https://doi.org/10.36570/jduhs.2024.3

JDUHS

ORIGINAL ARTICLE

Prevalence and Risk Factors of Giardiasis in Children with Persistent Watery Diarrhea: A Cross-Sectional Study

Shafqat Ali,[1] Arit Parkash,[1] Fahad Ali Mangrio,[2] Shabana Shaikh[1]

1. National Institute of Child Health Karachi, Pakistan.
2. Chulalongkorn University, Bangkok, Thailand.

Correspondence to: Dr. Shafqat Ali, Email: dr.shafqatali87@gmail.com, ORCiD: 0009-0005-5033-3174

ABSTRACT

Objective: This study aimed to examine the prevalence and risk factors of giardiasis in children with persistent watery diarrhea at a tertiary care hospital Karachi, Pakistan.

Methods: This cross-sectional study was conducted at the National Institute of Child Health in Karachi, Sindh, Pakistan, between November 2023 to April 2024. Children aged ≤15 years, with persistent watery diarrhea lasting more than six days were included in the study. The study assessed two primary outcomes, prevalence of giardiasis with persistent watery diarrhea and associated risk factors. Giardia was diagnosed by examining stool samples using fluorescent antibody testing to detect cysts and trophozoites of Entamoeba histolytica and Giardia lamblia. Risk factors were assessed based on children's demographic information and clinical history.

Results: Of total 133 children, the mean age was 6.76 ±4.28 years. Giardiasis was detected in 18 (13.5%) children. The risk of giardiasis was 5 times significantly higher in children whose mothers did not practice handwashing before feeding (aOR 5.04, 95% CI 1.10 to 23.02, p-value 0.037) and had piped drinking water sources (aOR 5.47, 95% CI 1.24 to 24.08, p-value 0.025). While, 92% siginificantly lower in children who had adequate domestic water storage (aOR 0.08, 95% CI 0.01 to 0.48, p-value 0.006) and 93% significantly lower in children had no recent traveling history (aOR 0.07, 95% CI 0.01 to 0.49, p-value 0.007).

Conclusion: This study identified giardiasis as a health concern, with infection risk influenced by maternal handwashing, domestic water storage, piped drinking water, and recent travel history.

Keywords: Children, Giardiasis, Persistent, Watery Diarrhea.

INTRODUCTION

Persistent watery diarrhea in children is a significant public health concern, often linked to giardiasis, particularly in developing nations like Pakistan.[1] Giardiasis is an intestinal infection caused by the flagellated protozoan parasite Giardia duodenalis, which is also known as giardia intestinalis and giardia lamblia, which can result in stunted growth and disrupted gut function, potentially leading to malnutrition if persistent, particularly in areas with high prevalence.[2,3] Giardia duodenalis is transmitted through ingesting cysts, which are the infectious form of the parasite.[4] This transmission occurs through the oral-fecal route, involving direct or indirect contact with infectious stages, including the human-to-human, zoonotic, waterborne, and foodborne transmission of both parasites.[4] Those affected by giardiasis may experience gastrointestinal symptoms, including persistent watery diarrhea, steatorrhea, fatigue, weakness, headache, weight loss, loss of appetite, bloating, abdominal pain, vomiting, excessive gas, flatulence, nausea, and abdominal cramps.[2]

Giardiasis is the most common cause of persistent watery diarrheal disease in individuals under five years of age worldwide and affects over a million children repeatedly.[3,5] Despite that, the disease's prevalence is inconsistent, varying based on the region and the diagnostic method used.[6] In developing countries, the infection rate in asymptomatic children has been reported to range from 8% to 30%, while in industrialized regions, it ranges from 1% to 8%.[7] In Pakistan, Khyber Pakhtunkhwa province found that 3.31% of the population was affected by giardiasis using commercial Elicia kits, with the highest risk group being children aged between 13 and 24 months.[8] Similarly, in the

