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Intestinal Parasites and HIV Co-infections in Mogadishu (Somalia): A Retrospective Evaluation of Four-Year Follow-up Data

Mogadişu'da (Somali) İntestinal Parazitler ve HIV Ko-enfeksiyonları: Dört Yıllık Takip Verilerinin Retrospektif Değerlendirmesi

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Abstract

This study aimed to evaluate the frequency and distribution characteristics of intestinal parasites and human immunodeficiency virus (HIV) seropositivity in children and adults presenting to a tertiary care hospital in Mogadishu, Somalia. The study included the results of all parasitological stool examinations conducted between November 2015 and November 2019. In addition, the HIV serological status of individuals was retrospectively analyzed. During the four-year study period, at least one intestinal parasite was found in stool samples from 1,538 (6.23%) of 24,676 individuals. A total of 1,570 intestinal parasites were detected in 1,538 patients (42.5% aged 10 years and under), including 44 parasites in mixed infections and 20 parasites in 10 patients at different times. The most common intestinal parasite was *Giardia lamblia* (n=730, 46.5%), followed by *Entamoeba histolytica* (n=677, 43.1%), *Ascaris lumbricoides* (n=30, 1.9%), *Hymenolepis nana* (n=28, 1.78%), *Trichomonas hominis* (n=26, 1.66%), *Trichuris trichiura* (n=26, 1.66%), and eight other species (n=53, 3.38%). HIV seropositivity was present in 1.12% (4/358) of the patients with parasitic infections and

0.39% (23/5868) of those with a negative stool test (p=0.0655). Intestinal parasitic infections increased in December and January. *A. lumbricoides* and *T. trichiura* were significantly increased in patients from refugee camps. This study included the most comprehensive data on the distribution and characteristics of intestinal parasitic infections and HIV seroprevalence in Somalia over the last 30 years. We consider that these data will contribute to the risk analysis and planning of preventive health policies.

Keywords: Immigrants, Refugees, Child health, Giardiasis, Amoebiasis.

Özet

Bu çalışmada Somali Mogadişu'da bulunan bir üçüncü basamak hastanesine başvuran çocuk ve yetişkinlerde intestinal parazitlerinin görülme sıklığı ve dağılım özellikleri ile insan immün yetmezlik virusu (HIV) seropozitifliğinin değerlendirilmesi amaçlanmıştır. Çalışma, Kasım 2015 ile Kasım 2019 arasında yapılan tüm parazitolojik dışkı incelemelerinin sonuçlarını içermektedir. Ek olarak, bireylerin HIV serolojik durumları retrospektif olarak incelenmiştir. Dört yıllık çalışma süresi boyunca, 24.676 kişiden 1.538'inin (%6.23) dışkı örneklerinde en az bir intestinal parazit varlığı bulundu. Çoklu enfeksiyonlarda 44 parazit ve 10 hastada farklı zamanlarda saptanan 20 parazit dahil olmak üzere 1.538 hastada (%42.5'i 10 yaş ve altı) toplam 1.570 intestinal parazit tespit edildi. En yaygın tespit edilen intestinal parazit *Giardia lamblia* 730 (%46.5) iken, diğerleri sırasıyla *Entamoeba histolytica* 677 (%43.1), *Ascaris lumbricoides* 30 (%1.9), *Hymenolepis nana* 28 (%1.78), *Trichomonas hominis* 26 (%1.66), *Trichuris trichiura* 26 (%1.66) ve diğer sekiz tür (n=53, %3.38) idi. Paraziter enfeksiyonu olan hastaların %1,12'sinde (4/358), dışkı testi negatif olanların ise %0,39'unda (23/5868) HIV seropozitifliği mevcuttu (p=0,0655). İntestinal parazit enfeksiyonları Aralık ve Ocak aylarında artmıştı. *A. lumbricoides* ve *T. trichiura* mülteci kamplarından gelen hastalarda önemli oranda yüksekti. Bu çalışma, Somali'de intestinal paraziter enfeksiyonların dağılımı ve özellikleri ile HIV seroprevalansı hakkında son 30 yıldaki en kapsamlı verileri içermektedir. Bu verilerin risk analizine ve koruyucu sağlık politikalarının planlanmasına katkı sağlayacağını düşünüyoruz.

Anahtar Kelimeler: Göçmenler, Mülteciler, Çocuk sağlığı, Giardiyazis, Amibiyazis.

Introduction

Intestinal parasitic diseases are among the most common infections worldwide, and it is estimated that approximately 30% of the world's population is affected by these infections [1-3]. *Entamoeba histolytica*, *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms (e.g., *Ancylostoma duodenale* and *Necator americanus*) are among the 10 most common infectious agents in the world [4]. While the general prevalence of intestinal parasitic infections is 2% or less in developed countries, it has been reported to reach 30-40% in developing countries [2,5,6]. These infections are more common in socioeconomically poor populations, with their prevalence depending on many factors, such as lack of access to clean water and food resources, poor dietary habits and hygiene conditions, inadequate toilet facilities, humidity of geographical regions, high population density, lack of veterinary and zoonotic awareness, and lack of access to healthcare services [1,3,5,7,8]. These infections can be overlooked by patients or clinicians in developing countries as they are not considered among primary individual health problems, but they actually constitute a major public health issue since they are associated with various health disorders, including iron deficiency anemia and malnutrition and require surgical interventions in some cases [3,9]. In addition, intestinal parasitic infections have even been associated with developmental delay and other physical and mental disorders in children [10,11].

