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Research Article

Post-COVID-19 Pandemic: Parasite Diseases New Status

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Abstract

This study has been done to estimate the reason of shift of incidence of intestinal and blood parasite infections. At the King Faisal Medical Complex (KFMC) Parasitology department in Taif, Saudi Arabi 500 stool samples received for examination during the Covid-19 pandemic (January-december 2020) and 1068 samples submitted during the same months of the following year (January-December 2021) were subjected to dataset analysis. Thorough, 12.8% (201/1568) of samples were parasites- positives; 12% (60/500) during the pandemic and 13.5% (141/1068) after, with increase of 81%. A significant difference in gender between the two periods ($p < 0.001$)as the majority of parasitism were in males. Patients aged 15-44 years Infections were frequent in both during (19/500; 3.8%) and after the pandemic (75/1068; 7%), with observed significant difference ($p < 0.002$). Moreover, non-Saudi (62.2%; 125/201)were more infected with a reported significant difference in nationality, ($p = 0.024$). Protozoa were identified in 8.1% (127) of all processed samples, of which, *Entamoeba coli, Entamoeba histolytica/dispar, Blastocystis hominis, Giardia* lamblia, and *Cryptosporidium* species were identified in 6.3% (53), 6% (49) 5.3% (47), 3.3% (21), and 2.1% (12), respectively while Helminths were diagnosed in 1.9% (19) of samples. Hookworm eggs, *Ascaris egg, Taenia spp egg,* and *Hymenolepis nana egg, Trichuris trichiura egg* and *Strongyloide stercoralis* larvae were detected in 0.9% (4), 0.3% (3), 0.3% (3), 0.4% (4), 0.3% (3) and 0.2% (2) respectively. Overall, 12.6% of blood samples were malaria positive; 1.3% during the pandemic and 11.3% after it. Out of positive samples, *Plasmodium ovale* was identified in 14 (36.8%) *Plasmodium falciparum* 12 (31.6%) *and Plasmodium vivax* in 11(29%). With the quarantine measures applied during the Covid-19 pandemic according to our research hypothesis, a reportable decrease in parasitic load infection was noticed.

Keywords: Intestinal Parasites; Prevalence Covid -19 Pandemic; Malaria Parasites; Blood Film

Introduction

High mutation rate in Coronaviridae family produce Coronaviruses (CoV) which belong to the beta-coronavirus leading to illnesses with variable severity. In China in 2003, a severe acute respiratory syndrome (SARS)leading to death of a number of people spread rapidly and highly infectious by different routes [1]. On 11 March,the WHO announced COVID-19 illness a global pandemic [2]. All regular non-urgent health care services was decreased as health authorities in Saudi Arabia took measures on time to confine the infectionwhich has affected diagnosis, treatment of all infectious diseases,parasitic diseases among them.

Enteric and blood parasites, a group of pathogens, are present worldwide [3]. They are frequently neglected as a important cause of gastrointestinal or systemic complaints because of over-confidence in public hygiene, municipal sanitization [4].

Haemoparasites generally have morbidity, may end to mortality [5].

Studies for parasitic diseases detection description of epidemiology should be continuous, to conceive proper case treatment and infection control [6].

The aim of this study was to study and analyse enteric and blood parasitic infections prevalence in the Saudi residents from January to December period in 2020 and their corresponding 12 months in 2021 and to review the impact of measures taken by the government during the Corona pandemic on the prevalence of these infections.

Material and Methods

The study area

The investigation was carried at one of the largest hospital in Taif Governorate KFMC at Western Saudi Arabia which is a referral center serving approximately one million resident, 500 beds capacity.

Data collection

In this search, data collected through Oasis patient medical records for stool and blood sample results received in the parasitology depart. at KFMC in the two period s of time: One was during the pandemic (from January 2020 to December 2020)and the other one after it from January 2021 to December 2021). Samples number was 1568 stool in total from hospitalized and non-hospitalized patients with gastrointestinal complaints and 300 blood samples for patients having fever >38°C and clinically diagnosed as malaria infection. The datasets used were demographic characters concerning the patients as the age, sex, and nationality, and results of their tests. Tabulatation, investigation, comparison were done and discussion finally.