Punjab province, giardiasis was prevalent among 9.5% of children aged ≤10 years, diagnosed based on microscopy, Enzyme-Linked Immunosorbent Assay (ELISA), and Polymerase Chain Reaction (PCR) targeting the Small Subunit Ribosomal RNA (SSU-rRNA) gene.[9] A study showed that giardiasis infections in humans varied between countries and regions, possibly due to differences in management, climate, and sanitation practices.[10] Furthermore, it has been revealed that diagnosing giardiasis is challenging, and the sensitivity of diagnostic tests varies depending on the method used.[9]

This study is crucial for understanding the prevalence and risk factors of giardiasis in children with persistent watery diarrhea, a common and often overlooked health issue. Identifying significant factors such as maternal hygiene practices, water source quality, domestic water storage, and travel history can help in developing targeted public health interventions. By focusing on these modifiable risk factors, the study provides valuable insights into how better hygiene, sanitation, and water management can reduce the burden of giardiasis in children. This knowledge is essential for informing health policies and prevention strategies, particularly in regions with high disease prevalence like Karachi, Pakistan.

METHOD

This cross-sectional study was conducted at the National Institute of Child Health (NICH) in Karachi, Sindh, Pakistan, between November 2023 to April 2024. Ethical approval for the study was granted by the Institutional Ethical Review Board of the National Institute of Child Health, Karachi (Reference: IERB-50/2023). Written informed consent was obtained from a parent or guardian.

By using Raosoft online sample size calculator taking prevelance of giardiasis 9.5%,[9] level of confidence 95%, 5% margin of error. The estimated sample size was 133. Children aged ≤15 years with water diarrhea persisting for over six days admitted to or visiting the outpatient department were included in the study. Children older than 15 years, those without watery diarrhea lasting less than six days, and those already receiving any medication (antibiotics, metronidazole, nitazoxanide) were excluded from the study.

Persistent watery diarrhea in children is generally defined as the passage of loose, watery stools lasting for 6 days or longer. Giardiasis is defined as an intestinal infection caused by the protozoan parasite Giardia duodenalis (also known as Giardia lamblia or Giardia intestinalis).

The data was collected using a purposive sampling technique based on specific eligibility criteria. Parents or guardians were interviewed using standardized proforma used in previous studies.[8,9] The questions were divided into three parts. The first part included demographic information such as age, gender, residence area, parents' education, type of family, and child travel history. The second part focused on clinical history and assessment, including signs and symptoms, duration of diarrhea (in days), and stool frequency (per day). The third part included questions about potential factors such as drinking water sources, domestic water storage vessels, drinking water boiled or unboiled, a rubbish heap near the house, and mothers' hand washing behavior.

After the clinical assessment a trained staff member collected 5-10 grams of fresh stool samples from each child in sterile containers. The samples were sent to the hospital laboratory for microscopy testing. Collected samples were macroscopic in color, consistency, blood, mucus, and smell; then, an examination using microscopy and direct fluorescent antibody testing (DFA) was conducted to detect cysts and trophozoites of intestinal protozoan parasites, specifically Entamoeba histolytica and Giardia lamblia. For direct examination of this, normal saline and a Lugol's Iodine were utilized.[11,12]

Data entry and analysis were performed using the Statistical Package for Social Sciences (SPSS) version 20.0. Mean ±SD was computed for quantitative variables like age, while frequency and percentages were computed for categorical variables like gender, type of famiy, education level of mother and father, residence, hand washing before feeding, drinking water, water sources, water storage, rubbish heap near the house, traveling history, pets, and clinical chrachteristics of children. Inferential statistics were explored using the Chi-square/Fisher exact test to identify the association of giardiasis with the general and clinical characteristics of children. The p-value of ≤0.05 was considered statistically significant. Moreover, binary logistic regression was applied to all those variables found significant in the Chi-square/Fisher exact contingency table. Both univariable and multivariable logistic regression were applied. Diagnostic measures, including the Variance Inflation Factor (VIF), condition index, and variance proportions, were used to detect multicollinearity. As a result, the variable 'Mother's education' was excluded due to high multicollinearity, in line with theoretical guidelines for model fitness.[13]

RESULTS

Of total 133 children, the mean age was 6.76 ±4.28 years. There were 57 (42.8%) males and 76 (57.2%) females. Most of the children belonged to nuclear families 79 (59.4%), their mother 118 (88.7%) and father 75 (56.4%) had secondary or higher education, were residents of central Karachi 59 (44.4%), and had no traveling history 122 (91.7%). Regarding hygiene practices, majorityof the children use unfiltered 86 (64.7%) and unpiped water 97 (72.9%), their mothers washed their hands before feeding 96 (72.2%), had adequate domestic water storage 120 (90.2%), lived in areas without rubbish heaps nearby 88 (66.2%), and had no pets 110 (82.7%).