While the frequency of opportunistic parasitic infections increases in human immunodeficiency virus (HIV) infections [12,13], some studies have suggested that helminth infections may differently affect the natural course and progression of an HIV infection [14]. Information and predictions concerning the species distribution of intestinal parasites and their association with HIV infections in the Somali population are based on publications in neighboring countries or studies conducted with migrants of Somali origin living in different countries, such as the United States of America (USA) and Australia [8,15,16]. Current epidemiological data on the infectious disease status (malaria, tuberculosis and intestinal parasites) of the Somali population are important to identify, evaluate and manage various potential risks [17]. However, the specific health problems of this population have been minimally investigated, and studies on the frequency and distribution of intestinal parasitic infections in Somalia date back almost 30 years [18-20]. This study aimed to investigate the current status of the distribution of intestinal parasitic infections and their association with HIV infections in Mogadishu, the largest city of Somalia, considering that each country and region has its own conditions, characteristics and problems.

Material and Method

The study was conducted after obtaining approval from the institutional ethics committee (*Ethics Committee of Somalia Turkey Recep Tayyip Erdogan Education and Research Hospital, date: 05.12.2019, decision no: 177, number: MSTH/2718*). Due to the retrospective nature of the study, the requirement of informed consent was waived by the ethics committee. The confidentiality of all patient data was maintained, and the study carried out in accordance with the tenets of the Declaration of Helsinki.

Study group and design

In the study, a total of 28,991 laboratory test requests belonging to 27,508 different individuals were retrospectively evaluated over the period between November 2015 and November 2019 in the Medical Microbiology Laboratory of the hospital. By examining all the test results, the test requests for each person and changes in the test results of the cases for which multiple requests had been were monitored over the four-year period. Requests with the same results in parasitological examinations within a week were evaluated as a single test.

Since the age of the individuals increased during the follow-up period, the age group distributions were revised for a small number of individuals; in positive individuals, patient age was accepted as the date of a positive result, while for those that were negative for four years, the date of the first test was considered. However, the impact of this situation was minimalized as the age groups were examined at five to 10-year intervals.

The number of positive stool samples and positivity rates were examined by month, and possible seasonal-periodical changes were investigated. The results of specific groups, such as job applicants or those coming from domestic refugee camps were also compared with the general study group. Lastly, possible differences between the hospital department requesting the stool tests were examined.

The HIV serological test results were retrospectively examined for all the 24,676 different individuals who had any reported parasitological stool test result during the screening of all stool test requests. The individuals tested for HIV were determined, and the results were compared with parasitological test results.

Parasitological examinations

Parasitological stool samples were examined first macroscopically, and then samples prepared with saline (physiological water, 0.85%) and native-Lugol were examined microscopically in 20× and 40× lenses. The inspection and evaluation process of the samples was completed within 30 minutes to one hour. According to each parasite type, the test was reported as positive in cases where cyst, egg or parasite (trophozoite, worm) was observed.

Parasitological examinations were carried out by microbiologists assigned for periods of four to six months from Turkey.

HIV serological tests

HIV serological tests were performed using the Architect HIV Ag/Ab Combo Reagent Kit (Abbott Diagnostic, Germany) on the Architect I 2000 SR (Abbott Diagnostics, USA) system. The Architect HIV Ag/Ab Combo assay is a chemiluminescent microparticle immunoassay for the detection of HIV p24 antigen and antibodies to HIV type 1 (HIV-1 group M and group O) and/or HIV type 2 in human serum and plasma (EDTA and heparin). The results were considered as reactive if S / CO ≥ 1.00 and non-reactive if S / CO < 1.00. The samples with low-level reactivity in the first screening assay were retested using a second screening assay (Elecsys HIV combi PT assay) on a different system (Cobas e 411 analyzer, Roche Diagnostics, Germany) to confirm the results. Repeated reactive results were accepted as a positive result. Some cases were re-tested using with the OnSite HIV 1/2 Ab Plus Combo Rapid Test (Beijing Genesee Biotech Inc., China).

Statistical analysis

At the end of the study, basic statistical data, such as frequency and mean values were obtained, and their comparisons were performed using basic statistical methods, including the chi-square and Fisher's exact probability tests. A "p" value of <0.05 was considered to be statistically significant at the 95% confidence interval.

Results

Between November 2015 and November 2019, our laboratory received parasitological stool test requests for 27,508 different individuals, but the tests were not conducted for 2,832 people (2,790 did not give any sample, and 42 with insufficient-inadequate samples). Thus, a total of 26,159 tests were reported for 24,676 different individuals (single test reported for 23,468 individuals and multiple tests reported for 1,208 individuals) (Figure 1). The distribution of the multiple test requests (at intervals longer than a week) was as follows: two tests for 1,004 people, three tests for 157, four tests for 31, five tests for 11, six tests for three, seven tests for one, and eight tests for one. Most of the patients with six to eight test requests (4/5) were pediatric patients aged 1 month-1 year. The age range was 1 month-100 (mean 23.6, median 19) years for the 24,676 individuals comprising the study group; and 1 month-96 (mean 21.8, median 15) years for the 1,538 individuals with at least one positive test (n = 404, 26.3% for those under five years and n = 653, 42.5% for those under 10 years). The stool sample examination results of the 23,138 (93.8%) tests requested for a total of 24,676 individuals were reported as negative (single negative result in 22,099 and 2,296 repeatedly negative results in 1,039), and at least one test positivity was detected in 1,538 (6.23%) patients during the four-year study period. Of these 1,538 patients, 1,373 had a single positive result from a single test, while 165 had a total of 391 test results, of which 175 were positive (presence of persistent or recurrent infections in 10 patients; Figure 2) and 216 were negative (tests reported before and after a positive result or negative tests between two positive tests).

