examination

The stool specimens were examined macroscopically for consistency, colour and the presence of blood, mucous or adult intestinal worms.

Microscopic examination

Each stool sample was divided into three equal parts and examined in parallel by three different procedures: direct smear measure, Mini-Parasep® solvent-free (SF) and Mini-FLOTAC commercial faecal concentrators. Formed and semi-formed specimens were measured by the sensitive gram scale, while liquid diarrheic samples were measured in millilitres using calibrated cylinders.

1. Direct smear examination was conducted using normal saline (0.9%), Lugol's iodine and eosin methods. Several slides were prepared from each single sample. For each slide, about 2 mg (the size of a match-stick head) of stool was obtained from both the surface and the inside of the specimen to increase the rate of detection of different parasites (Cheesbrough 1991). Wet mount preparations were used for detecting helminth ova and protozoan cysts. Permanent stained smears were performed using the modified Ziehl–Neelsen (MZN) technique for detecting intestinal coccidian parasites (Uttinger et al. 2010).
2. The Mini-Parasep®SF (DiaSys Ltd, Berkshire, England, DYS057-V14 04/2008) device is composed of a sedimentation cone, mixing chamber, Parasep lid and a filtration matrix. The device was assembled and sealed by fastening the filter thimble onto the sedimentation cone and mixing chamber. The tubes and sedimentation cones were labelled with the specimen identification codes. The Mini-Parasep® SF faecal concentrator was used per the manufacturer's instructions as follows: the stool sample filled the spoon at the end of the filter. After adding 3.3 ml of 10% formalin and 0.1% Triton-X, the mixture was vortexed for 15 s. The Mini-Parasep® SF apparatus was then inverted and centrifuged at 1500 r/min for 2 min. The mixing chamber and filter were then
3. The Mini-FLOTAC apparatus comprises two main units, the base and the reading disc. There are two flotation chambers (1 ml each) which are designed for optimal examination of faecal suspensions. Fill-FLOTAC is a disposable device, which is part of the FLOTAC and mini-FLOTAC kits. It is used for the collection, homogenization and filtration of faecal samples (Cringoli 2006). Each faecal sample was processed using two flotation solutions of the Mini-FLOTAC concentrator: FS2 (saturated sodium chloride solution: specific gravity = 1.20) and FS7 (zinc sulphate solution: specific gravity = 1.35). The Mini-FLOTAC procedure was conducted according to Barda et al. (2013) protocol as follows: 2 g of fresh faeces was placed in the Fill-FLOTAC container. The faecal sample was then diluted in 2 ml of 5% formalin, thoroughly homogenized and filtered. Afterwards, 2 ml of the suspension (2 g of stool and 2 ml of formalin) was added to 36 ml of the FS2 and to 46 ml of FS7. The faecal suspension was then poured into the two flotation chambers of the Mini-FLOTAC. An average time of 10 min was required for the cysts and eggs to float before examining the reading disc (Barda et al. 2014).

Following the performance of different diagnostic techniques, slides were scanned under 10×, 40× and 100× objectives and examined by two qualified medical parasitologists who were blind to the method used for sample preparation.

Statistical analysis

Collected data were tabulated and analysed using IBM SPSS Statistics for Windows version 25. Descriptive statistics were used to report the prevalence that could be described as the proportion of positive samples over total samples analysed (Burning and Kintz 1997). The non-parametric chi-square (χ^2) test was applied to check the statistical association between intestinal parasitic infection and the used variables (gender, residence, socioeconomic status and age groups). Significance was set at P values < 0.05, and 95% CI values were estimated. Logistic regression analyses were employed to determine independent risk factors for the infection (Bursac et al. 2008). According to Versi (1992), the term gold standard refers to the best available one that has a standard with known results. In the current study settings, this term best applied to the direct smear method.

Ethical considerations.

Before data or sample collection, all procedures were explained to the study participants and informed written or thumb-printed consents were obtained. Parents/guardians

of the selected children also completed consent agreement forms. Patients were recognized by codes, as data were kept anonymous. The current study was also reviewed and approved by the Committee of Research, Publications and Ethics of the Faculty of Medicine, Zagazig University, Egypt. We certify that the study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Results

Characteristics of the study population

In total, 500 patients participated in this study. Among them, 290 (58%) were males, and 210 (42%) were females. The age of the patients ranged from 11 to 60 years old (age mean \pm SD = 31.478 \pm 14.67). The distribution of patients by age groups was as follows: 11–20 years, 160 (32%); 21–40 years, 195 (39%); and 41–60 years, 145 (29%). More than half (57.6%) of the cases came from rural areas, and only 20% were of a high social status (Table 1). Out of the 500 patients, 105 (21%) were hospitalized (in-patients) and 395 (79%) were non-hospitalized (outpatients).

Prevalence of intestinal parasitic infections

Based on microscopic examination using the direct smear method, the overall prevalence of intestinal parasitic infections among the 500 examined cases was determined to be 56% (280/500). The prevalence of protozoan infections 32.4% (162/500) was higher than the helminth infections 23.6% (118/500). The most commonly detected protozoa were *Giardia lamblia* (*G. lamblia*) (12.6%), *Entamoeba histolytica/dispar* (*E. histolytica/dispar*) (10%) and *Entamoeba coli* (*E. coli*) (6.4%). While the most recovered helminths were *Ascaris lumbricoides* (*A. lumbricoides*) (8.8%),

Hymenolepis nana (*H. nana*) (8.6%) and *Enterobius vermicularis* (*E. vermicularis*) (3.2%), the least recovered parasites during this study were *Iodamoeba buetschlii* (*I. buetschlii*) (0.4%), *Heterophyes heterophyes* (*H. heterophyes*) (0.8%) and *Ancylostoma duodenale* (*A. duodenale*) (2.2%) (Fig. 1).

According to Table 2, the prevalence of intestinal parasitic infections was significantly higher in the age group 11–20 years (65.6%, $P < 0.05$), while the other age groups 21–40 years and 41–60 years were less affected, with similar infection rates (51.3% and 51.7%, respectively). Males were found to have a higher percentage of infection (66.6%) compared with female subjects (41.4%). The prevalence of intestinal parasitism was significantly ($P < 0.001$) related to residence, socioeconomic status and the household crowding index (HCI). Rural residents had more frequent intestinal parasitic infections (64.9%) than urban residents (43.9%). Patients of low social classes and high crowding indices had the highest rates of infections (79.5% and 64.4%, respectively).