Giardiasis was detected in 18 (13.5%) children. A significantly higher association of giardiasis found with children from joint families (p-value 0.015), use piped drinking water (p-value <0.001), had adequate domestic water storage (p-value <0.001), presence of rubbish heaps near the house (p-value 0.002), had no recent travel history (p-value <0.001), their mothers had primary education (p-value <0.001), and those whose mothers did not practice handwashing before feeding (p-value <0.001) (Table 1).

Table 2 showed that giardiasis was significantly associated with several clinical factors. Duration of diarrhea 6–10 days (p-value <0.001), frequency of stool per day 1-4 (p-value <0.001), 0-4 episodes of vomitimng per day (p-value <0.001), presence of abdominal cramps (p-value 0.003), blood (p-value <0.001) and mucus (p-value <0.001) in the stool were observed more frequently in giardiasis-positive cases. Furtehrmore, children with sunken eyes (p-value 0.001), lethargic (p-value <0.001), and dehydration (p-value 0.011) were also significant indicators of giardiasis.

Table 3 reveals binary logistic regression analysis for predicting giardiasis among children with persistent watery diarrhea. At the univariate level, all variables presented in Table 3 showed significant odds ratios. Furthermore, the findings of the multivariable analysis were presented after adjusting the variables that were significant in the univariable analysis. The risk of giardiasis was 5 times significantly higher in children whose mothers did not practice handwashing before feeding (aOR 5.04, 95% CI 1.10 to 23.02, p-value 0.037) and had piped drinking water sources (aOR 5.47, 95% CI 1.24 to 24.08, p-value 0.025). While, the risk of giardiasis was 92% siginificantly lower in children who had adequate domestic water storage (aOR 0.08, 95% CI 0.01 to 0.48, p-value 0.006) and 93% times significantly lower in children had no recent traveling history (aOR 0.07, 95% CI 0.01 to 0.49, p-value 0.007).

DISCUSSION

The present study aimed to identify the prevalence and potential risk factors of Giardiasis infection among children with persistent watery diarrhea who visited the outpatient department or were admitted to wards at the National Institute of Child Health Karachi, Sindh, Pakistan. This is the first study conducted in this healthcare center to address the disease burden in this specific region, especially among individuals living in densely populated areas. The findings of this study indicate that giardiasis is thirteen percent prevalent, underscoring its status as a considerable public health concern. These findings are consistent with previous research conducted in Pakistan's Punjab and Khyber Pakhtunkhwa provinces, which reported similarly low prevalence rates.[8,9] Likewise, a study in Iraq found notably higher prevalence rates among children.14 The rate of giardiasis positivity was similar across both genders, aligning with findings from other studies in similar regions.[15,16]

This study identified a significant association between giardiasis and children from joint families, suggesting that crowded living conditions may elevate their exposure to fecal pathogens. This finding is consistent with existing literature, which indicates that densely populated environments facilitate the transmission of infectious diseases. For instance, previous researches have shown that children living in crowded households face a higher risk of giardiasis and other intestinal infections due to limited access to sanitation and hygiene practices.[17,18]

Furthermore, this study revealed that the association between piped drinking water and an increased risk of giardiasis among children presents a paradox, as piped water is generally considered a safer alternative to other drinking water sources.[19] However, several contextual factors may contribute to this unexpected finding. In Pakistan, the quality of piped drinking water is often compromised by contamination due to aging infrastructure, inadequate treatment facilities, and pollution from industrial and domestic waste.[20] Moreover, the socio-economic context plays a crucial role in determining the safety of piped water. Households with limited resources may lack the means to adequately treat or store piped water, leading to further contamination.[21] These deteriorations can lead to the presence of pathogens, such as Giardia, in piped water systems, thus increasing the risk of giardiasis