In this retrospective follow-up study covering a long period of four years, the distribution of patients with control tests or repeated tests was as follows: 80 people recovered after infection (test turning negative), 54 people's tests turned positive after an initial negative test or tests, and 21 people had an initially negative test, but then an infection was detected and their test result was reported negative again during their follow-up.

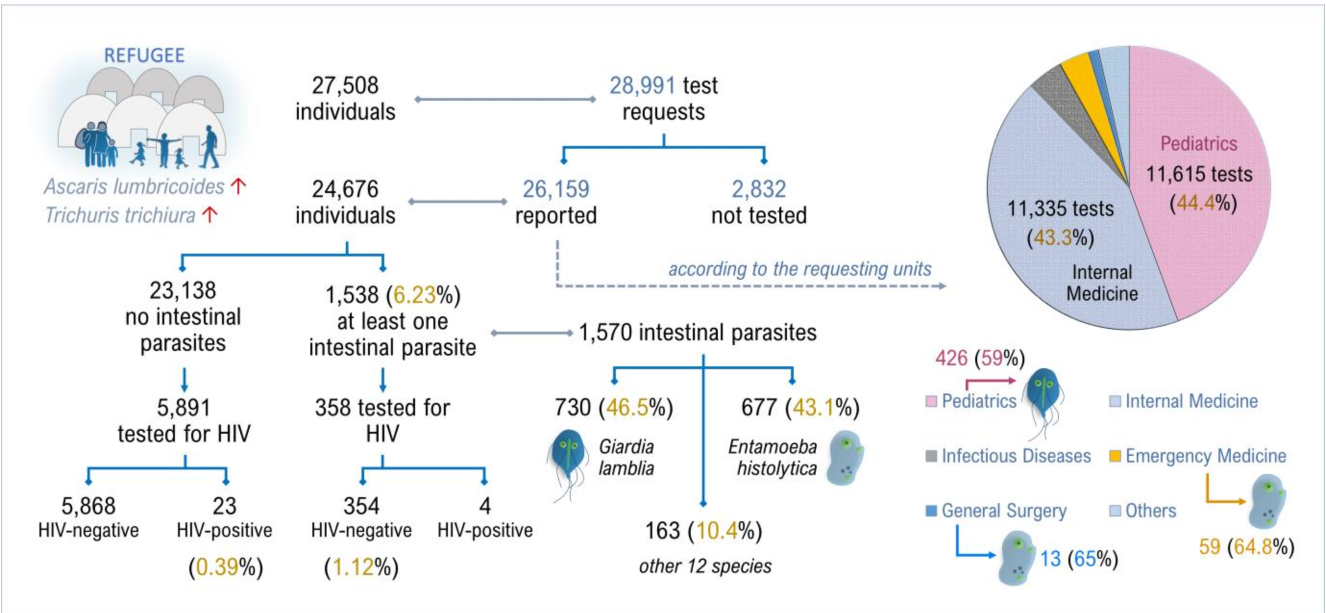

Figure 1. Overview of the study group and positivity rates in different subgroups.

Table 1. Distribution of intestinal parasites detected in the stool samples of 1,538 patients and their HIV seropositivity.

		Single infection group	Mixed infection group	Total	%	HIV-positive, n (%)	HIV-negative (single + mixed)
Giardia lamblia	protozoa - *flagellate*	715	15	730	46.5	2 (1.39)	139 + 3
Entamoeba histolytica	protozoa - *ameboid*	666	11	677	43.1	2 (1.11)	175 + 2
Ascaris lumbricoides	helminth - *nematode*	25	5	30	1.9	0	6 + 2
Hymenolepis nana	helminth - *cestode*	25	3	28	1.78	0	4
Trichomonas hominis	protozoa - *flagellate*	25	1	26	1.66	0	3 + 1
Trichuris trichiura	helminth - *nematode*	22	4	26	1.66	0	3 + 2
Enteromonas hominis	protozoa - *flagellate*	21	1	22	1.40	0	9 + 1
Entamoeba coli	protozoa - *ameboid*	6	3	9	0.57	0	3 + 2
Enterobius vermicularis	helminth - *nematode*	9		9	0.57	0	1
Blastocystis hominis	protozoa - *ameboid*	5	1	6	0.38	0	0 + 1
Strongyloides stercoralis	helminth - *nematode*	3		3	0.19	0	2
Retortamonas intestinalis	protozoa - *flagellate*	2		2	0.13	0	0
Ancylostoma duodenale	helminth - *nematode*	1		1	0.06	0	1
Chilomastix mesnili	protozoa - *flagellate*	1		1	0.06	0	1
	Total	1,526* (1,516 pts[a])	44* (22 pts[b])	1,570* (1,538 pts)		4 pts (1.11%)	354 pts (347 + 14)

[a]A single parasite was detected in a single sample of 1,506 patients, but 10 patients tested positive in multiple tests (Figure 2). [b]Two different parasites were simultaneously detected in a single sample in 22 patients. pts; patients. *intestinal parasites.