Regarding the status of the patients, intestinal parasitic infections were more frequent in non-hospitalized cases with 57.2% than in hospitalized patients with 51.4%. However, the difference was statistically insignificant ($P > 0.05$) (Table 2). There was a significant variability ($P < 0.001$) in the distribution of parasitic infections in different seasons of study. The infection was highest in summer (66.9%) and spring (60%) and lowest in winter (35.8%) (Fig. 2).

Factors associated with intestinal parasitic infections

Further analysis of data was performed to determine the possible risk factors that could be related to intestinal parasitic infections. In the logistic regression analyses,

Table 1 Socio-demographic features of the study population ($n = 500$)

Characteristics	Category	Number	Percentage
Age groups	11–20	160	32%
	21–40	195	39%
	41–60	145	29%
Sex	Male	290	58%
	Female	210	42%
Residence	Rural	288	57.6%
	Urban	212	42.4%
Socioeconomic status (SES)	Low	205	41%
	Medium	195	39%
	High	100	20%
Crowding index	< 1	65	13%
	1–2	210	42%
	> 2	225	45%

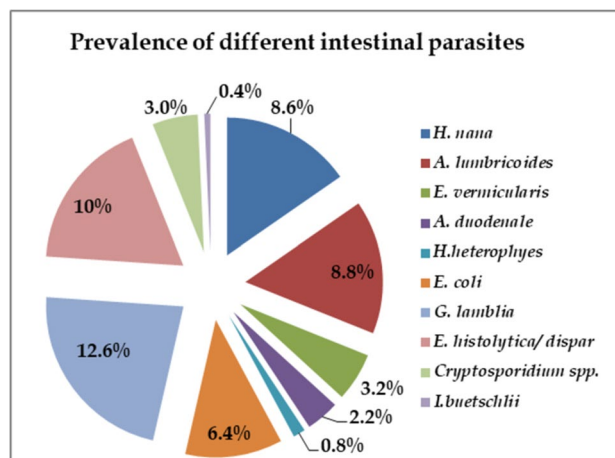
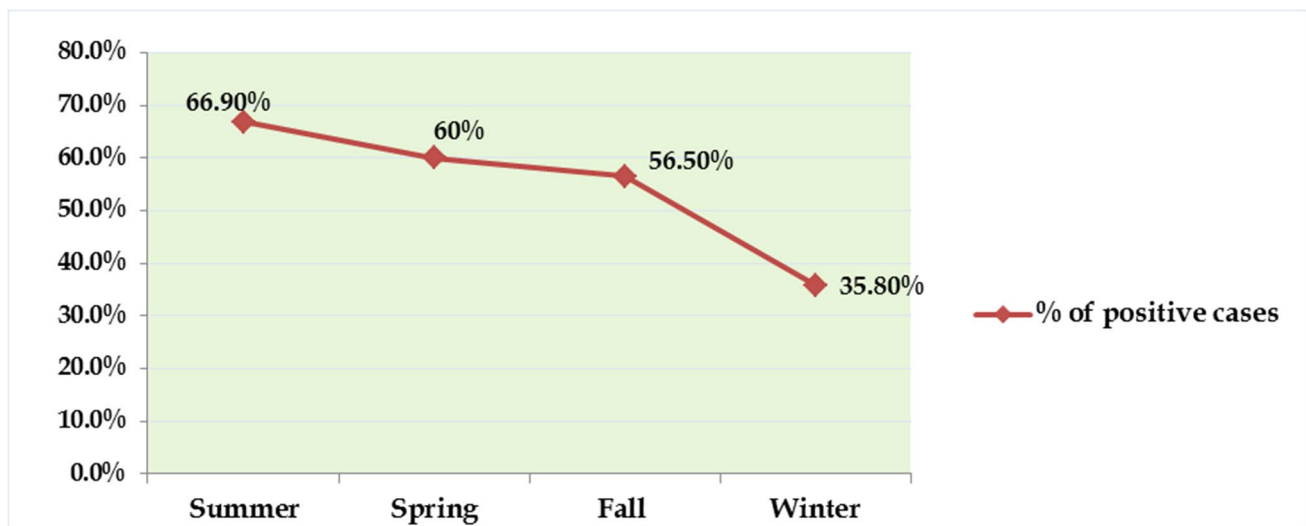


Fig. 1 Prevalence of intestinal parasitic infections, by species, among 500 examined cases

Table 2 The association between intestinal parasitic infections and potential risk factors among 500 examined cases

Risk factor	Category	Total (n = 500)	Positive cases (n = 280)		Negative cases (n = 220)		χ^2	P value	OR (95% CI)
			No	%	No	%			
Age groups	11–20	160	105	65.6%	55	34.4%	8.85	0.01*	1.78 (1.12–2.83)
	21–40	195	100	51.3%	95	48.7%			
	41–60	145	75	51.7%	70	48.3%			
Sex	Male	290	193	66.6%	97	33.4%	31.2	< 0.001**	2.81 (1.95–4.06)
	Female	210	87	41.4%	123	58.6%			
Residence	Rural	288	187	64.9%	101	35.1%	21.99	< 0.001**	2.37 (1.65–3.41)
	Urban	212	93	43.9%	119	56.1%			
Socioeconomic status (SES)	Low	205	163	79.5%	42	20.5%	80.68	< 0.001**	7.88 (4.6–13.49)
	Medium	195	84	43.1%	111	56.9%			
	High	100	33	33%	67	67%			
Crowding index	< 1	65	19	29.2%	46	70.8%	25.46	< 0.001**	Ref
	1–2	210	116	55.2%	94	44.8%			
	> 2	225	145	64.4%	80	35.6%			
Status of the patients	Hospitalized	105	54	51.4%	51	48.6%	1.13	0.29 NS	1.26 (0.82–1.94)
	Non-hospitalized	395	226	57.2%	169	42.8%			

χ^2 chi-square test, OR odds ratio, CI confidence interval. *Significant ($P < 0.05$), **highly significant ($P < 0.001$), NS non-significant ($P > 0.05$).

**Fig. 2** Distribution of intestinal parasitic infections during different seasons of study

different socio-demographic factors like the age of the participants, 11–20 years (OR = 1.78; 95% CI, 1.12–2.83); male patients (OR = 2.81, 95% CI, 1.95–4.06); and rural residents (OR = 2.37; 95% CI, 1.65–3.41) were significantly associated with intestinal parasitic infections. Likewise, participants of low social class (OR = 7.88; 95% CI, 4.6–13.49) and high crowding index > 2 (OR = 4.39; 95% CI, 2.41–8) were identified as significant risk factors for intestinal parasitism. On the other hand, the prevalence of the infection was independent of the hospitalized/non-hospitalized status of the patients (OR = 1.26; 95% CI, 0.82–1.94) (Table 2).

