Am. J. Trop. Med. Hyg., 104(3), 2021, pp. 910–916
doi:10.4269/ajtmh.20-0187

Prevalence and Clinical Manifestations of *Giardia intestinalis* and Other Intestinal Parasites in Children and Adults in Algeria

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Abstract. *Giardia intestinalis* is one of the most common causes of parasite-induced diarrhea, abdominal pain, flatulence, and malabsorption. Yet, data on the epidemiology of *G. intestinalis* infections in North Africa are limited. The purpose of this study was to carry out a retrospective survey on the level of intestinal parasitism with a particular emphasis on *G. intestinalis* in children and adults in Algiers, Algeria. A total of 2,054 individuals from outpatient clinics or hospitalized at Beni-Messous University Hospital of Algiers undergoing stool microscopy for ova and parasites were included. The overall parasite infection rate was 28%. In the 567 parasite-positive samples, *Blastocystis* was found most frequently (57.3%), followed in frequency by *Endolimax nana* (41.0%), *Entamoeba histolytica/dispar* (19.6%), *G. intestinalis* (17.1%), *Entamoeba coli* (13.9%), *Chilomastix mesnili* (1.0%), *Iodamoeba bütschlii* (0.7%), *Entamoeba hartmanni* (0.5%), and *Cryptosporidium* spp. (0.2%). Intestinal parasites were generally more common in adults than in children, except for *Giardia*, which was more common in children ($P = 0.0001$). *Giardia* infection was independent of gender ($P = 0.94$). Compared with other intestinal parasitic infections, clinical manifestations, such as abdominal pain ($P = 0.28$) and diarrhea ($P = 0.82$), were found not to be significantly linked to *Giardia* infection. In conclusion, *G. intestinalis* is common in individuals referred to the University Hospital of Beni-Messous with digestive symptoms, particularly so in children. However, in our study, intestinal symptoms appeared not to be more linked to *Giardia* than to other intestinal parasites.

INTRODUCTION

Infections due to intestinal protozoa take a toll on public health, especially in low- and middle-income countries in tropical and subtropical regions.[1]

Giardia intestinalis (syn. *Giardia lamblia* and *Giardia duodenalis*) is a protozoan intestinal parasite, which can infect various mammalian hosts, including humans, wildlife, livestock, and companion animals.[2] The prevalence of *Giardia* infection varies from approximately 2–5% in the industrialized world[3] to 20–30% in low- and middle-income countries,[4,5] with children typically being more frequently infected than adults.[6] Owing to the elevated burden of *G. intestinalis*–related illnesses in developing countries, its impact on developmental and socioeconomic improvements, and its close connection with poverty, this parasite has been included in the WHO's Neglected Diseases Initiative since 2004.[7–9]

Giardia transmission typically occurs following ingestion of infectious cysts via the consumption of contaminated food or water or through a direct fecal–oral route. The clinical manifestations of *G. intestinalis* infection vary and can range from acute to chronic infections, whereas some carriers may remain/become asymptomatic. When present, the clinical signs of infection may include diarrhea, nausea, weight loss, bloating, and abdominal pain.[10,11] In addition to provoking acute symptoms, *Giardia* has been associated with long-term postinfectious sequelae, including functional gastrointestinal disorders, failure to thrive, chronic fatigue syndrome, arthritis, ocular pathology, and cognitive impairment in children.[12] Many factors contribute to the variation observed in clinical manifestations, including the virulence of the parasite strain, the number of cysts ingested, the age of the host, and the state of the immune system at the time of infection.[13] Much of our knowledge on infection risk factors has been derived from outbreak investigations, whereas only few studies have addressed risk factors for endemic or sporadic giardiasis.[14–17] Insight into the epidemiology of *Giardia* infection is critical to developing effective preventive strategies and activities. However, in the entire area of North Africa, only a limited number of studies have been carried out, and these tend to report only on the prevalence, without focusing on clinical manifestations and epidemiological characteristics of giardiasis in children and adults and investigating factors that influence the distribution of *G. intestinalis* in this area (Table 1). The scope of the current study was to elucidate the epidemiology and clinical significance of *G. intestinalis* infections in the area of Algiers, Algeria, by identifying the prevalence of *Giardia* infection and comparing sociodemographic and clinical data of *Giardia*-infected individuals with those pertaining to individuals infected by other intestinal parasitic protists.