Table 2. Distribution of intestinal parasites by age groups and gender.

	Age groups (years)																			
Parasitic infection	1 m*-5		6-10		11-20		21-30		31-40		41-50		51-60		61-70		71-100		Total	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
G. lamblia	111	146	62	79	48	45	37	43	28	34	26	20	11	16	7	7	4	6	334	396
E. histolytica	63	70	44	38	55	51	55	62	42	39	31	30	20	23	19	8	15	12	344	333
A. lumbricoides	4	1	2	2		5	2	3	4	3		1	1		1			1	14	16
H. nana	3	2	7	3	4	1	1	4		1			1	1					16	12
T. hominis			2	2	2	1	2	4	6		3		2			1		1	17	9
T. trichiura	1	5	2	8	1	3	1	1	1	1		1					1		7	19
E. hominis	2				1		4	1	3	2	1	3		2	1		1	1	13	9
E. coli	1	1				1	2	2		1		1							3	6
E. vermicularis		1	3	1		2	1					1							4	5
B. hominis					2		1		1	1							1		5	1
S. stercoralis			1				1		1										3	
R. intestinalis	1					1													1	1
A. duodenale							1												1	
C. mesnili										1										1
Total (n = 1,570)	186	226	123	133	113	110	108	120	86	83	61	57	35	42	28	16	22	21	762	808
*Negative*** *(n = 24,395)*	2,559	3,509	1,448	1,608	1,764	1,778	1,678	2,402	1,146	1,390	1,010	882	753	713	535	525	366	329	11,259	13,136

*m: month. ** In the repeated tests of the same patient, the age at the date of the first positive test was selected. F: Female, M: Male.

Two different parasites were simultaneously detected in 22 samples (mixed infection) (Table 1). The most common types of mixed infections were "*Giardia lamblia* + *E. histolytica*" detected in nine patients, followed by "*T. trichiura* + *A. lumbricoides*" in three, "*G. lamblia* + *Hymenolepis nana*" in two, and "*G. lamblia* + *Entamoeba coli*" in two. Ten (45.4%) of the patients with mixed infections were children aged 10 years and under, and also most patients with intestinal parasites (668/1,570; 42.5%) were children under 10.

The study population consisted of patients presenting to various inpatient and outpatient clinics. The two departments that requested the most tests were pediatrics (11,615 tests, 722 positive results; 6.22%, predominant species: *G.*

lamblia n = 426; 59%) and internal medicine (11,335 tests, 625 positive results; 5.51%). *E. histolytica* was detected at a higher rate than the overall study population in three units: infectious diseases (1,089 tests, 67 positive results; 6.15%, *E. histolytica* n = 38; 56.7%), emergency medicine (900 tests, 91 positive results; 10.1%, *E. histolytica* n = 59; 64.8%), and general surgery (303 tests, 20 positive results; 6.6%, *E. histolytica* n = 13; 65%).

There were 364 individuals had no medical complaints and applied for medical board approval to obtain a work permit in Saudi Arabia and other countries. Parasitic infections were found in nine (2.47%) of these individuals, all male. In this group, except two patients (one with *G. lamblia* and the other with *H. nana*), the stool samples of the remaining seven patients were found to contain leukocytes and accompanying *E. histolytica* cysts.

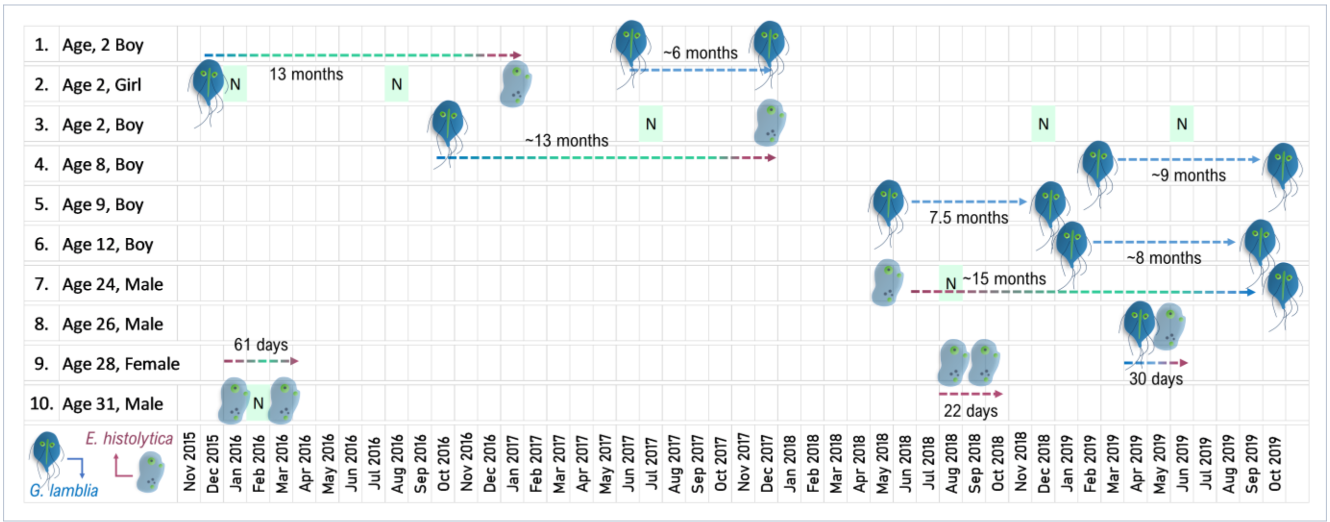

Figure 2. Patients with persistent or re-infections during the four-year follow-up (N: a negative test result).