Among the potential risk factors investigated during this study, seasonality was found to have a significant correlation with intestinal parasitism. There was a statistically significant increase in the frequency of the infection in summer (OR = 3.63; 95% CI, 2.16–6.09), spring (OR = 2.69; 95% CI, 1.58–4.58) and fall (OR = 2.33; 95% CI, 1.36–4) compared to winter (Table 3).

Table 3 Logistic regression analysis of intestinal parasitic infections during different seasons

Season	Total	Positive cases (n = 280)		Negative cases (n = 220)		χ^2	P value	OR (95% CI)
		No	%	No	%			
Summer	151	101	66.9%	50	33.1%	26.18	<0.001**	3.63 (2.16–6.09)
Spring	125	75	60%	50	40%			2.69 (1.58–4.58)
Fall	115	65	56.5%	50	43.5%			2.33 (1.36–4)
Winter	109	39	35.8%	70	64.2%			Ref

χ^2 chi-square test, OR odds ratio, CI confidence interval. **Highly significant ($P < 0.001$).

Comparison of commercial faecal concentrators in the recovery of different intestinal parasites

The diagnostic performance of the used commercial faecal concentrators in diagnosing different intestinal parasites, using direct smear as a gold standard test, is demonstrated in Table 4. Our results showed that the Mini-Parasep®(SF) procedure had the highest efficacy in the detection of different intestinal parasites. Its overall sensitivity, specificity and accuracy were 68.2%, 95.9% and 80.4%, respectively. The kit has also exhibited a higher sensitivity for helminths (72.9%) than for protozoan infections (64.8%). Regarding the two flotation solutions of the Mini-FLOTAC technique, FS2 showed a higher sensitivity than FS7 in the recovery of intestinal helminths (74.6% vs 53.4%), while FS7 was more sensitive in diagnosing intestinal protozoa (50.6% vs 43.8%) (Table 4).

Positive detection rates of the recovered parasite species using faecal concentration kits are shown in Fig. 3. The Mini-Parasep® (SF) method showed higher infection rates for *H. nana* (9%), *G. lamblia* (7%) and *E. histolytica/dispar* (4.8%). Among the recovered parasite species, *I. buetschlii* cysts were found using only the Mini-Parasep®(SF)

measure, which recorded a positivity of 0.6%, where the Mini-FLOTAC approach failed to detect any case (0%). As for geohelminths, more frequent infections were reported using the Mini-FLOTAC method. Infection rates for *A. lumbricoides* (6%) and *A. duodenale* (3%) were demonstrated using Mini-FLOTAC NaCl (FS2), while more *E. vermicularis* cases (4.4%) were diagnosed by Mini-FLOTAC ZnSO₄ (FS7). *H. heterophyes*-infected patients were better diagnosed by the Mini-FLOTAC (FS7) measure, which detected 1.6% of the cases, while the Mini-Parasep®(SF) kit diagnosed only 0.4% of the cases (Fig. 3).

Both protozoan and helminthic parasitic elements were recovered in stool samples. Photomicrographs of some intestinal parasites detected using different techniques are depicted in Fig. 4.

Discussion

Parasitic infections constitute the greatest single worldwide cause of disease and illness. They cause critical health threats because of their morbid nature (Hailu and Ayele 2021). Intestinal parasitic infections affect millions

Table 4 Diagnostic performance of commercial faecal parasite concentrators in the diagnosis of intestinal parasitic infections using direct faecal smear as a gold standard test

Parasitic infection	Calculated parameter	Mini-FLOTAC (FS2)	Mini-FLOTAC (FS7)	MP®SF
Overall	Sensitivity	56.7%	51.7%	68.2%
	Specificity	91.8%	89.5%	95.9%
	NPV	62.5%	59.3%	70.3%
	PPV	89.8%	86.3%	95.5%
	Accuracy	72.2%	68.4%	80.4%
Helminths	Sensitivity	74.6%	53.4%	72.9%
	Specificity	93.8%	93.8%	97.5%
	NPV	83.5%	73.4%	83.1%
	PPV	89.8%	86.3%	95.6%
	Accuracy	85.7%	76.8%	87.1%
Protozoa	Sensitivity	43.8%	50.6%	64.8%
	Specificity	93.2%	88.9%	95.8%
	NPV	54.7%	56.7%	66.5%
	PPV	89.8%	86.3%	95.5%
	Accuracy	64.6%	66.8%	77.9%

MP® SF, Mini-Parasep® solvent-free concentrator; Mini-FLOTAC NaCl (FS2), Mini-FLOTAC ZnSO₄ (FS7); NPV, negative predictive value; PPV, positive predictive value.