MATERIALS AND METHODS

Study population and sample collection. A community-based cross-sectional descriptive study was performed between September 2012 and October 2013 in the western part of Algiers, Algeria. Consecutive stool samples were collected from 1) outpatients who came and went the same day after providing a sample, and 2) individuals hospitalized for various medical conditions. For parasite-positive patients, epidemiological information was provided either by using a questionnaire or from medical records. No epidemiological information was available for the parasite-negative individuals.

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TABLE 1

Prevalence of *Giardia intestinalis* in humans reported in North African countries

	Giardia prevalence (%)	Population size	Study population	Study period	Age range of study population (years)	Diagnostic method(s) used	Reference
Algeria (Algiers)	4.7	2,054	Inpatients and outpatients	September 2012–October 2013	1 to ≤ 90	Direct microscopy and formol-ether concentration technique	Present study
Algeria (Oran)	3.6	1,042	Patients with digestive disorders	December 2010–November 2011	≤ 80	Direct wet mount and formol-ether concentration technique	Ref. 24
Algeria (Boufarik)	41.67	542	Sporadic cases	March–October 2011	≤ 75	Direct microscopy examination and iodine staining	Ref. 44
Egypt	38	185	Outpatients with a variety of gastrointestinal and non-gastrointestinal symptoms	Not stated	2–58	Microscopic examination after centrifugation associated with iodine staining and immunoassay (ELISA)	Ref. 43
Egypt	8.5	200	Mentally handicapped individuals	December 2012–November 2013	< 10 to ≥ 20	Trichrome staining (without concentration)	Ref. 28
Egypt	3.8	346	Municipality solid-waste workers	January and April 2013	21–59	Formol-ether concentration technique	Ref. 48
Egypt	24.2	330	Individuals with or without symptoms	January 2010–January 2011	All ages	Direct wet smear method, Sheather's sugar flotation, acid ether sedimentation technique, and lugol staining	Ref. 49
Libya	1.3	305	Individuals with diarrhea	October 2011 –July 2012	Not specified	Direct microscopy under normal saline, iodine, and eosin stains, and four concentration methods (formalin-ether, normal saline sedimentation, zinc sulfate, and Sheather's sugar flotation)	Ref. 26
Libya	26.3	505	Children with diarrhea	September 2013–June 2014	2–17	Immunofluorescence assay including DAPI*	Ref. 29
Libya	1.3	239	Children with diarrhea	February 2008–October 2008	≤ 5	Enzyme-immunoassays (EIAs)	Ref. 50
Tunisia (Sfax)	48	3,025	Hospitalized patients in pediatric services	December 1980–November 1990	≤ 10	Direct microscopy under physiological water and lugol, and formol-ether concentration technique and Willis technique with MIF†	Ref. 22
Tunisia	1.48	20,033	Not stated	January 1996–December 2012	Not stated	Direct microscopy, formol-ether concentration technique, and Baermann method	Ref. 51
Morocco (Settat)	11.7	333	Individuals using raw sewage waters in agriculture	Not stated	3–60	Direct microscopy, concentration technique of Bailenger	Ref. 52
Morocco (Beni-Mellal)	34.3	1,343	Children	January–March 1999	≤ 12	Direct microscopy and formol-ether concentration technique	Ref. 53
Morocco (Center of health El Idrissi, Kenitra)	22.7	4,285	Population living in Kenitra and suburbs	1996–2005	< 18 and ≥ 18	Direct microscopy and lugol staining	Ref. 25
Morocco (Tetouan)	19.8	673	Children (urban and rural)	May 2012–June 2013	5–14	Lugol staining, Faust's and Ritchie's concentration methods, and molecular analysis	Ref. 30

* DAPI = 4′,6-diamidino-2-phenylindole fluorescent stain.

† MIF = merthiolate-iodo-formol stain.

Fresh fecal samples were collected from each patient in a labeled and sterile container. Informed written consent was provided for children involved in the study by parents or guardians. A single stool sample from each study individual was examined by microscopy for the presence of intestinal parasites. All samples testing positive for *Giardia* were stored at 4°C in 2.5% (w/v) potassium dichromate solution for subsequent DNA extraction and molecular analyses (these data are not included in the present article). Individuals aged 15 years or older were considered adults.