Table 1: Association between giardiasis and sociodemographic characteristics of the patients (n= 133)

Variables	Total	Giardiasis		p-value
		Positive (n =18)	Negative (n= 115)	
Age (years)				
< 6	60	11 (18.3)	49 (81.7)	0.142^
≥ 6	73	7 (9.6)	66 (90.4)	
Gender				
Male	57	5 (8.8)	52 (91.2)	0.164^
Female	76	13 (17.1)	63 (82.9)	
Type of Family				
Nuclear	79	6 (7.6)	73 (92.4)	0.015^*
Joint	54	12 (22.2)	42 (77.8)	
Mother Education Level				
Primary	15	12 (80.0)	3 (20.0)	<0.001~*
Secondary/Higher	118	6 (5.1)	112 (94.9)	
Father Education Level				
Secondary	58	8 (13.8)	50 (86.2)	0.939^
Higher	75	10 (13.3)	65 (86.7)	
Residence Districts Karachi				
Central Karachi	59	5 (8.5)	54 (91.5)	0.083^
Malir	32	8 (25.0)	24 (75.0)	
Kemari/West	42	5 (11.9)	37 (88.1)	
Hand Washing before Feeding				
Yes	96	5 (5.2)	91 (94.8)	<0.001^*
No	37	13 (35.1)	24 (64.9)	
Drinking Water				
Filtered	47	3 (6.4)	44 (93.6)	0.075^
Uniltered	86	15 (17.4)	71 (82.6)	
Drinking Water Sources				
Unpiped	97	6 (6.2)	91 (93.8)	<0.001~*
Piped	36	12 (33.3)	24 (66.7)	
Domestic Water Storage				
Inadequate	13	6 (46.2)	7 (53.8)	<0.001~*
Adequate	120	12 (10.0)	108 (90.0)	
Presence of Rubbish Heap near the House				
Yes	45	12 (26.7)	33 (73.3)	0.002^*
No	88	6 (6.8)	82 (93.2)	
Recent Traveling History				
Yes	11	7 (63.6)	4 (36.4)	<0.001~*
No	122	11 (9.0)	111 (91.0)	
Pets				
Yes	23	5 (21.7)	18 (78.3)	0.206~
No	110	13 (11.8)	97 (88.2)	

***** p-value ≤ 0.05 (^Chi-Square test/~Fisher Exact test)

Table 2: Association between giardiasis and clinical characteristics of the patients (n= 133)

Variables	Total	Giardiasis		p-value
		Positive (n =18)	Negative (n= 115)	
Duration of Diarrhea (days)				
6-10	130	15 (11.5)	115 (88.5)	<0.001~*
11-15	3	3 (100.0)	0 (0.0)	
Frequency of Stool (per day)				
1-4	126	13 (10.3)	113 (89.7)	<0.001~*
5-6	7	5 (71.4)	2 (28.6)	
Vomiting (per day)				
0-4 Episodes	129	14 (10.9)	115 (89.1)	<0.001~*
More than 5 Episodes	4	4 (100.0)	0 (0.0)	
Abdominal Cramp				
Yes	47	12 (25.5)	35 (74.5)	0.003^*
No	86	6 (7.0)	80 (93.0)	
Fever				
Yes	63	8 (12.7)	55 (87.3)	0.789^
No	70	10 (14.3)	60 (85.7)	
Blood in Stool				
Yes	14	11 (78.6)	3 (21.4)	<0.001~*
NO	119	7 (5.9)	112 (94.1)	
Mucus in Stool				
Yes	20	10 (50.0)	10 (50.0)	<0.001~*
No	113	8 (7.1)	105 (92.9	
Smell in Stool				
Yes	108	1 (0.9)	107 (99.1)	<0.001~*
No	25	17 (68.0)	8 (32.0)	
Conscious Alert				
Alert	66	3 (4.5)	63 (95.5)	0.003^*
Disoriented/Lethargic	67	15 (22.4)	52 (77.6)	
Sunken Eyes				
Yes	55	14 (25.5)	41 (74.5)	0.001^*
No	78	4 (5.1)	74 (94.9)	
Pinch Skin (Skin turgor)				
Normal (retracts)	55	3 (5.5)	52 (94.5)	<0.001^*
Going Slowly (retract less than 2 seconds)	70	7 (10.0)	63 (90.0)	
Very Slowly (more than 2 seconds)	8	8 (100.0)	0 (0.0)	
Dehydration				
Yes	74	15 (20.3)	59 (79.7)	0.011^*
No	59	3 (5.1)	56 (94.9)	