Methods used mainly for diagnosis of enteric parasites; was wet mount microscopy first, formol-ether concentrated technique, and staining techniques with Lugol's iodine, trichrome, and/or acid-fast stain [7].

Blood was collected by vein puncture on EDTA tubes for malaria testing shortly to prevent morphological changes of malaria parasites. Thick and thin blood films were done and examined for the presence or absence of *Plasmodium* spp. Parasites and Malaria RDTs were done together with the blood film. Staining was done with freshly prepared 10% Giemsa's stain and microscopic examination by X l00 oil immersion was done. No malaria parasite seen reported when no parasites detected in 300 fields of thick film, thin film preparations were examined to detect the species of malaria: P. *falciparum, Pl. malariae, Pl. ovale, Pl. vivax,* or mixed infection from positive thick films. Parasitaemia was calculated in 100 fields of thin films using the leucocytes counts of the patients as following: parasite number/microliter = Total parasitic count/ WBC count X total leucocytic count/microliter.

The patients were 1061 (67.6%) males and 507 (32.3%) females, with an average age of 15 - 44 years.

Ethical considerations

Ethical clearance was received from the King Faisal Medical Complex Research Committee (Ref: KFMC-02-T-123 to conduct this study). Consents from participants were not included.

Data analysis

Chi-square test (X2). data analysis is conducted using SPSS version 20 (SPSS Inc, Chicago, Illinois) to compare prevalences of Infection and relative frequencies between different groups (sex and age). P-value <0.05 was significant.

Results

In the present study, 1568 fecal samples datasets were obtained, extracted, tabulated and finally analyzed. Table 1 shows the demographic characters and patients descriptive results during and after the pandemic time period. During the pandemic time period out of 500 patients submitted their feces, 340 males and 160 females. Of these patients, 225 were Saudi and 275 were non-Saudi. Ages were ranging in between 3 and 70 years, present into one of three age groups. Out of 1068 stool samples submitted in the laboratory after the pandemic time period, 721 were male patients and 347 female patients. Of these patients, 556 were Saudi and 512 were non-Saudi residents.

Demographic character	During COVID-19 (n = 500; 60 positives and 440 negatives)								Post-COVID -19 (n = 1.068,141 positives and 927 negatives)								P-value
	<15y		15-44y		>45y		Total		<15y		15-44y		>45y		Total		
	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	
Gender																	
Male	10	50	17	150	13	100	40	300	35	108	50	230	6	201	91	630	P < 0.001
	2%	10%	3.4%	30%	2.6%	%20	8%	60%	3.3%	10.1%	4.7%	21.5%	0.6%	18.8%	8.5%	59%	
Female	7	30	2	56	4	54	20	140	19	81	25	100	6	66	50	297	
	1.4%	6%	0.4%	11.2%	0.8%	10.8%	4%	28%	1.8%	7.6%	2.3%	9.4%	0.6%	6.2%	4.7%	28%	
Nationality																	
Saudi	5	23	11	107	4	75	20	205	16	150	20	158	20	192	56	500	P = 0.0024
	1%	4.6%	2.2%	21.4%	0.8%	15%	4%	41%	1.5%	1.4%	1.9%	14.8 %	1.9%	18%	5.2%	47%	
Non - Saudi	10	20	20	129	10	86	40	235	33	120	38	179	14	128	85	427	
	2%	4%	4%	25.8%	2%	17.2%	8%	47%	3.1%	1.12%	3.6%	16.8%	1.3%	12%	8 %	40%	
Total	15	43	31	236	14	161	60	440	49	270	58	337	34	320	141	927	
	3%	8.6%	6.2%	47.2%	2.8%	32.2%	12%	88%	4.6%	2.5%	5.5%	31.5%	3.2%	30%	13.2%	87%	

Table 1: Patients demographic &descriptive intestinal parasite results , both during and post- pandemic.