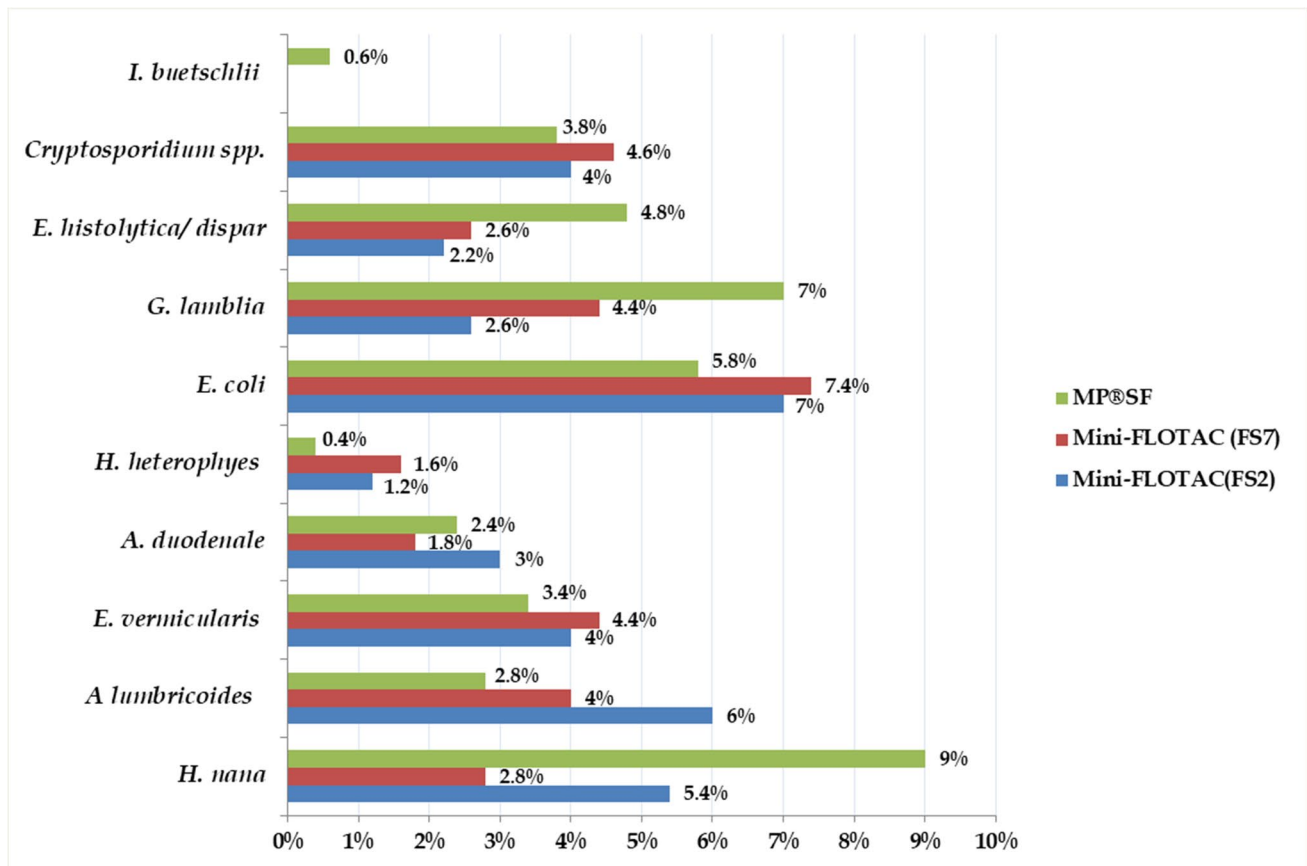


Fig. 3 Positive detection rates of intestinal parasites determined by the commercial faecal parasite concentrators. Each bar of the chart represents the proportion of cases infected. MP@SF, Midi-Parasep@solvent-free concentrator; Mini-FLOTAC ZnSO₄ (FS7); Mini-FLOTAC NaCl (FS2)

of people around the world, particularly in developing countries (PAHO 2019). Reliable and practical diagnostic measures are essential for the proper evaluation of the prevalence of intestinal parasitism. Understanding the distribution pattern of intestinal parasitic infections is a crucial step for planning efficient intervention programmes to improve the health status (McCarthy et al. 2012). The present study assessed the current situation of human intestinal parasitism among patients attending two major teaching hospitals in Zagazig city, Northeastern Egypt.

In the present study, 56% of the examined cases were positive for different intestinal parasitic infections. This finding was consistent with Yones et al. (2019), who reported a 56.3% prevalence rate of gastrointestinal parasites among Egyptian school children in rural Assiut Governorate. Yet, a considerable variation in the overall prevalence of intestinal parasitism was observed by comparing our results to those already recorded in different regions of Egypt. This variation could be explained by the group of patients examined. In the group of food handlers, Badaway et al. (2015) reported an overall prevalence of 32.4% for enteric parasitic infections among food handlers in Sharqia

Governorate. Also, Yimam et al. (2020) recorded prevalence estimates of 33.6% for intestinal parasites among food handlers in Ethiopia. In the group of school children, Abdel Fatah and Nofal (2012), as well as Mahmoud et al. (2017), recorded prevalence rates of 33.6% and 37% among school children in Alexandria and Dakhalia Governorates, respectively.

In terms of the detected intestinal parasites, the most commonly identified species were *G. lamblia* (12.6%), *E. histolytica/dispar* (10%), *A. lumbricoides* (8.8%) and *H. nana* (8.6%) (Fig. 1). These results come in accordance with previous studies conducted inside Egypt. Farghly et al. (2016) reported *G. lamblia* (26%) and *E. histolytica* (13.4%) as the most prevalent parasitic infections among school children in Zagazig district, Northeastern Egypt. Likewise, Hussein et al. (2017) described *G. lamblia* as the most common parasitic infection (26%) among patients with gastrointestinal troubles in the Greater Cairo region, Northern Egypt. The similarity between the parasitic species recovered during the present research and other comparable studies conducted in Egypt could be attributed to the fact that the Egyptians might be subjected to the