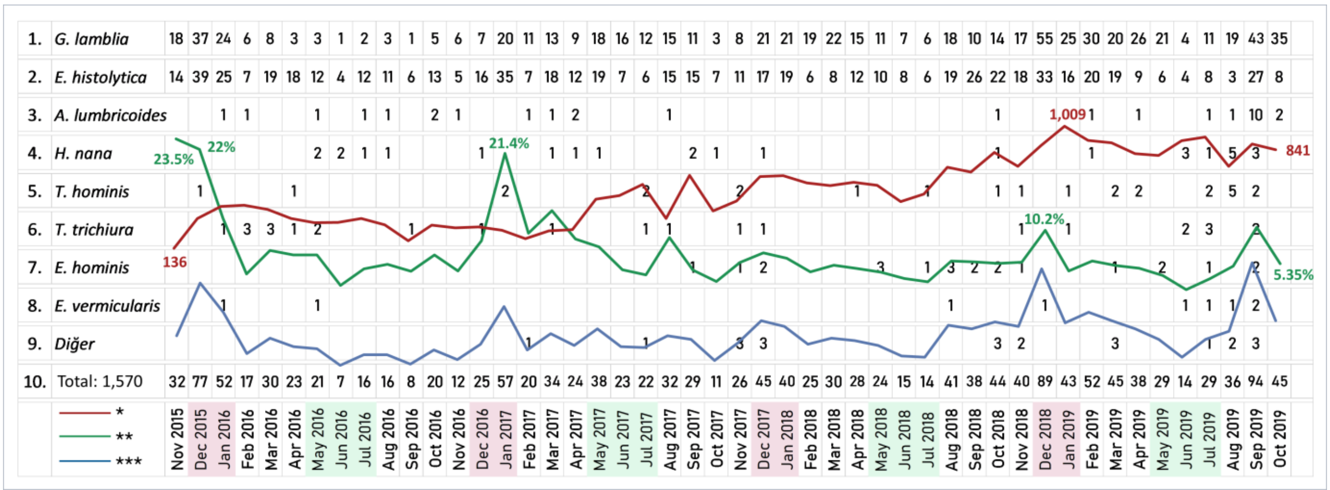

Figure 3. Distribution of parasitic infections by month over the four-year period. *Red line indicates all reported tests; 26,159. **Green line represents the positivity rate over all reported tests. ***Blue line shows the distribution of all 1,570 parasites).

Twenty-nine parasites were detected in 27 of the patients from the refugee camps. The most common parasite was *E. histolytica*, which was detected at a higher rate, although not statistically significant, compared to the whole study group (15/29; 51.7%; p = 0.3537), and the second most common parasite was *G. lamblia*, which had a lower rate, statistically significant, than in the study group (5/29; 17.2%; p = 0.0017). Two patients had a mixed infection of "*T. trichiura* + *A. lumbricoides*", while two had an *A. lumbricoides* infection and one had *T. trichiura* alone. The rate of *A. lumbricoides* (4/29; 13.8%) was 7.22 times higher and that of *T. trichiura* (3/29; 10.3%) was 6.23 times higher among the patients from the refugee camps compared to the whole study group (p = 0.0028 and p = 0.0143, respectively). In addition, *H. nana* was detected in one patient and *Enteromonas hominis* in other patient in the group from the refugee camps.

Table 3. Distribution of the HIV test results by age groups and gender.

	Age groups (years)																			
	1 m*-5		6-10		11-20		21-30		31-40		41-50		51-60		61-70		71-100		Total	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
At least one stool test positive (n = 1,538)	184	220	121	128	113	108	103	116	83	82	61	56	34	43	28	16	22	20	749	789
HIV test results in people with parasitic infections (n = 358)	10	15	1	8	18	13	49	63	24	33	24	31	12	19	9	8	6	11	153	201
										1^{+}	2^{+}					1^{+}			2^{+}	2^{+}
Stool tests were negative (n = 23,138)	2,427	3,328	1,373	1,525	1,673	1,686	1,592	2,278	1,087	1,318	960	837	714	676	507	498	347	312	10,680	12,458
HIV test results of those with no parasitic infections (n = 5,891)	118	204	43	31	255	343	612	1,156	364	694	416	296	342	268	160	288	139	139	2,449	3,419
				1^{+}	3^{+}			3^{+}	1^{+}	4^{+}	2^{+}	4^{+}	1^{+}		1^{+}	2^{+}		1^{+}	8^{+}	15^{+}
All HIV-infected patients (27/6,249) (0.43%)				1^{+}	3^{+}			3^{+}	1^{+}	5^{+}	4^{+}	4^{+}	1^{+}		1^{+}	3^{+}		1^{+}	10^{+}	17^{+}
Whole study group (n = 24,676)	2,611	3,548	1,494	1,653	1,786	1,794	1,695	2,394	1,170	1,400	1,021	893	748	719	535	514	369	332	11,429	13,247

*m: month. $^{+}$ Patients with a positive HIV result. The mean S / CO in 23 parasite-negative HIV-positive patients was 609.97 (205.7 - 1768). The S / CO values of four parasite-positive and HIV-positive patients were as follows: 6.18, 475.14, 512.5, and 534.12 (the test was repeated in a patient with low S / CO reactivity, and the same result was found in the second assay).