*: Highly significant difference observed.

+ Significant difference observed.

Symbols :(+) enteric parasites positives (-) enteric parasites negatives.

During the pandemic out of 500 specimens tested, 60 (12%) were positive for one or more enteric parasites compared to 1068 sample results after the pandemic, 141 (13,2%) were positive for them, which mean that there was a rise in the number of positive specimens "parasitosis" between the two periods, estimated to be 80.6%. In addition, a highly significant parasitism- gender relationship present between the two cohorts ($p < 0.001$), where most of positive specimens were belonging to males. During the Corona pandemic, male patients were positives in 8% (40/500) of samples while the female patients positives in 4% (20/500) of specimens. Meanwhile, after the Corona, intestinal parasites were identified in 8.5% (91/1068) of male patients and in 4.7% (50/1068) of female patients.

Figure 1 Shows positive patients distribution among sex and different age groups in both during and after the pandemic time period. The majority of parasitosis was recorded in patients aged 15-44 years both during (19/500; 3.8%) and after (75/1068; 7%) the pandemic time periods. Moreover, Figure 2, shows that most of patients infected by enteric parasites were non-Saudi residents. Forty (8%) out of 275 non-Saudi patients,20 (4%) out of 225 saudi stool samples were received during the pandemic period, were positives for intestinal parasite(s). On the other hand, In the postpandemic time period, 85 (8%) out of 512 non-Saudi patients tested 56 (5.2%) out of 556 saudi patients were positives for one or more enteric parasites.The nationality difference of patients between the two cohorts were significant ($p = 0.024$), (Table 1).

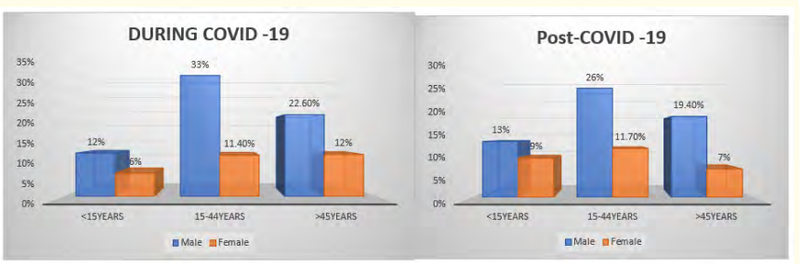

Figure 1: Age and gender distribution of parasites-positive patients after (right) and during (left) the COVID-19 pandemic time period.

Figure 2: Distribution of age and nationality of parasites-positive patients after (right) and during (left) the COVID-19 pandemic time periods.

Intestinal protozoa shows a highly significant difference reported ($p < 0.001$) for all diagnosed species which were detected more commonly among age group 5 - 14 year, followed by the 0 - 4 year, and less commenly in patients > 45 years of age, compared to that of helminthic infections which was highest in patients aged over 15 years and in the 0 - 4 year age group was the lowest, with no significant difference reported, ($p = 0.660$).

Table 2 demonstrates the prevalence of enteric parasites species, detected in the patients stool specimen according to ages and genders, during and post-pandemic periods. Out of 500 samples submitted during the pandemic time period and found positive for intestinal parasites, 55 (91.7%) were protozoa-positive and 5 (8.3%) positives for helminths. As Regarding protozoa, *E. coli* were detected in 2.6% (13/500), secondary *B. hominis* in 3.2% (16/500), *G. lamblia* in 2.2% (9/500), *E. histolytica/dispar* in 2.6% (12/500) and, *Cryptosporidium* spp. in 1.4% (5/500). Moreover helminths identified according to the following incidence, the hookworm, was identified in 0.4% (2/500), *A. lumbricoides*, *H. nana* and *Taenia* spp. for each (0.2%; 1/500).