Questionnaires. Parasite-positive individuals enrolled in the study completed a structured questionnaire with the purpose to collect data pertaining to epidemiological characteristics such as age, gender, and symptoms possibly related to intestinal parasitic infections such as diarrhea, nausea, vomiting, abdominal pain, anal pruritus, paleness, failure to thrive, and fever. Diarrhea was defined as the voiding of three or more unformed stools within a 24-h period.[18]

Sample processing. Stool samples were examined by the naked eye for color, consistency, and the presence of helminths, and subsequently examined by direct microscopy using Ritchie's modified concentration technique.[19] A small amount of stool (commensurate to the size of a pea) was mixed with 7 mL of 10% formalin solution and sieved through double-layered gauze and collected in a beaker. Next, the suspension was transferred into a 15-mL centrifuge tube and topped up with 3 mL of diethyl ether. Afterward, we capped the centrifuge tube and mixed the suspension by shaking before centrifuging for 3 minutes at 1,500 rpm. The top three layers (ether, debris, and formalin) were removed, whereas the sediment was retained. Wet mounts of each fresh concentrate fecal sample were prepared in saline and iodine, and observed by light microscopy for parasite eggs, cysts, and trophozoites using ×100 and ×400 magnification. Also, a permanently stained slide was prepared for each sample using modified Ziehl–Neelsen staining for the detection of *Cryptosporidium* spp.[20] and other protozoan oocysts.

Statistical analysis. Data were entered in Excel (Microsoft Corp., Redmond, WA), and statistical analysis was performed using Statistica 6.0 (Tibco Software Inc., Palo Alto, CA) software adapted to epidemiology. The χ^2-square test was used to test differences in parasite prevalence according to age-group, gender, and symptoms (diarrhea, nausea, fever, and gastrointestinal complaints). Probability (*P*) values were calculated with an alpha risk = 5% for a CI of 95%. A difference was considered significant when the *P*-value was < 0.05.

RESULTS

A total of 2,054 individuals were tested. Altogether, 567 of the samples (27.6%) from 543 outpatients and 24 inpatients were scored as parasite positive by microscopy for ova and parasites. Of these patients, 297 were males and 270 females: 239 were children (less than 15 years old) and 255 were adults (Table 2). For 121 of the parasite-positive individuals, no exact age could be established, but for 16 of these, the age was < 15 years, and for 32, the age was known to be ≥ 15 years. For the 494 individuals with specific age information, the age range was 1–90 years (median age, 15 years; interquartile range = 6–39).

Parasites frequently observed included *Blastocystis*, *Endolimax nana*, *Entamoeba histolytica/dispar*, *G. intestinalis*, and *Entamoeba coli*, with observed overall prevalence rates of 15.8%, 11.3%, 5.4%, 4.7%, and 3.8%, respectively. *Entamoeba hartmanni*, *Cryptosporidium* spp., *Chilomastix mesnili*, and *Iodamoeba bütschlii* were all detected in very few cases, with overall observed prevalences of less than 1% for each (Table 2).

Of the 97 *Giardia*-infected individuals, almost two-thirds (62/97, 63.9%) were children aged 1–10 years. Among parasite-positive adults, the proportion of *Giardia*-infected individuals was 5.5% compared with 27.5% among parasite-positive children ($P < 0.0001$; Table 2). Among the 239 parasite-positive children, cases of *Giardia* appeared to decrease by age: among toddlers (children aged 1–3 years of age), the proportion was 40.7%; it remained relatively high in children aged 4–6 and 7–10 years (33.8% and 29.5%, respectively), but decreased to the level of adults in children aged 11–15 years (4.7%).

The most common parasite in adults was *Blastocystis* (64.7%), followed in frequency by *E. nana* (48.6%) and species of *Entamoeba* (16.9–18.8%). Also, in parasite-positive children, *Blastocystis* was most common (48.8%), mainly in children aged 11–15 years, followed by *E. nana* (35.4%) and *G. intestinalis* (27.5%). *Blastocystis* and *E. nana* were more commonly detected in adults than in children ($P = 0.0006$ and $P = 0.0044$, respectively; Table 2). For the remaining parasites found, there was no association between age and occurrence. A link between gender and parasitism rate could not be identified for any of the species (Table 2).

In 65/97 (69.1%) of the *Giardia* cases, *Giardia* was the only parasite detected (Table 3); in the remaining 32 cases, one or more other parasites were also detected. Unsurprisingly, *Blastocystis* and *E. nana* were the parasites most often associated with *Giardia* (12 and eight cases, respectively). The level of coinfection was quite similar across all age-groups.