Discussion

In addition to premature birth and intrapartum-related complications, infectious diseases, such as pneumonia, diarrhea (including intestinal parasites, bacteria, and viruses), and malaria remain the leading cause of death under the age of five on a global scale [21]. Intestinal parasitic infections are one of the major problems associated with childhood health, especially in some developing countries [22-24]. This study includes the most comprehensive data on the distribution of intestinal parasites in Somalia with a population of approximately 12 million [25]. This study includes more than 25 thousand parasitological examination results from different communities living in Mogadishu (the largest city of the country with an estimated population of 2.5 million) and the surrounding regions, and the results were generally comparable to similar previous studies, but there were also distinct differences (Table 4).

In this study, the parasitic positivity rate was found to be 6.23% in the stool samples, and the most predominant parasites were found to be *G. lamblia* (46.5%) and *E. histolytica* (43.1%). In a 2017 study conducted in Jordan, which presented the four-year results of 21,906 stool sample examinations, parasitic infections were detected in 9,611 (44%) samples, which is higher than our rate, but the most common parasites were reported as *G. lamblia* (41%) and *E. histolytica* (31%) [3], as in our study. These two infections were also among the most frequently detected intestinal parasites in other studies conducted in Iran and Saudi Arabia (Table 4) [5,26].

It is noteworthy that while *Taenia* species were detected in studies conducted in Jordan and Iran [3,26], at low rates (2/658 and 48/9611, respectively), none were detected in our study. In a study examining data from 27 regions of different countries in Africa, the rate of *Taenia saginata* cases was reported as 0.32%-2.9%, 0.30%-3.2% and 0.06-0.8% in Ethiopia, Kenya and Tanzania, respectively, but the authors stated that there was no report from Somalia unlike these neighboring countries [15]. Furthermore, among the several studies conducted in Somalia 30 years ago, only one case of *T. saginata* was reported in a town located near Mogadishu [18-20]. The rarity of taeniasis cases may be related to the limited meat consumption in Somalia and the preference of sheep-goat and camel meat over cattle and beef, and pork never [20]. This idea is also supported by the absence of tenia species among intestinal parasites in Saudi Arabia, which has similar eating habits [5].

Blastocystis species are reported to be the most common intestinal parasites in many developed and developing countries [6,27,28]. In a comprehensive study conducted in Turkey, 58,669 stool samples were examined, and *Blastocystis* spp. and *Cryptosporidium* spp. were determined as dominant species at the rates of 39.8% and 37.4%, respectively [29]. In another previous study, *Blastocystis* spp. and *Dientamoeba fragilis* were reported at the rates of 0.4%-18.1% and 0.4%-6.3%, respectively in developed countries, and most were associated with asymptomatic infections [6]. Although *Blastocystis* spp. may be a part of the microbiota and their pathogenicity is discussed, they are accepted as a possible cause of diseases in cases with gastrointestinal complaints in which but no other underlying cause can be found, and the treatment is planned accordingly [30]. The lower rate detected in our study (0.38%) may be associated with underdiagnosis due to the uncertain and controversial role of *Blastocystis* spp. in revealing gastrointestinal pathologies and symptoms [6,27]. However, in a comprehensive literature review [6], it was stated that some enteric protozoa, such as *Entamoeba* spp., *Cryptosporidium* spp., and *Giardia* spp. were frequently isolated from diarrheic patients in developing regions, including Asia and Sub-Saharan Africa, which is consistent with our data, while *Blastocystis* spp. and *D. fragilis* were mostly isolated from developed countries. Among the most common enteric protozoa in developed countries, *G. intestinalis* (0.2%-29.2%) and *Entamoeba* spp. (0.2%-12.5%) stand out together with *Cryptosporidium* spp. (0.1%-9.1%) and *Cyclospora cayetanensis* (0.2%-4.3%) [6]. We consider that *Cryptosporidium* spp. not being detected in our study may be related to different reasons. *Microsporidium* spp., *Cryptosporidium* spp., and *Cyclospora* spp. attract attention as parasites that are common in immunosuppressed populations and can cause serious infections in HIV-infected patients [12,13,31,32]. In our study group, HIV seropositivity rate was found to be 0.43% in 6,249 individuals, conspicuously HIV positivity was not found in children under five years (Table 3). Although the rate of HIV infections was higher in patients with parasitic infections compared to those with negative stool test results (1.12% and 0.39%, respectively, p = 0.0655), HIV infections may not have a significant effect on the distribution of intestinal parasites due to their low prevalence in Somalia. Therefore, the low prevalence of HIV infections in Somalia [33,34], the population being very young (median age is 18.5 years in 2020) [35], and the low rate of population receiving immunosuppressive therapy due to the lack of a center treating oncology patients may explain the low prevalence of mentioned species [36]. If examined in detail, there is no national cancer registry system in Somalia, and anticancer treatments such as radiotherapy and chemotherapy cannot be applied to cancer patients since there is no oncology clinic. In addition, due to the very high costs, only a small proportion of patients are able to travel to Turkey, India, United Kingdom, or other countries to receive oncological treatment or other advanced treatments, such as organ transplantation [36]. All these factors probably affect the distribution of parasites that may pose a risk to the population, and the experience of laboratory specialists is also important since some species are more difficult to diagnose than others.