Parasite species	During COVID-19 (n500,60 positives)										Post-COVID-19 (n1068, 141 positives)										p-value
	0-4		5-14		15-44		>45		Total		0-4		5-14		15-44		>45		Total		
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
E. hist./dis-par	1 (0.2)	0 (0)	7 (0)	1 (0.2)	0 (0)	2 (0.4)	0 (0)	1 (0.2)	8 (1.6)	4 (1)	1 (0.1)	1 (0.1)	6 (0.6)	3 (0.3)	15 (1.4)	5 (0.5)	5 (0.5)	1 (0.1)	27 (2.5)	10 (0.9)	<0.001
E. coli	1 (0.2)	1 (0.2)	4 (0.8)	1 (0.2)	3 (0.6)	2 (0.8)	1 (0.2)	0 (0)	9 (1.8)	4 (0.8)	1 (0.1)	0 (0)	5 (0.5)	1 (0.5)	17 (1.6)	7 (0.6)	4 (0.4)	2 (0.2)	27 (2.5)	13 (1.2)	<0.001
G. lamblia	1 (0.2)	0 (0)	1 (0.2)	0 (0)	3 (0.6)	1 (0.2)	2 (0.8)	1 (0.2)	7 (1.4)	2 (0.8)	0 (0).	0 (0)	1 (0.1)	2 (0.2)	3 (0.3)	4 (0.4)	1 (0.1)	1 (0.4)	5 (0.5)	7 (0.6)	0.004
Crypt. spp	0 (0)	1 (0.2)	0 (0)	3 (0.6)	0 (0)	0 (0)	1 (0.2)	0 (0)	3 (0.6)	2 (0.8)	0 (0)	0 (0)	1 (0.6)	1 (0.1)	2 (0.2)	2 (0.2)	0 (0)	1 (0.1)	3 (0.3)	4 (0.4)	<0.001
B. hominis	2 (0.8)	0 (0)	2 (0.8)	1 (0.2)	5 (1)	2 (0.4)	1 (0.2)	3 (0.6)	10 (2)	6 (1.2)	0 (0)	0 (0)	1 (0.1)	2 (0.2)	15 (1.4)	6 (0.6)	5 (0.5)	2 (0.2)	21 (2)	10 (0.1)	<0.001
A. lumbri-coids	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	N/A
Hookworm	0 (0)	0 (0)	0 (0)	1 (0.2)	1 (0.2)	0 (0)	0 (0)	0 (0)	1 (0.2)	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	1 (0.1)	0 (0)	0 (0)	1 (0.1)	1 (0.1)	N/A
Taenia spp	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	0 (0)	0 (0)	1 (0.1)	1 (0.1)	1 (0.1)	N/A
H. nana	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	1 (0.2)	1 (0.1)	0 (0)	0 (0)	1 (0.1)	1 (0.1)	0 (0)	0 (0)	0 (0)	2 (0.2)	1 (0.1)	0.832
Trichiuris Trichura	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	0 (0)	0 (0)	1 (0.1)	1 (0.1)	0 (0)	0 (0)	0 (0)	2 (0.3)	1 (0.1)	0.832
Strongyloide stercoralis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0.1)	0(0)	0 (0)	1 (0.1)	1 (0.1)	0 (0)	0 (0)	0 (0)	1 (0.1)	1 (0.1)	0.832
Enterobius spp	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0.1)	0 (0)	0 (0)	0 (0.1)	1 (0.1)	0 (0)	0 (0)	0 (0)	1 (0.1)	0 (0.1)	0.832
Total	5 (1)	2 (0.4)	14 (2.8)	5 (1)	13 (2.6)	6 (1.2)	6 (1.2)	6 (1.2)	40 (8)	20 (4)	4 (0.4)	1 (0.1)	14 (1.3)	13 (1.2)	59 (5.5)	24 (2.2)	15 (1.4)	8 (0.7)	91 (8.5)	50 (4.7)	

Table 2: Distribution of intestinal parasites species based on patients age and gender both pre-and during the pandemic.