Of 567 parasite-positive individuals, 104 (18.3%) were symptomatic, whereas the remaining 463 (81.7%) were non-symptomatic. The most commonly reported symptoms were abdominal pain and diarrhea, reported in 56/567 (9.9%) and 35/567 (6.2%) in parasite-positive cases, respectively (Table 4). Of note, for 62/65 (95.4%) cases with *Giardia* mono-infections, no diarrhea was reported. Similarly, even for cases where *Giardia* was observed with other parasites, diarrhea was reported only in 6.3% (Table 3); thus, only five samples (three with *Giardia* only and two with *Giardia* + *Blastocystis* and *Giardia* + *E. nana*, respectively) could be linked to diarrheal episodes (Tables 3 and 4). In fact, when comparing the 35 reports on diarrhea, 30 of these cases were positive for parasites other than *Giardia*, namely, *Blastocystis* (48.6%; 17/35), *E. nana* and *E. histolytica/dispar* (31.4%; 11/35% and 28.6%; and 10/35, respectively), *C. mesnili*, and *Cryptosporidium* spp. (2.9%; 1/35 of each).

The total number of *Giardia*-positive cases reporting symptoms was 21. When reviewing all reports on gastrointestinal symptoms, none of these were more common in individuals testing positive for *Giardia* than in individuals testing positive for other parasites (Table 4).

DISCUSSION

The overall prevalence of intestinal parasitism in the present study (27.6%) is in agreement with data reported previously from North African countries,[21–23] where rates of intestinal

TABLE 2

Distribution of intestinal parasites among parasite-positive individuals ($N = 567$) according to age and gender in the current study

	Age range (years),* *n* (%)								Gender			
	(1–3) ($n = 54$)	(4–6) ($n = 65$)	(7–10) ($n = 61$)	(11–15) ($n = 43$)	Individuals aged < 15 years ($n = 239$)	Individuals aged ≥ 15 years ($n = 255$)	Total of individuals with neither exact nor approximated age ($n = 73$)	Total/overall prevalence (%) ($n = 567$)	Level of statistical significance for prevalence differences between children and adults† (*P*-value)	Prevalence in females ($n = 270$), *n* (%)	Prevalence in males ($n = 297$), *n* (%)	Level of statistical significance for prevalence differences between genders[2] (*P*-value)
Giardia intestinalis	22 (40.7)	22 (33.8)	18 (29.5)	2 (4.7)	66 (27.5)	14 (5.5)	17 (23.3)	97 (17.1)	$P < 0.0001$*	47 (17.4)	50 (16.8)	$P = 0.94$
Cryptosporidium spp.	0	1 (1.5)	0	0	1 (0.4)	0	0	1 (0.2)	$P = 0.97$	0	1 (0.3)	$P = 0.33$
Entamoeba histolytica/ dispar	12 (22.2)	13 (20.0)	12 (19.7)	11 (25.6)	50 (20.8)	48 (18.8)	13 (17.8)	111 (19.6)	$P = 0.63$	56 (20.7)	55 (18.5)	$P = 0.57$
Entamoeba coli	5 (9.2)	7 (10.7)	9 (14.8)	3 (7.0)	27 (11.3)	43 (16.9)	9 (12.3)	79 (13.9)	$P = 0.1$	35 (13.0)	44 (14.8)	$P = 0.60$
Entamoeba hartmanni	0	1 (1.5)	0	1 (2.3)	2 (0.8)	1 (0.4)	0	3 (0.5)	$P = 0.95$	1 (0.4)	2 (0.7)	$P = 0.61$
Iodamoeba bütschlii	1 (1.9)	0	0	1 (2.3)	1 (0.4)	2 (0.8)	1 (1.4)	4 (0.7)	$P = 0.60$	1 (0.4)	3 (1.0)	$P = 0.68$
Endolimax nana	13 (24.0)	25 (38.4)	16 (26.2)	27 (62.8)	85 (35.4)	124 (48.6)	23 (31.5)	233 (41.0)	$P = 0.0044$*	104 (38.5	129 (43.4)	$P = 0.27$
Chilomastix mesnili	0	0	1 (1.6)	1 (2.3)	3 (1.3)	2 (0.8)	1 (1.4)	6 (1.0)	$P = 0.94$	2 (0.7)	4 (1.3)	$P = 0.76$
Blastocystis hominis	24 (44.4)	27 (41.5)	32 (52.5)	24 (55.8)	117 (48.8)	165 (64.7)	43 (59.0)	325 (57.3)	$P = 0.0006$*	158 (58.5)	167 (56.2)	$P = 0.64$

* It should be noted that there were 121 individuals whose age was not specifically reported; however, 32 of these were adults and therefore included in the group of individuals aged ≥ 15 years, and 16 were children who were included in the group of individuals aged < 15 years. Individuals younger than 15 years were considered as children.