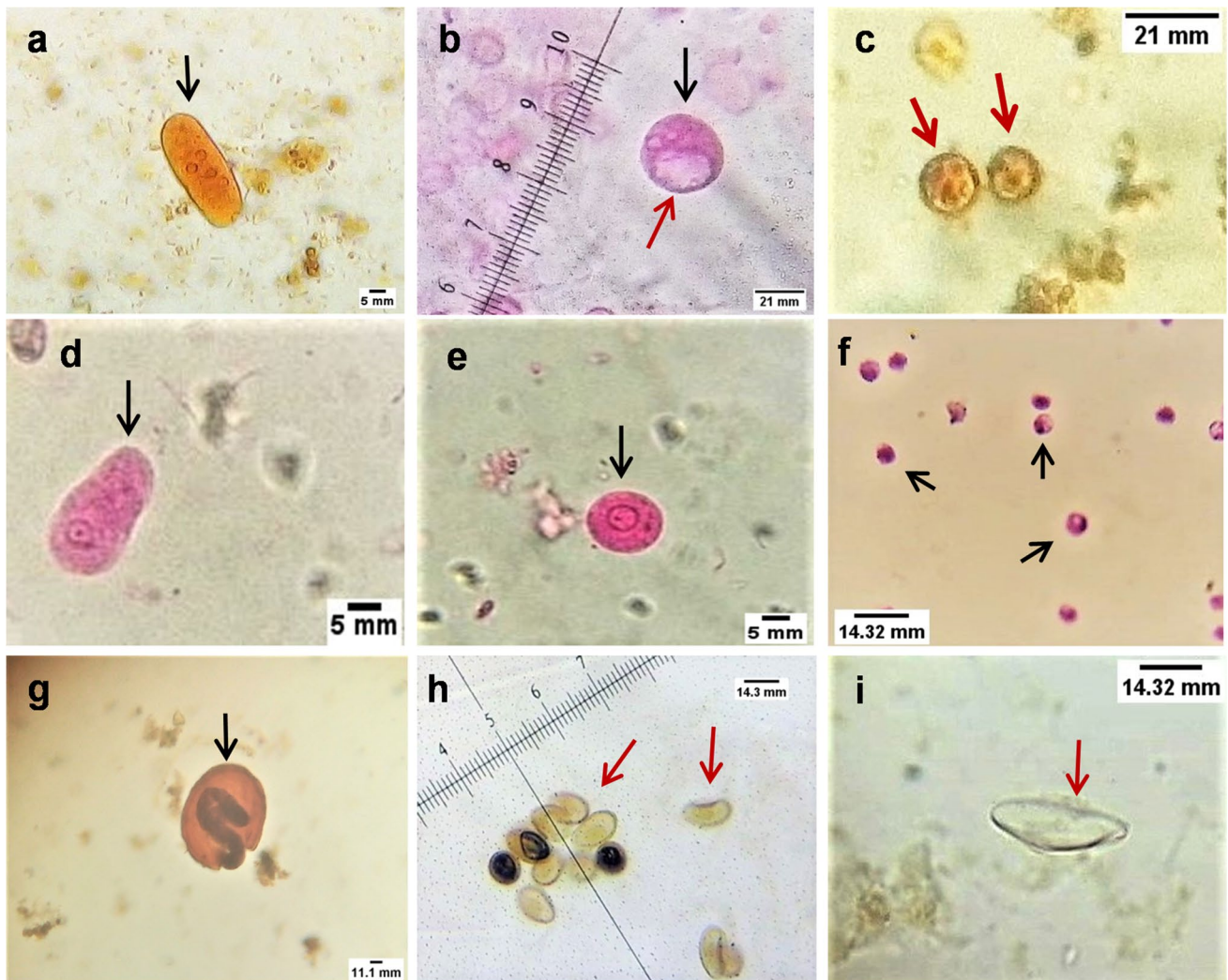


Fig. 4 Photomicrographs of different intestinal parasites recovered during the study. **a** Elongated *E. coli* dividing trophozoite with 4 nuclei seen in the plane of focus (black arrow) (iodine stain, $\times 400$). **b** *I. buetschlii* cyst (black arrow) with a large glycogen vacuole (red arrow) (eosin stain, $\times 1000$). **c** *E. histolytica/dispar* cysts (red arrows) (iodine stain, $\times 400$). **d** *E. coli* trophozoite (black arrow) (eosin stain, $\times 400$). **e** *E. coli* pre-cystic stage with one nucleus seen in the plane of focus (black arrow) (eosin stain, $\times 400$). **f** *Cryptosporidium* oocysts (black arrows) (MZN stain, $\times 1000$). **g** *A. lum-*

bricoides embryonated egg containing second stage larva (black arrow) (iodine stain, $\times 400$). **h** *H. heterophyes* eggs (red arrows) (unstained smear, $\times 400$). **i** *E. vermicularis* egg (red arrow) (unstained smear, $\times 400$). **a–c** Recovered parasite species after concentration by Mini-Parasep®(SF). **d–f** Recovered parasite species after concentration by Mini-FLOTAC ZnSO₄ (FS7). **g, h** Recovered parasite species after concentration by Mini-FLOTAC NaCl (FS2). **i** Recovered parasite in the unprocessed stool sample

same risk factors, which include consumption of unwashed vegetables, ineffective water treatment systems and poor hygienic habits.

Our results were also endorsed by different studies outside Egypt. Baral et al. (2017) recorded *G. lamblia* (3.34%) followed by *E. histolytica/dispar* (1.96%) as the most prevalent parasitic infections in a tertiary care hospital in Nepal. Similarly, *E. histolytica* (5.5%) followed by *A. lumbricoides* (4%) and *G. lamblia* (3%) were reported as the dominant parasites detected among asymptomatic food handlers in Ethiopia (Kebede et al. 2019).

Among different helminth species detected during this study, *A. lumbricoides* was the most frequently recovered parasite (8.8%), followed by *H. nana* (8.6%) (Fig. 1). The obtained results were supported by a recently conducted study in Kafr El-Sheikh Governorate, Northwestern Egypt. In their research, Allam et al. (2021) found that *Schistosoma mansoni*, *H. nana* and *A. lumbricoides* were the most prevalent helminthic infections among the primary school children of the Governorate. In the current work, *A. duodenale* was one of the least recovered parasites (2.2%) (Fig. 1). Yet, this finding contradicts Yones et al. (2019), who showed

that *A. duodenale* (8.7%) was one of the dominant parasitic infections among rural school children in Assiut Governorate, Southern Egypt. Recent studies have demonstrated a rise in the prevalence rates of hookworm infections. Eyayu et al. (2021) identified hookworm species (13.3%) as the second leading cause of intestinal parasitosis among patients attending a primary hospital, Northwestern Ethiopia. Also, Taghipour et al. (2021) recorded high levels of hookworm infections (80.7%) among pregnant females.

The results of the current study revealed a high prevalence of intestinal parasitic infections among the 11–20 years age group (65.6%) (Table 2). This finding was endorsed by Amer et al. (2018) who attributed the high rate of infection in this age category to their close contact with the contaminated environment. Regarding the gender, this study reported significantly ($P < 0.001$) higher infection rates in males (66.6%) compared with female cases (41.4%) (Table 2). Similar observations were demonstrated by other studies inside and outside Egypt. El-Sherbini and Abosdera (2013) recorded higher infection rates of intestinal parasites among male children in Giza Governorate, Egypt. Also, Hailu and Ayele (2021) have demonstrated more positive parasitic infections among male school children in Debre Berhan town, North-east Ethiopia. However, Gelaw et al. (2013) and Diongue et al. (2017) reported a higher frequency of intestinal parasitic infections among female subjects.

The relationship between the prevalence of parasitic infections and either age or gender of the study population remains controversial. Our study demonstrated a strong association of intestinal parasitic infections with both the age and gender of the study participants (Table 2). Similarly, Akinbo et al. (2011), as well as Hailu and Ayele (2021), reported age as a potential risk factor for intestinal parasitism. Moreover, Hassen Amer et al. (2016) have reported a significant relationship between gender and intestinal parasitic infections. On the other hand, Hussein et al. (2017) and Abbaszadeh Afshar et al. (2020) denied any correlation between either age or gender and intestinal parasitism. We have also shown that intestinal parasitosis was dependent on the type of residence, socioeconomic status and the household crowding index (Table 2). This finding was compatible with Geneidy (2019), who reported that low social classes were significant risk factors for intestinal parasitic infections. Likewise, Ngui et al. (2011) confirmed the influence of low household purchasing power on intestinal parasitosis in Malaysia. Conversely, Almeida et al. (2017) recorded that low family income was not significantly associated with intestinal parasitic infections.