* P-value ≤ 0.05 (^Chi-Square test/~Fisher Exact test)

Table 3: Binary logistic regression analysis for predicting giardiasis among children with persistent watery diarrhea (n = 133)

Variables	Univariable analysis		Multivariable analysis	
	cOR (95% CI)	p-value	aOR (95% CI)	p-value
Type of Family				
Nuclear	1		1	
Joint	3.47 (1.21 to 9.94)	0.020*	3.73 (0.84 to16.48)	0.082
Mother Education Level$				
Primary	1			
Secondary/Higher	0.01 (0.01 to 0.06)	<0.001*		
Hand Washing before Feeding				
Yes	1		1	
No	9.85 (3.20 to 30.37)	<0.001*	5.04 (1.10 to 23.02)	0.037*
Drinking Water Sources				
Unpiped	1		1	
Piped	7.58 (2.58 to 22.29)	<0.001*	5.47 (1.24 to 24.08)	0.025*
Domestic Water Storage				
Inadequate	1		1	
Adequate	0.13 (0.03 to 0.44)	<0.001*	0.08 (0.01 to 0.48)	0.006*
Presence of Rubbish Heap near House				
Yes	1		1	
No	0.20 (0.07 to 0.58)	0.003*	0.63 (0.13 to 3.00)	0.563
Recent Traveling History				
Yes	1		1	
No	0.05 (0.01 to 0.22)	<0.001*	0.07 (0.01 to 0.49)	0.007*

$ The variable "Mother's Education" was excluded from the multivariable analysis due to high multicollinearity, as identiied by an elevated Variance Inlation Factor (VIF)
cOR: Crude odds ratio, aOR: Adjusted odds ratio, *p-value ≤ 0.05

among children who depend on this water source.

The results of this study indicate significant associations between giardiasis positivity and various clinical parameters among patients with persistent watery diarrhea. For example, the duration of diarrhea, stool frequency, vomiting episodes, presence of blood and mucus in stool, consciousness levels, and physical signs of dehydration were all found to have significant associations with giardiasis positivity. These findings are consistent with previous researches on the clinical manifestations of giardiasis.[22,23] Therefore, these clinical signs and symptoms should be considered when diagnosing giardiasis patients with persistent watery diarrhea.

The logistic regression analysis of this study underscored the significant influence of family structure, mothers' handwashing habits during feeding, drinking water sources, domestic water storage, rubbish heaps near the house, and recent travel history on the likelihood of positive giardiasis among patients with persistent watery diarrhea. These findings highlight the importance of considering environmental and behavioral factors in assessing the risk of giardiasis among patients with persistent watery diarrhea.[3] Further study also revealed that tape water resources increased the chance of giardiasis infection compared to filtered water.[14] In addition, individuals close to waste collection points are more likely to contract intestinal pathogens due to the favorable environment for pathogen development in household wastes.[24] Moreover, studies showed that inadequate hand-washing practices by mothers are linked with a higher risk of giardiasis among children.[8,25]

This study has several limitations. First, the study

focused solely on children with persistent watery diarrhea, which may not accurately represent all cases of giardiasis. Second, the study's concentration on a single healthcare center in Karachi may not fully capture the diversity of experiences and risk factors for giardiasis in children with persistent watery diarrhea in other regions of Sindh province. Moreover, the study's exclusion criteria, such as excluding children already receiving medication, may have led to the exclusion of relevant cases, potentially impacting the comprehensiveness of the findings. Despite these limitations, this study has notable strengths, the results underscore the need for comprehensive interventions that address both clinical and environmental factors to effectively prevent and manage giardiasis in this population. Future research should prioritize selecting healthcare centers across Sindh province, ensuring a large and diverse sample size, utilizing a longitudinal research design, and focusing on general cases of giardiasis without specific symptom considerations.