On the other hand, out of 141 samples received post-pandemic and were positive for intestinal parasites, 127 (90.1%) were positive for protozoa and 14(9.1%) positives for helminths. The identified protozoan species were *Blastocystis hominis* 2.1%;(30/1068) followed by *Entamoeba coli* 3.7%; (40/ 1068), *Giardia lamblia*, 1.1%; (12/1068), *Entamoeba histolytica/dispar* 3.4%; (27/1068) and, *Cryptosporidium* spp. 0.7%;(7/1068). The intestinal helminths detected in the post-pandemic period,; *Trichuris trichiura and Hymenolepis nana were* found in 0.3%; (3/1068), hookworm, *Taenia* spp. *And Strongyloide stercoralis* in 0.2%; (2/1068) of patients finally *Ascaris lumbricoides in* 0.1%; (1/1068). Table 1, shows that protozoa were more detected in samples received post- pandemic than during pandemic, with a highly observed significant difference, ($p < 0.001$).

Also gut helminths were found more in post-pandemic specimens than he pandemic one as absolute numbers, with no significant difference statistically-reported ($p = 0.798$).

Table 2 shows identification of enteric parasite species more in males (64.5%; 91/141) than in females (35.5%; 50/141) in the post-pandemic period. Moreover samples submitted during the pandemic, the intestinal parasites were more in males (66.7%; 40/60) than in females (33.3%; 20/60). So all intestinal protozoan were prevalent t in males both during and post-pandemic periods, with observed highly significant difference between the two cohorts for all species, ($p < 0.05$).

Table 3 describes the demographic features of 300 patient blood sample results, both during and after the pandemic periods. Out of fifty specimens submitted during pandemic period, 35 for males and 15 for female,30 and 20 saudi and non-saudi respectively. On the other hand, out of 250 blood specimens received in the lab. in the post-pandemic period, 200 were males and 50 females. Out of them,130 and 120 Saudi and non-Saudi respectively. The ages arranged in three groups ranging from 15 to >45 years old.

Demo-graphic character	**During COVID-19 (n = 50; 4 positives and 46 negatives)**								**Post-COVID -19 (n = 250; 34 positives and 213 negatives)**								**P-value**
	<15y		**15-44y**		**>45y**		**Total**		**<15y**		**15-44y**		**>45y**		**Total**		
	(+)	**(-)**	**(+)**	**(-)**	**(+)**	**(-)**	**(+)**	**(-)**	**(+)**	**(-)**	**(+)**	**(-)**	**(+)**	**(-)**	**(+)**	**(-)**	
Gender																	
Male	0	0	3	32	0	0	3	32	0	0	27	101	2	70	29	171	P < 0.001
	0%	0%	6%	64%	0%	0%	6%	64%	0%	0%	10.8%	40.4%	0.8%	28%	11.6%	68.4%	
Female	0	0	1	9	0	5	1	14	0	0	4	30	1	15	5	45	
	0%	0%	2%	18%	0%	10%	2%	28%	0%	0%	1,6%	12%	0.4%	5%	2%	18%	
Nationality																	
Saudi	0	0	2	18	0	10	2	28	0	0	2	98	0	30	2	128	P = 0.0024
	0%	0%	4%	36%	0%	20%	4%	56%	0%	0%	0.4%	39.2%	0%	12%	0.4%	51.2%	
Non - Saudi	0	0	2	13	0	5	2	18	0	0	29	71	3	17	32	88	
	0%	0%	4%	26%	0%	10%	4%	36%	0%	0%	11.6%	28.4%	1.2%	6.8%	12.8%	35.2%	
Total	0	0	4	31	0	0	4	46	0	0	31	169	3	47	34	216	
	0%	0%	8%	62%	0%	30%	8%	92%	0%	0%	12%	67.6%	1.2%	18.8%	13.2%	86.4%	

Table 3: Patients demographic &descriptive malaria results, both during and Post- pandemic.