† $P > 0.05$ = Not statistically significant; *$P < 0.05$ = statistically significant.

TABLE 3
Repartition of coinfection cases involving *G. intestinalis* and other protozoan species by age range and presence of diarrhea

Infection by *G. intestinalis*	Age range (years)						Presence/absence of diarrhea	
	(1–3)	(4–6)	(7–10)	(11–15)	> 15	Undetermined age	Presence of diarrhea	Absence of diarrhea
G. intestinalis	15	15	14	1	9	11	3	62
G. intestinalis + *B. hominis*	3	1	2	–	1	5	1	11
G. intestinalis + *E. nana*	2	3	1	1	1	0	1	7
G. intestinalis + *B. hominis* + *E. nana*	1	1	–	–	–	–	–	2
G. intestinalis + *B. hominis* + *E. histolytica/dispar*	–	1	–	–	1	–	–	2
G. intestinalis + *E. nana* + *E. coli*	–	–	–	–	1	1	–	2
G. intestinalis + *E. nana* + *I. bütschlii*	–	–	–	–	1	–	–	1
G. intestinalis + *E. nana* + *E. histolytica/dispar*	1	–	–	–	–	–	–	1
G. intestinalis + *E. coli* + *E. histolytica/dispar*	–	1	–	–	–	–	–	1
G. intestinalis + *E. coli* + *B. hominis*	–	–	1	–	–	–	–	1
G. intestinalis + *E. coli* + *E. histolytica/dispar* + *B. hominis*	–	–	–	–	–	1	–	1
G. intestinalis + *B. hominis* + *E. nana* + *E. histolytica/dispar* + *I. bütschlii*	–	–	–	–	–	1	–	1
Total	22	22	18	2	14	19	5	92

Blastocystis hominis = *B. hominis*; *Entamoeba coli* = *E. coli*; *Entamoeba histolytica/dispar* = *E. histolytica/dispar*; *Giardia intestinalis* = *G. intestinalis*; *Iodamoeba bütschlii* = *I. bütschlii*.

parasitism reportedly range from 26.6% to 30.6%. Nevertheless, other studies have reported somewhat lower prevalence rates, ranging from 6.7% to 19.7%.[24–27] Only one study indicated a higher rate of parasitism (42.6–44.6%).[28] In our study, the prevalence of *Giardia* was significantly higher in children than in adults. Conversely, the prevalence of other parasites, especially *Blastocystis* and *Endolimax*, was higher in adults than in children. Some studies have identified a similar pattern, where age appeared to influence the rate of *Giardia* infection, with children being significantly more infected than adults.[29–33] Two studies were recently performed in Libya, the first comprising 305 individuals of unspecified age with diarrhea, where the prevalence of *Giardia* was found to be 1.3%,[26] whereas the second included 505 children aged 2–17 years with diarrhea, where the prevalence was reported to be 26.3%.[29]

As of today, quite a few studies have identified that some parasites appear to be markedly more common in adults than in children. In the present study, *E. nana* and *Blastocystis* were more often found in adults than in children. A recent study involving Nigerian individuals also found an increasing prevalence of *Blastocytis* by age,[34] and similar trends have been observed by other research teams for *Blastocystis* and species belonging to Archaemoeba.[35–39] There might be a general tendency of flagellates such as *Giardia* and *Dientamoeba* to be more common in children than in adults, whereas *Blastocystis* and genera belonging to the Archamoebae become more common with increasing age.[24,40–42] Because all these parasites are common and transmitted fecal orally, and because both adults and children may not be differentially exposed, differences in infection may reflect differences in factors related to immunity and gut microbiota.

In our study, direct microscopy of fecal concentrates was used for detection and differentiation of intestinal protists, whereas a few previous studies[28,29,43,44] used a combination of or different examination and diagnostic tests, including microscopy of fecal concentrates, immunoassays, an immunofluorescence assay including 4′,6-diamidine-2-phenylindole-dihydrochloride, trichrome staining, and iodine staining, all of which may differ in terms of sensitivity with a consequence for the reported *Giardia* prevalence. This can be exemplified by a study carried out recently in Egypt,[43] where the prevalence of *Giardia* was 38% based on immunoassay results compared with 18% based on results from microscopy of fecal concentrates.