CONCLUSION

This study highlighted giardiasis as a concerning health issue, concluding that inadequate maternal hand washing practices before feeding, piped drinking water sources, domestic water storage, and recent travel history are significant factors influencing infection risk. These findings emphasize the need for targeted hygiene and sanitation improvements to mitigate giardiasis risk.

ETHICAL APPROVAL: The institutional Ethical Review Board of the National Institute of Child Health Karachi approved the study (Reference number: IERB-50/2023, dated: 03 November 2023).

AUTHORS' CONTRIBUTIONS: SA: Conception, design, and interpretation of data for the work, final draft preparation. AP: Critical article revision for important intellectual content, and approval. FAM: Statistical expertise, data curation, and draft preparation. SS: Formal analysis, Investigation, visualization, and interpretation. All authors approved the final version of the manuscript to be published.

CONFLICT OF INTEREST: The authors confirm they have no conflict of interest.

FUNDING: This research received no external funding.

ACKNOWLEDGMENT: The authors would like to express their sincere gratitude to the National Institute of Child Health Karachi laboratory staff for their invaluable assistance in collecting stool samples from the participants.

Received: November 9, 2024
Accepted: January 15, 2025

REFERENCES

1. Jehanzeb K, Haq ZU, Shah SA, Lodhi MA, Ashraf N. Comparison of manifestations of giardia and Ascaris infestations between both genders presenting with diarrhea: Comparison of giardia and Ascaris infestations among children in GB. Pak Armed Forces Med J 2020; 70:1681-5. doi:10.51253/pafmj.v70i6.2798
2. Ryan U, Hijjawi N, Feng Y, Xiao L. Giardia: An under-reported foodborne parasite. Int J Parasitol 2019; 49:1-11. doi:10.1016/j.ijpara.2018.07.003
3. Dougherty M, Bartelt LA. Girdia and growth impairment in children in high-prevalence settings: consequence or co-incidence? Curr Opin Infect Dis 2022; 35:417-23. doi:10.1097/QCO.0000000000000877
4. Hemphil A, Muller N, Muler J. Comparative pathobiology of the intestinal protozoan parasites Giardia lamblia, entamoeba histolytica, and Cryptosporidium parvum. J Pathog 2019; 8:116. doi:10.3390/pathogens8030116
5. Rogawski ET, Bartelt LA, Platts-Mills JA, Seidman JC, Samie A, Havt A, et al. Determinants and impact of giardia infection in the first 2 years of life in the mal-ed birth cohort. J Pediatric Infect Dis Soc 2017; 6:153-60. doi:10.1093/jpids/piw082
6. Pouryousef A, Fararouei M, Sarkari B. Antigen-based diagnosis of human giardiasis: A systematic review and meta-analysis. Iran J Parasitol 2023; 18:140-54. doi:10.18502/ijpa.v18i2.13180
7. Hooshyar H, Rostamkhani P, Arbabi M, Delavari M. Giardia lamblia infection: Review of current diagnostic strategies. Gastroenterol Hepatol Bed Bench 2019; 12:3-12. doi:10.22037/ghfbb.v0i0.1414
8. Khattak I, Yen WL, Usman T, Nasreen N, Khan A, Ahmad S, et al. Individual and community-level risk factors for giardiasis in children under five years of age in Pakistan: A prospective multi-regional study. Children (Basel) 2023; 10:1087. doi:10.3390/children10061087
9. Nawaz Z, Rasool MH, Siddique AB, Zahoor MA, Naz A, Ali S, et al. Frequency and molecular detection of giardia intestinalis in children attending pediatrics of Punjab, Pakistan. Jundishapur J Microbiol 2020; 13:e97080 doi:10.5812/jjm.97080
10. Veronesi F, Passamonti F, Caccio S, Diaferia M, Piergili Fioretti D. Epidemiological survey on equine cryptosporidium and giardia infections in Italy and molecular characterization of isolates. Zoonoses Public Health 2010; 57:510-7. doi:10.1111/j.1863-2378.2009.01261