During the pandemic out of 50 specimens tested, 4 (1.3%) were positive for one or more malaria species in contrary to after pandemic out of 250 samples, 34 (11.3%) were positive for one or more malaria species proving significant increase in the number and proportion of parasitism between the both cohorts. Moreover, most positive specimens were detected in males denoting highly significant parasitism-gender relationship in both time periods ($p < 0.001$).Malaria parasites were diagnosed in 6% of male cases and in 2% of female cases during the pandemic in comparison with 11.6% and 2% respectively after the pandemic.

Both during (8%) and after (12%) the pandemic the majority of parasitic infection was diagnosed in patients among age group 15-44 years compared to none and 1.5% during and post- pandemic respectively among age group >45 years.

Total Patients positive for malaria species; (89.5%); out of 30 Saudi patients during the pandemic period 2(4%)compared to 32 (12.8%) out of 120 non-saudi patients, were positives for malaria parasites during post-pandemic period.

All malaria species, showing highly significant difference reported ($p < 0.001$) were more frequently found in age group 15-44 years, followed by the >45 years, and less <15 of age.

Table 4 shows a observed highly significant difference, ($p < 0.001$) for malaria species identified in blood specimens after the pandemic.

Applied test	Direct microscopy			P-value
	+ve (%)	-ve (%)	Total (%)	P < 0.001
During pandemic	4 (1.3%)	46 (15.3 %)	50 (16.6%)	
Post-pandemic	34(11.3%)	216 (72%)	250 (83.3%)	
Total	38 (12.6%)	262 (87.3%)	300 (100%)	

Table 4: Descriptive results of Malaria during and Post- pandemic period.

Table 5 shows malaria species incidence rate: out of 300 clinically suspected cases, 38 (12.6%) were positive for *Plasmodium* spp., and out of them, *Plasmodium ovale* was identified in 14 (36.8%) *Plasmodium falciparum* 12(31.6%), *Plasmodium vivax* in 11(29%) least species *was Plasmodium malariae* 1 (2.6%).

Direct microscopy	Malaria species				Total
	P. vivax	*P. falciparum*	*P. malariae*	*P. ovale*	
During pandemic	2 (5.3%)	2 (5.3%)	0 (0%)	0 (0%)	4 (10.5%)
Post-pandemic	9 (23.7%)	10 (26.3%)	1 (2.6%)	14 (36.8%)	34 (89.4%)
Total	11 (29%)	12 (31.6%)	1(2.6%)	14 (36.8%)	38 (100%)

Table 5: Results of microscopy for detection of malaria species.

On the other hand out 4(10.5%) of 50 cases suspected to have malaria during the pandemic, were positive for *Plasmodium* infection out of these 2 (5.3%) *P. falciparum*, 2 (5.3%) *P. vivax*, (0%) *P. ovale*. On the contrary Out of 250 cases suspected clinically havig malaria after pandemic, 34(89.4%) were positive for *Plasmodium* infection out of these 14 (36.8%) *P. ovale*, 10 (26.3%) were *P. falciparum*, 9(23.7%) *P. vivax*, *and* 1(2.6%) *P. malariae*.

Discussion

Comparing our study results By Hawash., *et al.* [8] as they study the intestinal parasite status before and during the pandemic; during the pandemic,there was a marked decrease in the total relative number of enteric parasites positive specimens during the pandemic. Meanwhile our study prove reduction and beginning of rise again in parasite prevalence. This decrease in prevalence during pandemic may be explained by protective measures done by the local health authority to reduce the spread of the virus same due time may be due to the reluctance s of patients to get medical services in hospitals fearing from catching the virus. Travel restriction, hand washing daily, and disinfectants used also might play a role in helping decrease possibility of catching infections.