Environmentally, several ecological factors depending on climatic conditions, including temperature, humidity, rainfall, soil type and vegetation play a role in the spread of parasitic diseases in society [3,18,20]. In a study published 30 years ago, stool samples were obtained from 517 children (0-16 years old) and mothers living in two rural towns in Somalia [18], and a large difference was observed in helminth infections between the two towns, with only 6% of samples showing worm eggs or larvae in Burao, while the prevalence was 84% in Kismayo ($p < 0.001$). Similarly, another study conducted in two different towns close to Mogadishu suggested that the difference in helminthic infection rates could be explained by different climatic factors, different population densities, soil type, or habits of people [20]. In our study, intestinal parasites were reported more frequently in December and January, and the positivity rates per requested test were higher in these months (Figure 3). In

Somalia, rainfall is at least (~3 mm) during January and February, and air temperature is the lowest (25.5°C) in December and January [37,38]. Drought and untreated drinking water supply causes poor hygienic conditions and malnutrition, leading to a high burden of intestinal parasites [23]. It was also previously determined that the general incidence of intestinal parasites increased in dry and hot summer months when humidity was low in Jordan [3]. This difference observed in our study may also be related to human behavior and other factors, which should be further examined within the scope of public health measures.

In this study, intestinal parasitic infections and mixed infections were common in children aged 10 years and under (42.5% and 45.4%, respectively) (Table 2). Considering that the pediatric department was determined as the hospital unit with the highest number of test requests and repeated tests during patient follow-up and such infections generally affect children to a greater extent, these parasitic infections constitute an important problem that needs to be overcome for pediatric disease specialists working in this country. However, reducing the spread and negative effects of these infections associated with many external factors is challenging. In our study, follow-up tests were performed after an initial positive test in only 111 of the 1,538 patients (7.2%). Recurrent or long-term persistent infections with the same parasite were observed at different times in six patients, while a new infection with a different parasite was found in four patients. A recent study conducted in Tanzania revealed that the rate of reinfection with *T. trichiura* was 37.2% (42/113 treated children) after 18 weeks of treatment with anti-helminthic drugs [39]. Furthermore, in a project targeting Somali immigrants, including the treatment of schoolchildren and provision of intense health education in close collaboration with the local community leaders, after three years of activities, only a 53% overall reduction was achieved in the prevalence of intestinal parasite infections, despite the rate of reduction being 92% for *A. lumbricoides* and 62% for *T. trichiura* [40]. These data show that unless there are intense efforts to improve living conditions and implement strict public health measures, society (especially children) will still be exposed to the recurrent or prolonged effects of intestinal parasitic infections [41]. For example, *Entamoeba* spp. (amoebic colitis and liver abscess) and *A. lumbricoides* infections (intestinal obstruction, biliary infestation with cholangitis and liver abscess, and pancreatitis) are also important since they often require surgical interventions among African children that are not treated in a timely manner and develop complications [9].

Parasitic infections are mostly reported in rural areas and refugee camps [3]. Intestinal parasitic infections among refugees have been perceived as a public health problem for decades. Soil-transmitted helminths (e.g. *A. lumbricoides*, *T. trichiura*, and *A. duodenale*) are common in refugee camps due to poor hygiene conditions, and these parasites are transmitted by migrants travelling from different countries [8,40]. In our study, for a small number of individuals from the refugee camps, *A. lumbricoides* and *T. trichiura* infections were seen at an increased incidence compared to the study group, both as single and mixed infections. *A. lumbricoides* and *T. trichiura* were 7.22 times ($p = 0.0028$) and 6.23 ($p = 0.0143$) times more common in patients from the refugee camps compared to the whole study group. This is in agreement with a study carried out in the USA, reporting that camp conditions were an important factor in the spread of *A. lumbricoides* and *T. trichiura* that are the two most frequently detected parasites among Somali immigrants with a history of staying in refugee camps for as long as five years (Table 4) [8]. In a study conducted 30 years ago with nomads in rural Somalia, it was reported that the presence of *Giardia* spp. in stool samples was very rare, and there was practically no *Entamoeba* spp. infection in nomads or seminomads; however *A. lumbricoides* and *T. trichiura* were the two most common parasites [19]. In another study conducted (1987) in two small towns (the Lafoole community and the Afgooye community located 20 and 28 km outside of Mogadishu, respectively), the most common intestinal parasites were determined as *T. trichiura* and hookworms (mixed infections were also common), while *Giardia* spp. and *Entamoeba* spp. ranked third and fourth, respectively (Table 4) [20]. In the same study, it was emphasized that the source of infection was contaminated areas around residential neighborhoods due to indiscriminate defecation. Similar results were obtained from another study conducted during the same period to investigate intestinal parasites in children and mothers in rural Somalia (*T. trichiura*, 45%; *E. coli*, 23%; *A. lumbricoides*, 17%; *G. lamblia*, 16%; and *A. duodenale*, 15%) [18]. In our study, while the soil-transmitted helminths were found at increased rates in patients from the refugee camps, *G. lamblia* and *E. histolytica* species generally had increased predominance probably due to urbanization.