Regarding the hospitalized/non-hospitalized status of the patients, we have denoted that, despite the statistically insignificant difference ($P = 0.29$), intestinal parasitic infections were more frequent among non-hospitalized cases (57.2%) (Table 2). This same observation

was supported by Diongue et al. (2017). Our study has reported the highest prevalence rates of the infection during the summer months (66.9%) and the lowest infection rates in winter (35.8%) (Fig. 2). Additionally, Amer et al. (2018) have denoted the relationship between seasonality and intestinal parasitic infections. They recorded a high level of infection in fall (0.79%) and summer (0.63%) seasons and a lower prevalence during winter (0.25%). The current study reported a significant ($P < 0.001$) seasonal variation in the prevalence of intestinal parasitic infections (Table 3). However, this finding disagrees with Akinbo et al. (2011), who demonstrated that intestinal parasitism was not significantly related to different seasons.

Accurate diagnosis of parasitic infections is critically important for both population-based studies and individual patient management. The choice of a single (gold standard) test for diagnosing intestinal parasitism is hard to achieve. According to Momčilović et al. (2019), direct microscopic stool examination remains the cornerstone of parasitological diagnosis. Furthermore, Mbong Ngwese et al. (2020) regarded the direct smear measure as an essential technique for detecting different parasitic elements in a faecal sample. Therein, our study tried to assess the intestinal parasitic situation in the city of Zagazig using two innovative faecal parasite concentrators (Mini-Parasep®SF and Mini-FLOTAC), with the direct smear measure as a gold standard. In the present study, the calculated analytical sensitivity, specificity and accuracy (68.2%, 95.9% and 80.4%, respectively) indicated that the MP®SF kit was the most effective tool in diagnosing different intestinal parasites. The faecal concentrator has also exhibited the highest diagnostic accuracy (87.1%) in detecting intestinal helminths (Table 4). This finding was supported by Ng'etich et al. (2016), who approved the diagnostic potential of Mini-Parasep as a promising alternative tool in diagnosing and monitoring schistosomiasis transmission. They denoted that the Mini-Parasep technique displayed a higher sensitivity (77.5%) than the standard Kato-Katz measure (33.8%) for detecting *Schistosoma mansoni* infections.

In comparison with the Mini-FLOTAC procedure, Mini-Parasep®SF had a higher sensitivity (64.8%) in diagnosing intestinal protozoa (Table 4). The highest positive detection rates of *G. lamblia* (7%), *E. histolytica/dispar* (4.8%) and *I. buetschlii* (0.6%) were obtained using the Mini-Parasep®SF technique (Fig. 3). Similar observations were achieved by Abdel Aziz et al. (2020), who also recorded a high sensitivity (83.3%) for the Mini-Parasep® kit in diagnosing intestinal protozoa, particularly *E. histolytica/dispar* and *G. lamblia*. Also, Mohram et al. (2020) have described Mini-Parasep® SF as the most effective method for detecting *Giardia* cysts. In their study, more than 80% (82.7%) of *G. lamblia*-infected cases were diagnosed using the Mini-Parasep procedure.

In the current study, two floatation solutions were used for each Mini-FLOTAC procedure. The first was NaCl (FS2) solution, which has shown the highest sensitivity in the recovery of helminth infections (74.6%). The other was ZnSO₄ (FS7) solution, which was more sensitive than FS2 in diagnosing intestinal protozoa (50.6% vs 43.8%) (Table 4). Compared with the Mini Parasep®SF technique, the study has also shown a superior efficacy of the Mini-FLOTAC kit in detecting geohelminths. The highest positive detection rates of *A. lumbricoides* (6%), *A. duodenale* (3%) and *E. vermicularis* (4.4%) were obtained using the Mini-FLOTAC approach (Fig. 3). The efficacy of the Mini-FLOTAC technique in detecting helminths infections has been confirmed in several studies. Levecke et al. (2009) recorded that the FLOTAC measure turned out to be the most sensitive approach (95%) for helminth diagnosis. Barda et al. (2013) have also reported that the Mini-FLOTAC technique was the most sensitive measure (90%) for diagnosing intestinal helminths, compared to only 30% sensitivity for the direct smear method. Likewise, El-Nadi et al. (2019) reported a 100% sensitivity of the Mini-FLOTAC approach in diagnosing helminth infections. Our study has also reported a relatively low diagnostic accuracy of the Mini-FLOTAC ZnSO₄ (FS7) in diagnosing intestinal protozoa (66.8%) (Table 4). However, this finding opposes Allam et al. (2021), who recorded a marked diagnostic accuracy of the FLOTAC procedure (99%) in diagnosing intestinal protozoan infections among rural Egyptian school children.

Conclusions

In conclusion, the present study revealed a high prevalence (56%) of intestinal parasitic infections among patients attending two major hospitals in Zagazig district, which indicates the public health importance of these infections. The study has identified low ages, male patients, rural residents, low social classes and high crowding indices as potential risk factors for intestinal parasitosis. The study has also shown the diagnostic accuracy of the Mini-Parasep®SF concentrator in diagnosing both helminth and protozoan infections, whereas Mini-FLOTAC (FS2) has exhibited the highest sensitivity for helminths recovery. Till now, little attention has been paid towards using different approaches for mass diagnosis under field conditions. Hence, the authors recommend combining the two innovative faecal parasite concentrators (Mini Parasep®SF and Mini-FLOTAC) as promising alternative tools in routine laboratory and community-based diagnosis of intestinal parasitic infections.

Acknowledgements The authors are grateful to Dr. Nahed E. Mostafa, Professor at the Medical Parasitology Department, Faculty of Medicine, Zagazig University, and Dr. Enas Fakhry Abdel-Hamed, Assistant

Professor at the Medical Parasitology Department, Faculty of Medicine, Zagazig University, for their valuable assistance in the parasitological examination and assessment.

Author contribution Marwa Omar came up with the study idea and drafted the initial proposal. Heba O. Abdelal conducted the statistical analysis of data. Both authors performed the study design and contributed in all previous versions of the manuscript. The authors have also read and approved the final manuscript.

Funding Open access funding provided by The Science, Technology & Innovation Funding Authority (STDF) in cooperation with The Egyptian Knowledge Bank (EKB). This research did not receive any specific grants from funding agencies in the public, commercial or not-for-profit sectors.

Data availability All data and materials used to support the findings of this study are included within this article.

Declarations

Conflict of interest The authors declare no competing interests.