Corresponding months of the proceeding year was chosen to compare both time periods avoiding environmental factors as climate change affecting distribution of these parasitic agents.

The intestinal parasites were found in 12.8% of all samples recorded during the two periods in the current study which was inconsistent with this result, community-based studies done in different geographical places in Saudi Arabia have reported higher prevalence indicating that intestinal parasite infection is a major public health problem in this country [9,10]. On the other hand lower prevalence have also been reported in a prospective research done in different cities like Makkah, Riyadh, and Jeddah [11-13]. Enteric parasites of 0.5% - 6.2% prevalence rate have been recorded in their studies. High rates of prevalence reported globally in countries less developing.

In addition, in the current study, patient-gender relationship was highly significant between the two cohorts, parasitosis was observed more in males, which was consistent with the previous study [14]. In the present research, males were more affected to parasitism than females. This sex-based disparity may be explained by behavior and culture variation between both sexes in Saudi Arabia. Opposite to our result, Ahmed., *et al*. reported more enteric parasites in females (57.4%) than males (42.6%) who did stool analysis at health center in Makkah for pre-employment medical examination [15], in that study, more female than male have filled women over men towards parasitism has also been noticed outside Saudi Arabia [16]. In a study carried in Cameroon, women commonly eat unwashed fruits and vegetables or salads that may be contaminated explaining the higher prevalence of protozoa in women [17]. Similarly, there was a consistant relationship between both two time-periods and the nationality of the cases in the present study, as most of parasitosis detected in non-Saudi expatriate workers coming from countries endemic for enteric parasites coinciding with other reports [17,18] so this population's group are an important source of transmission of parasitic diseases in the region and hence require special care.

In a study done previously in AL-Taif, a 20.8% prevalence rate of intestinal protozoa in diarrheal feces of patients was documented which is identical to the figure reported in the current study [19]. In contrast, Hegazi., *et al*. have reported enteric protozoa in 5.3% schoolchildren in Jeddah [13]. While Amer., *et al*. have recorded only 0.5% of children under 5 years living in King Fahd Medical City, Riyadh, with intestinal protozoa [12]. Regarding enteric protozoa outside Kingdom Saudi Arabia prevalence rates exceeding 50% have been reported in Pakistan, Ethiopia, Cuba, Nigeria, and Malaysia [6,20-23]. Differences between the studied populations, parasitological methods used, geographical location, environmental sanitation level, drinking water sources, research period and cultural differences may explaine these reported variations in the prevalence of enteric protozoa among different studies.

In a study done in 2021 by Hawash., *et al*. samples recorded prior the pandemic were found to have more enteric protozoa than those examined during the pandemic period [8]. The explanation of this difference is most effectively due to the action taken to contain the viral pandemic by the health authority, same can be illustrate our results during and post pandemic. In addition, the Covid-19 pandemic has affected parasitic disease elimination programs in endemic regions and influenced the diagnosis number of human parasitosis [24]. In previous reports, *Blastocystis hominis*, *Giardia*, and *Cryptosporidium* were the most common protozoan species found in the area studied [25,26] and in other Saudi regions [27,28]. Also in our study, hookworm was the most prevalent of helminths species with an overall rate of 1.9%, followed by *Ascaris lumbricoides*, *Hymenolepsis nana* and *Taenia* spp. According to Wakid study [28], *Hymenolepis nana*, *Ascaris* and *Trichuris trichiura* were the predominant helminthic species found in stool samples of middle- school boys in Jeddah. While in another study [29], the major helminths that have been found the pinworms, *Trichuris trichiura* and *Hymenolepis nana* among the apparently healthy immigrant workers at Dammam, Saudi Arabia.