In our study, the detection of parasitic infections (*E. histolytica*, *G. lamblia*, and *H. nana*) at a rate of 2.47% in 364 individuals that presented to the hospital for a work permit without any complaints offers an insight into the prediction of the prevalence of these infections in the general population. The co-presence of leukocytes with *E. histolytica* cysts in seven patients supports the possibility of this agent being a pathogenic species and indicates that an important part of the society may not present to hospitals for treatment unless it is absolutely necessary, which contributes to the spread of these infections. In a study investigating the epidemiological characteristics of intestinal infections caused by *E. histolytica* in Taiwan from 2002 to 2010, the average annual incidence rate of these infections was found to be 0.49 and 9.26 per 100,000 people for local patients and immigrants/foreign workers from endemic countries, respectively [42]. In the same study, the authors underlined the importance of establishing a sensitive surveillance system to control *E. histolytica* infections and implementing amebiasis screening program for immigrants/foreign workers from endemic countries.

Table 4. Similar studies on intestinal parasitic infections and the most common species.

Country:	Somalia (present study)		Somalia (Nomads)		Somalia (Afgooye com.)		Somalia (Lafoole com.)		USA (Somalian refugees)		Jordan		Turkey		S. Arabia		Iran		Sudan (age, 6-14 years)	
n = s/p*	26,159		<100		278*		237*		331*		21,906		58,669		5,987		13,698		134*	
Year (ref)			1987 [19]		1988 [20]		1989 [20]		2000 [8]		2016 [3]		2019 [29]		2018 [5]		2017 [26]		2020 [24]	
	GL	730	AL	23	TT	179	TT	164	TT	92	GL	3,953	Bla sp.	4,271	EH	16	GL	433	EH	22
	EH	677	TT	7	Hw	107	Hw	4	AL	29	EH	3,021	Cry sp.	4,010	CP	6	EH	96	HN	14
	AL	30	GL	4	GL	61	GL	103	GL	25	EC	1,254	Cyc sp.	828	GL	4	EC	77	EC	10
	HN	28	AD	4	EH	45	EH	92	EH	7	EV	634	EV	497	TT	2	EHa	29	AL	7
	TH	26			AL	46	AL	19	Hw	3	TH	533	GL	423	CM	1	BH	14	SM	7
	TT	26			SS	7	SS	0	SS	3	AL	84	EC	298	HN	1	HN	6	GL	5
	EHo	22			HN	3	HN	20	HN	3	HN	82	EH	197			Tae sp.	2	Tae sp.	2
	EC	9			TS	0	TS	1	EC	64	Tae sp.	48	IB	104			EV	1		
	EV	9							BH	39	CMi	2	TS	51						
	BH	6							IB	4			CM	11						
	SS	3											Mic sp.	11						
	RI	2											DF	10						
	AD	1											IBe	7						
	CM	1											AL	2						
													HN	2						
													EHa	2						
													EN	2						

n=s/p: samples (or patients*) number. **ref**: reference. **com.**: community. **AD**: *Ancylostoma duodenale.* **AL**: *Ascaris lumbricoides.* **BH**: *Blastocystis hominis.* **CM**: *Chilomastix mesnili.* **CP**: *Cryptosporidium parvum.* **DF**: *Dientamoeba fragilis.* **EC**: *Entamoeba coli.* **EH**: *Entamoeba histolytica-dispar.* **EHa**: *Entamoeba hartmannii.* **EHo**: *Enteromonas hominis.* **EN**: *Endolimax nana.* **EV**: *Enterobius vermicularis.* **GL**: *Giardia lamblia (intestinalis).* **HN**: *Hymenolepis nana.* **Hw**: Hookworms. **IB**: *Iodamoeba bütschlii.* **IBe**: *Isospora belli.* **SM**: *Schistosoma mansoni.* **RI**: *Retortamonas intestinalis.* **SS**: *Strongyloides stercoralis.* **TH**: *Trichomonas hominis.* **TT**: *Trichuris trichiura.* **TS**: *Taenia saginata.* **Bla sp**: *Blastocystis* spp. **Cry sp**: *Cryptosporidium* spp. **Cyc sp**: *Cyclospora* spp. **Tae sp**: *Taenia* spp. **Mic sp**: *Microsporidium* spp.

Conclusion

Protozoal and helminthic infections maintain their importance as a public health problem in underdeveloped and developing countries. The inability to meet water and food requirements due to drought and civil war, unhygienic behavior and habits, intense migration movements, and the insufficiency of infrastructure investments increase the prevalence of intestinal parasitic infections and have prolonged-repeated negative effects on these infections in Somalia.

Although the prevalence of HIV infections remains low in the country, many serious public health problems are still not seen as a priority due to the high cost of healthcare and other challenges, such as severe malnutrition [43]. We consider that this study, presented and examined a four-year follow-up of intestinal parasitic infections will provide important data for future public health policies and act as a preliminary study for further comprehensive comparative studies to be conducted with specific groups.

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