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References

- Abbaszadeh Afshar MJ, Barkhori Mehni M, Rezaeian M, Mohebbali M, Baigi V, Amiri S, Amirshakari MB, Hamidinia R, Samimi M (2020) Prevalence and associated risk factors of human intestinal parasitic infections: a population-based study in the southeast of Kerman province, southeastern Iran. *BMC Infect Dis* 20(1):12
- Abdel Aziz M, Abd El-Rahman E, El-Bahaie E (2020) Evaluation of Midi Parasep® faecal parasite concentrator for the detection of intestinal parasitic infections: a comparative study. *J Egypt Soc Parasitol* 50(2):423–430
- Abdel Fatah N, Nofal L (2012) Anthropometric status, anemia and intestinal parasitic infections among primary school children in Alexandria. *Egypt J High Inst Public Health* 42(1):82–102
- Abera B, Alem G, Yimer M, Herrador Z (2013) Epidemiology of soil-transmitted helminths, *Schistosoma mansoni*, and haematocrit values among schoolchildren in Ethiopia. *J Infect Dev Ctries* 7(3):253–260
- Akinbo FO, Omoregie R, Eromwon R, Igbemimah IO, Airueghiomon UE (2011) Prevalence of intestinal parasites among patients of a tertiary hospital in Benin city. *Nigeria N Am J Med Sci* 3(10):462–464
- Allam AF, Farag HF, Lotfy W, Fawzy HH, Elhadad H, Shehab AY (2021) Comparison among FLOTAC, Kato-Katz and formalin ether concentration techniques for diagnosis of intestinal parasitic

- infections in school children in an Egyptian rural setting. *Parasitology* 148(3):289–294
- Almeida IA, Jeske S, Mesemburg MA, Berne MEA, Villela MM (2017) Prevalence of and risk factors for intestinal parasite infections in pediatric patients admitted to public hospitals in Southern Brazil. *Rev Soc Bras Med Trop* 50(6):853–856
- Amer OSO, Al-Malki ES, Waly MI, AlAgeel A, Lubbad MY (2018) Prevalence of intestinal parasitic infections among patients of King Fahd medical city in Riyadh region, Saudi Arabia: a 5-year retrospective study. *J Parasitol Res* 2018:8076274
- Badawey M, Metwaly S, Mahmoud KG (2015) Prevalence of enteric parasitic infection among food handlers in Zagazig and its surroundings. *Egypt J Med Sci* 36(2):1023–1037
- Baral R, Jha P, Amatya R, Khanal B (2017) Prevalence of intestinal parasitic infections among patients attending in a tertiary care hospital of eastern region of Nepal – a retrospective, laboratory based study. *Asian J Med Sci* 8(3):55–59
- Barda BD, Rinaldi L, Ianniello D, Zepherine H, Salvo F, Sadutshang T, Cringoli G, Clementi M, Albonico M (2013) Mini-FLOTAC, an innovative direct diagnostic technique for intestinal parasitic infections: experience from the field. *PLoS Negl Trop Dis* 7(8):e2344
- Barda B, Cajal P, Villagran E, Cimino R, Juarez M, Krolewiecki A, Rinaldi L, Cringoli G, Burioni R, Albonico M (2014) Mini-FLOTAC, Kato-Katz and McMaster: three methods, one goal; highlights from north Argentina. *Parasit Vectors* 7:271
- Burning JL, Kintz BL (1997) *Computational handbook of statistics*, 4th edn. Addison Wesley Longman Inc, Massachusetts
- Bursac Z, Gauss CH, Williams DK, Hosmer DW (2008) Purposeful selection of variables in logistic regression. *Source Code Biol Med* 3(17):1–8
- Cheesbrough M (1991) *Techniques used to identify parasite in: Medical Laboratory Manual for Tropical Countries*. Britain, Butterworth-Heinemann Ltd., Oxford, UK, 178–197
- Cringoli G (2006) FLOTAC, a novel apparatus for a multivalent faecal egg count technique. *Parassitologia* 48:381–384
- Diongue K, Ndiaye M, Seck MC, Diallo MA, Ndiaye YD, Badiane AS, Ndiaye D (2017) Distribution of parasites detected in stool samples of patients in Le Dantec University Hospital of Dakar, Senegal, from 2011 to 2015. *J Trop Med* 2017:8296313
- El-Barmelgy M, El-Khateb M (2020) Developing and increasing open spaces by using smart growth approach applied to Zagazig city-Egypt. *J Eng Appl Sci* 67(2):275–293
- El-Nadi NAF, Omran EK, Ahmed NS, Fadel EF (2017) Current status of intestinal parasites among elementary school children in Sohag. *Egypt J Adv Parasitol* 4(2):33–40
- El-Nadi N, Ahmed A, Ahmed N, El-Laah A (2019) Evaluation of mini-FLOTAC method for diagnosing intestinal parasitic infections. *P UJ* 12(2):147–152
- El-Sherbini GT, Abosdera MM (2013) Risk factors associated with intestinal parasitic infections among children. *J Egypt Soc Parasitol* 43(1):287–294
- Eyayu T, Kiros T, Workineh L, Sema M, Damtie S, Hailemichael W, Dejen E, Tiruneh T (2021) Prevalence of intestinal parasitic infections and associated factors among patients attending at Sanja Primary Hospital, Northwest Ethiopia: an institutional-based cross-sectional study. *PLoS One* 16(2):e0247075
- Fahmy SI, Nofal LM, Shehata SF, El Kady HM, Ibrahim HK (2015) Updating indicators for scaling the socioeconomic level of families for health research. *J Egypt Public Health Assoc* 90(1):1–7
- Farghly AM, Mohamed SM, Abdel-Rahman SA, Mohammed FE, El-Bahaie ES, El-Shafey MA (2016) The relation between the prevalence of soil transmitted parasites in the soil and among school children in Zagazig district, Sharkyia Governorate. *Egypt J Parasitol Dis* 40(3):1021–1029
- Garcia LS (2001) *Diagnostic Medical Parasitology*, 4th edn. DC, ASM Press, Washington, p 1069
- Gelaw A, Anagaw B, Nigussie B, Silesh B, Yirga A, Alem M, Endris M, Gelaw B (2013) Prevalence of intestinal parasitic infections and risk factors among schoolchildren at the University of Gondar Community School, Northwest Ethiopia: a cross-sectional study. *BMC Public Health* 13:304
- Geneidy MR (2019) A Study on intestinal parasitic infections among immunocompetent Egyptian children attending Al-Hussein University Hospital. *Cairo Egypt J Hops Med* 77(4):5322–5337
- Hailegebriel T (2017) Prevalence of intestinal parasitic infections and associated risk factors among students at Dona Berber primary school, Bahir Dar. *Ethiopia BMC Infect Dis* 17(1):362
- Hailu GG, Ayele ET (2021) Assessment of the prevalence of intestinal parasitic infections and associated habit and culture-related risk factors among primary schoolchildren in Debre Berhan town, Northeast Ethiopia *BMC Public Health* 21(1):112
- Hassen Amer O, Ashankyty IM, Haouas NA (2016) Prevalence of intestinal parasite infections among patients in local public hospitals of Hail, Northwestern Saudi Arabia. *Asian Pac J Trop Med* 9(1):44–48
- Hussein AH, Rashed SM, El-Hayawan IA, Aly NSM, Abou Ouf EA, Ali AT (2017) Intestinal parasite infections and accuracy of direct thin and thick smear, formol-ether sedimentation, centrifugal flotation, and Mini-FLOTAC techniques among patients with gastrointestinal tract disorders from the Greater Cairo Region. *Egypt Am J Trop Med Hyg* 96(3):589–594
- Kebede E, Seid A, Akele S (2019) Prevalence and associated risk factors of intestinal parasitic infections among asymptomatic food handlers in Wollo University student's cafeteria. *Northeast Ethiopia BMC Res Notes* 12(1):139
- Levecke B, De Wilde N, Vandenhoute E, Vercruysse J (2009) Field validity and feasibility of four techniques for the detection of *Trichuris* in simians: a model for monitoring drug efficacy in public health? *PLoS Negl Trop Dis* 3:e366
- Mahmoud A, Abdul Fattah M, Zaher T, Abdel-Rahman S, Mosaad N (2017) Intestinal parasitic infections and iron deficiency anaemia among school children in El Khalige village, Dakhalia. *Egypt Afro-Egypt J Infect Endem Dis* 7(1):28–36
- Mahmud MA, Spigt M, Bezabih AM, Dinant GJ, Velasco RB (2020) Associations between intestinal parasitic infections, anaemia, and diarrhoea among school aged children, and the impact of hand-washing and nail clipping. *BMC Res Notes* 13(1):1
- Mbong NM, Prince MG, Nguema MPA, Ramharter M, Esen M, Adégnika AA (2020) Diagnostic techniques of soil-transmitted helminths: impact on control measures. *Trop Med Infect Dis* 5(2):93
- McCarthy JS, Lustigman S, Yang GJ, Barakat RM, García HH, Sripta B, Willingham AL, Prichard RK, Basáñez MG (2012) A research agenda for helminth diseases of humans: diagnostics for control and elimination programmes. *PLoS Negl Trop Dis* 6(4):e1601
- Melki IS, Beydoun HA, Khogali M, Tamim H, Yunis KA (2004) National Collaborative Perinatal Neonatal Network (NCPNN). Household crowding index: a correlate of socioeconomic status and inter-pregnancy spacing in an urban setting. *J Epidemiol Community Health* 58(6):476–480
- Mohammad SM, Ali M, Abdel-rahman SA, Moustafa RA, Salama MA (2021) Molecular prevalence of *Cryptosporidium* isolates among Egyptian children with cancer. *J Parasitol Dis* 45(3):746–753
- Mohram AF, Elawamy WE, Nageeb MM, Ali HS, Kishik SM (2020) Combined Mini-Parasep SF and nanogold immunoassay show potential in stool antigen immunodetection for giardiasis diagnosis. *Sci Rep* 10(1):2
- Momčilović S, Cantacessi C, Arsić-Arsenijević V, Otranto D, Tasić-Otašević S (2019) Rapid diagnosis of parasitic diseases: current scenario and future needs. *Clin Microbiol Infect* 25(3):290–309