A good numbers of these parasites are transferred from animals to humans "zoonotic". Since intestinal parasitic infection is mostly linked to food and drinking water hygiene Certainly, there is no particular age is immune from getting the infection although in the present study, the demographic characteristic review of positive cases shows that ages 15-44 years had the highest percent distribution towards protozoan infections which is consistent with one report [30] who state also that whereas older ages (>45 years) had the highest percent distribution towards helminths while inconsistent with other [31], the two age groups need special care since they are more vulnerable and prone to parasitic diseases. Malnutrition, low immunity, poor sanitation, polluted food or water, unsafe waste disposal and poor hygiene can be associated with this high infection risk.

Malaria is one of the most widespread infectious diseases in tropical and sub-tropical countries. There are four countries

certified by The World Health Organization (WHO) as malaria free, Kingdom of Saudi Arabia is among 34 countries actively attempting to eradicate malaria. The Arabian American Oil Company (ARAMCO) in the Eastern province started malaria control in 1948, to protect employees living around this area [32]. A national malaria programs in 1952 was started by the Saudi Arabian government targeting malarious districts present across the kingdom planing to protect pilgrims while visiting Mecca and Medina.Transmission was arrested in the Eastern and Northern provinces in 1963 and, by the early 1970s, when Saudi Arabia joined the WHO global malaria eradication program.

The malaria parasites were found in 12.7% of all specimens submitted during the two periods in the our present study. This higher rates can be explained by lack of hygiene and presence of unsuitable agricultural backgrounds in these areas.

Same as with intestinal parasites, a highly significant patient-gender relationship between the 2 cohorts was noticed, where most of parasitic infection was observed in males, this was in coincidence with the study done by [15]. In the current study, males were more predisposed to infection compared to females. This disparity may be explained by behaviour and culture variability between the both them in Saudi Arabia.

The sex distribution in this study demonstrated that males are more affected with malaria than females in figure 1, this shows agreement with the study done by Ismail., *et al*. [30], it can explained the presence greater occupational risk for male in contracting malaria than women being exposed to moquito bites when working in mines, fields or forests at biting peak times, or migration to places where there is high endemicity, adding to this leisure activities, also sleeping habits may affect malaria transmission. Also, study done by Cotter., *et al*. [31] prove that men may be more exposed while women may be more committed than men to apply malaria-prevention measures such as insecticide-treated bed nets.

As shown in table 5 our study showed *Pl. falciparum* 31.6% of diagnosed cases with malaria this is in contrast to result reached by Abdel-Wahab., *et al*. [32] as most of our patients were from Africa where *Pl. falciparum* is endemic noting that resulted cases in this study where non-Saudi.

Out of 50 clinically suspected cases during the pandemic no *P. ovale* detected. On the contrary Out of 250 clinically suspected malaria cases after the pandemic, *P. ovale* was diagnosed in 36.8%. It is possible that covid-19 have set the fight against the parasite back by at least a decade by lock-down measures restricting health care movement providers which could result in more malaria cases and deaths [23]. Also it is also noted in our study the shift in species prevalence as *P. ovale* become the most prominent species this will need more study and advanced investigations.

As fewer investigation studies similar were taken, it was difficult for us to compare our findings. In fact our study doesnt reflect the true prevalence of parasitic infections, data based on clinical symptoms and the socio-demographic variables, have been missing from patients records which could provide a detailed explanation of the prevalence of intestinal parasites particularly among the population, also being a hospital based data, our findings do not reflect the true prevalence in the country. Meanwhile our study depend on routine diagnostic methods in hospital having a low sensitivity for parasite detection that may under- estimate the true prevalence of parasites in addition to many other factors.

Conclusion

Infections with parasitic diseases remain an important problem for the studied population. A rise in the distribution of these parasites was detected after the COVID-19 pandemic time period, in comparison to the corresponding pandemic one. Lock-down measures taken by the Saudi government to suppress the pandemic could play a role leading to the reduction of this type of infections during the pandemic period. Invaluable data given by this study recommend restoring prevention programs to treat and control the neglected parasitic diseases to decrease the incidence of morbidity and mortality.

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Conflict of Interests

The authors declare that they have no conflict of interests.

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