The extent of coinfection between *Giardia* and other intestinal parasitic protists was investigated in the present study. *Giardia* in association with *Blastocystis* was found in 12

TABLE 4
Clinical symptoms observed for patients positive for *Giardia* and for parasites other than *Giardia*, respectively, for whom clinical information was available

Clinical signs and symptoms	Total no. of patients	Positive for *Giardia* (n = 97), n (%)		Positive for parasites other than *Giardia* (n = 470), n (%)		χ^2	P-value
Abdominal pain	56	13	(13.4)	43	(9.1)	1.19	0.28
Diarrhea	35	5	(5.2)	30	(6.4)	0.05	0.82
Constipation	17	2	(2.1)	15	(3.2)	007	0.79
Anorexia	4	2	(2.1)	2	(0.4)	1.18	0.28
Vomiting and nausea	11	3	(3.1)	8	(1.7)	0.25	0.62
Fever	18	5	(5.2)	13	(2.8)	0.82	0.37
Anal pruritus	22	5	(5.2)	17	(3.6)	0.18	0.67
Paleness	5	2	(2.1)	3	(0.6)	0.59	0.44
Failure to thrive	8	3	(3.1)	5	(1.1)	1.14	0.28

$P > 0.05$ = not statistically significant.

cases (2.1%), which is consistent with the study carried out in Oran, Algeria.[24] In another recent study performed in urban Bissau, Guinea-Bissau, comprising 1,274 children in cohort I (healthcare-seeking children, n = 566) and cohort II (background population; i.e., non–healthcare-seeking children, n = 708), 2–15 years of age, the authors found *Giardia* and *E. histolytica/dispar* together in 10 cases (1.8%) and 20 cases (2.8%), respectively, and *Giardia* and *E. nana* together in seven cases (1.2%) and nine cases (1.3%), respectively, which is concordant with our results (1.4%).[31]

In a study based in sub-Saharan Africa and South Asia,[45] *Giardia* was not significantly associated with moderate-to-severe diarrhea; a similar observation was made in another report of endemic pediatric giardiasis concluding that there was an ostensibly paradoxical association with protection against acute diarrhea from other specific enteropathogens, yet an enhanced risk of persistent diarrhea in *Giardia* carriers.[46] In the present study, none of the reported symptoms were more common in those with *Giardia* than among those who were positive for other parasites (Table 4). Apart from diarrhea, *Giardia* has been linked with other gastrointestinal symptoms, such as abdominal distension, vomiting, fever, and weight loss mainly in children.[47] Unfortunately, for all the symptomatic individuals, no information was available on whether infections were light, moderate, or heavy. This information would have been relevant to possibly establish links on relative infection intensity as assessed by, for example, real-time PCR where cycle threshold values for *Giardia*-positive patients could be collated and analyzed in the context of symptoms.

Our study has a few limitations. First, it was performed over a period of only 12 months, and, consequently, the number of identified *Giardia*-infected individuals was relatively small. Second, it was hospital based, and no healthy control population was examined to obtain data on the background prevalence of *Giardia* and other parasites in the area, which means that we were not able to identify whether individuals seeking medical care are more prone to testing positive for *Giardia* and other intestinal parasites than those not seeking medical care (background population) in the study area. Third, no clinical or epidemiological data were available for the parasite-negative patients. Therefore, we were not able to investigate whether colonization by parasites could be protective of intestinal symptoms. In addition to these limitations, because of time constraints, it was not possible to investigate more than one stool sample per participant, although the diagnostic sensitivity of microscopy would increase with an increased number of samples examined per person.[31] It is plausible that our study design would underestimate the factual prevalence; however, it must be noted that this limitation has been seen in a previously published study in Algeria,[24] which renders the context of our prevalence comparable.

CONCLUSION

This study gives an important indication of the extent of *Giardia* infections in both children and adults in the Algiers area. Of particular note, we found that *Giardia* was most common in smaller children and that *Giardia* infection overall was not particularly linked to intestinal symptoms. However, we were not able to identify to which extent symptoms might be associated with infection intensity. Finally, we confirmed clear differences in the distribution of *Giardia*, *Blastocystis*, and archamoebids across age-groups. Studies identifying the distribution of these parasites in the context of the bacterial gut microbiome are warranted to learn whether differences in parasite distribution are reflected in differences in the gut microbiome.

Received March 13, 2020. Accepted for publication September 6, 2020.

Published online January 18, 2021.

Acknowledgments: We would like to thank the staff of the Unit of Parasitology–Mycology at the University Hospital of Beni-Messous for providing us with all materials needed for achieving this study and making time to answer our questions. We also acknowledge Jakob Skov, Technical University of Denmark, for his critical review of earlier versions of this manuscript.

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