- Monib MEM, Hassan AAAE, Attia RAEH, Khalifa MM (2016) Prevalence of intestinal parasites among children attending Assiut university children's hospital, Assiut. *Egypt J Adv Parasitol* 3(4):125–131
- Moses A, Uchenna U, Michael E (2013) Prevalence of intestinal parasites from the fingers of school children in Ohaozara, Ebonyi State, Nigeria. *Am J Biol Chem Pharm Sci* 1(5):22–27
- Ng'etich AI, Rawago FO, Jura WG, Mwinzi PN, Won KY, Odiere MR (2016) A cross-sectional study on schistosomiasis and soil-transmitted helminths in Mbita district, western Kenya using different copromicroscopic techniques. *Parasit Vectors* 16(9):87
- Ngui R, Saidon I, Chow SC, Rohela M, Lim YAL (2011) Prevalence and risk factors of intestinal parasitism in rural and remote West Malaysia. *PLoS Negl Trop Dis* 5(3):e974
- Paho (2019) Neglected infectious diseases in the Americas: success stories and innovation to reach the neediest. *Parasit Epidemiol Control* 3:e00071
- Saez AC, Manser MM, Andrews N, Chiodini PL (2011) Comparison between Midi Parasep® and Midi Parasep® solvent free (SF) fecal parasite concentrators. *J Clin Pathol* 64:901–904
- Stephenson LS, Latham MC, Ottesen EA (2000) Malnutrition and parasitic helminth infections. *Parasitology* 121:23–38
- Taghipour A, Ghodsian S, Jabbari M, Olfatifar M, Abdoli A, Ghafarififar F (2021) Global prevalence of intestinal parasitic infections and associated risk factors in pregnant women: a systematic review and meta-analysis. *Trans R Soc Trop Med Hyg* 115(5):457–470
- Utzinger J, Botero-Kleiven S, Castelli F, Chiodini PL, Edwards H, Köhler N, Gulletta M, Lebbad M, Manser M, Matthys B, N'Goran EK, Tannich E, Vounatsou P, Marti H (2010) Microscopic diagnosis of sodium acetate-acetic acid-formalin-fixed stool samples for helminths and intestinal protozoa: a comparison among European reference laboratories. *Clin Microbiol Infect* 3:267–273
- Versi E (1992) “Gold standard” is an appropriate term? *BMJ* 305(6846):187–187
- Yimam Y, Woreta A, Mohebbi M (2020) Intestinal parasites among food handlers of food service establishments in Ethiopia: a systematic review and meta-analysis. *BMC Public Health* 20:73
- Yones D, Othman R, Hassan T, Kotb S, Mohamed A (2019) Prevalence of gastrointestinal parasites and its predictors among rural Egyptian school children. *J Egypt Soc Parasitol* 49(3):619–630

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