11. Zaki DM. Prevalence of entamoeba histolytica and giardia lamblia associated with diarrhea in children referring to Ibn al-atheer hospital in mosul, Iraq. Arch Razi Inst 2022; 77:73-9. doi:10.22092/ARI.2021.356312.182012
12. Khan AH, Gul NA, Hammad HM, Bibi Y, Bibi A, Mohsan J. Prevalence of giardia intestinalis and hymenolepis nana in Afghan refugee population of Mianwali district, Pakistan. Afr Health Sci 2015; 15:394-400. doi:10.4314/ahs.v15i2.12
13. Senaviratna N, Cooray T. Multicollinearity in binary logistic regression model. Theory Pract Math Comput Sci 2021; 8:11-9. doi:10.9734/bpi/tpmcs/v6/2417E
14. Ali IY, Mero WM, Mohammed AB. Prevalence and risk factors of giardia lamblia among infants and children in duhok province/kurdistan region, Iraq. Asian J Nurs 2022; 11:147-52. doi:10.25007/ajnu.v11n4a1597
15. Naz A, Nawaz Z, Rasool MH, Zahoor MA. Cross-sectional epidemiological investigations of giardia lamblia in children in Pakistan. Sao Paulo Med J 2018; 136:449-53. doi:10.1590/1516-3180.2018.0350060918
16. Anim-Baidoo I, Narh CA, Oddei D, Brown CA, Enweronu-Laryea C, Bandoh B, et al. Giardia lamblia infections in children in Ghana. Pan Afr Med J 2016; 24:217. doi:10.11604/pamj.2016.24.217.8012
17. Ali SH, Foster T, Hall NL. The relationship between infectious diseases and housing maintenance in Indigenous Australian households. Int J Environ Res Public Health 2018; 15:2827 doi:10.3390/ijerph15122827
18. Fahim SM, Das S, Gazi MA, Mahfuz M, Ahmed T. Association of intestinal pathogens with fecal markers of environmental enteric dysfunction among slum-dwelling children in Bangladesh's first 2 years of life. Trop Med Int Health 2018; 23:1242-50.doi:10.1111/tmi.13141
19. Foster T, Rand E, Sami E, Dance B, Kohlitz J, Willetts J. Does the source of water for piped supplies affect child health? Evidence from rural Vanuatu. J Water Sanit Hyg Dev 2019; 9:591-5. doi:10.2166/washdev.2019.161
20. Hassan GZ, Shabir G, Akhtar S, Rafique H, Hassan MA. Groundwater and nutritional health challenges- a case study from indus river system in pakistan. J Nutr Health Food Eng 2022; 12:61-4. doi:10.15406/jnhfe.2022.12.00357
21. Ishaque W, Tanvir R, Mukhtar M. Climate change and water crises in Pakistan: Implications on water quality and health risks. J Environ Public Health 2022; 2022:1-12. doi:10.1155/2022/5484561
22 . Bahari A, Nazemi H, Ganji A, Farzanehfar M, Namdar AB, Goshayeshi L, et al. Association between giardia duodenalis infection and irritable bowel syndrome. Acta Med Iran 2023; 61:289-93. doi:10.18502/acta.v61i5.13484
23. Roshidi N, Arifin N. Disease biomarkers of giardiasis. J Parasitol Res 2022; 2022:1-12. doi:10.1155/2022/1932518
24. Mochungong PI, Gulis G, Sodeman M. Morbidity among children living around clinical waste treatment and disposal site in the northwest region of cameroon. J Public Health Afr 2011; 2:e13. doi:10.4081/jphia.2011.e13
25. Quazi S, Wadde SK, Nagaonkar AS. Hand washing practices amongst mothers of under-fives in an urban slum. Int J Community Med Public Health 2019; 6:4748. doi:10.18203/2394-6040.ijcmph20195050