

CENTRAL ASIAN JOURNAL OF MEDICAL AND NATURAL SCIENCES
https://cajmns.casjournal.org/index.php/CAJMNS
Volume: 08 Issue: 01 | January 2027 ISSN: 2660-4159

Article

Oxidative Stress and Cytokine Profiles in Children with Giardiasis and Helicobacter Pylori Co-Infection

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Abstract: Background: Giardiasis and Helicobacter pylori infection are commonly seen gastrointestinal infections among young children which lead to inflammation and oxidative stress; however, there is not enough information about their combined effect in children who have both infections together. Aim: This study aimed at assessment and comparison of the oxidative stress markers and cytokines profile of children infected either with G. lamblia, H. pylori or with both infections at the same time. Materials & Methods: This cross-sectional study involved 150 children, aged between 1 to 13 years, attending the Parasitology Section at the Children's Hospital, Kirkuk, from April 2026 to July 2026. Stool samples of children were examined microscopically for presence of G. lamblia and serum samples were tested for the levels of IL-6, IL-10, TNF-α, MDA, and GSH through commercially available ELISA Kits from SUNLONG, China. Results: Among 150 examined children, G. lamblia was detected in 13 (8.67%), H. pylori in 21 (14.00%), and co-infection in 7 (4.67%). Males predominated among positive cases (73.17%), while G. lamblia was most frequent at 7–9 years (38.46%), H. pylori at 4–6 years (47.62%), and co-infection at 7–9 years (57.14%). All measured inflammatory and oxidative stress markers differed significantly among groups (P = 0.001). The co-infection group showed the highest IL-6 (85.14 ± 7.39 pg/mL), TNF-α (92.11 ± 7.41 pg/mL), and MDA (42.18 ± 2.20 pg/mL) concentrations, while GSH was lowest (14.29 ± 1.55 pg/mL), indicating a marked inflammatory and oxidative imbalance. Conclusions: The results indicate that co-infection with G. lamblia and H. pylori is associated with a more severe inflammatory response and oxidative imbalance—manifested by elevated levels of IL-6, IL-10, TNF-α, and MDA, and reduced GSH concentrations—compared to control groups and groups with single infections.

Keywords: G. lamblia; H. pylori; Co-infection; Cytokines; Oxidative stress

Citation: Hussein, S. I. Kadhim, K. K & Mohammed, W. J. Systemic IL-17A, IL-22 and IL-27, and Mucosal IgA Responses in Patients with Cutaneous Leishmaniasis: Correlation with Lesion Characteristics and Clinical Phenotypes. Central Asian Journal of Medical and Natural Science 2027, 8(1), 63-69

Received: 13th Aug 2026
Revised: 28th Sep 2026
Accepted: 15th Oct 2026
Published: 11th Nov 2026

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1. Introduction

The prevalence of giardiasis and Helicobacter pylori infection is high among children, making these conditions crucial public health problems. Giardia duodenalis is recognized as an important protozoan pathogen of the intestine and is primarily transmitted by food and water contamination. On the other hand, H. pylori is known as a stomach bacterium that is usually acquired during childhood and is capable of persistent colonization of gastric mucosa [1], [2], [3]. According to epidemiological data, about one-third of children are infected by H. pylori worldwide, even though the prevalence differs greatly depending on the age, socio-economic status, geographical region, and diagnostic methods used [4]. Similarly to giardiasis, many children suffer from infection with this

parasite, which leads to diarrhea, abdominal pain, malabsorption, damage to the intestinal barrier, and disturbances in nutrition [5], [6].

The clinical consequences of G. duodenalis are influenced by different processes involving the interaction between the parasite, the intestinal epithelium, the microbiota, and the immune system of the host. Experimental and clinical data show that Giardia infection has the ability to induce the appropriate immune response, including the activation of T-helper cells [7]. Children with giardiasis have shown modification in plasma cytokine profiles, including IL-8 and IL-17. It has also been observed that the association of IL-17, TNF, and intestinal fatty acid-binding protein indicates that inflammation has something to do with epithelial damage. This shows that cytokine-induced inflammation can play a role in the development of intestinal injury and not just represent a result of infection [8]. In addition, oxidative stress may be another mediator between infection and damage. More importantly, the way in which the production of reactive oxygen species exceeds the capacity of antioxidants can lead to damage of lipids, proteins, and cell membranes. Many investigations carried out among children in the context of chronic giardiasis have indicated increased malondialdehyde (MDA) levels as well as certain changes in the corresponding antioxidant capacity, showing that children with chronic giardiasis move toward oxidative stress [9]. These days, it has been found that children infected with giardia have also high levels of MDA and low antioxidant ability, with the differences being caused by the genotype of parasites[10]. Consequently, oxidative stress might have an influence on the pathophysiology of gastrointestinal giardiasis. A similar association between an illness, inflammation, and oxidative balance disturbance has been reported for H. pylori. The bacteria establish their infection in the gastric mucosa stimulating epithelial and immune cells to produce pro-inflammatory markers such as IL-8, IFN-γ, TNF-α, IL-6 and IL-10 [11], [12], [13]. The rise in IFN-γ and IL-8 production is known to correlate with the gastric inflammation in children. Impairment of oxidative balance has been observed in children with H. pylori infection as well. Increased gastric MDA levels and changes in antioxidant parameters such as glutathione and catalase have been identified in infected children [14], [15], [16]. The current findings prove that oxidative stress participates in the process of gastric mucosal injury induced by H. pylori. It is also known that children are infected with both Giardia and H. pylori. Research from Uganda, Egypt, and other countries has shown that the two pathological conditions can co–exist, as well as that Giardia is likely to be the most frequently detected intestinal parasite among the infected children [17], [18]. Although giardiasis and H. pylori infection were proved to affect the processes of oxidative stress independently from one another, there is little information concerning the effect of such co-infection on oxidative stress parameters and contents of pro-inflammatory cytokines in children specifically.

2. Materials and Methods

2.1 Study design and patients

A cross-sectional research design was employed with 150 subjects aged 1–13 years at the Parasitology Section of Children's Hospital of the town of Kirkuk between April and July 2026. A total of 150 children who suffered from gastrointestinal disorders with special emphasis on abdominal pain and/or diarrhea were initially checked for the presence of intestinal parasites. The subjects aged 1–13 met the eligibility criteria for the study and were selected to participate. The stool samples from the children were collected for microscopic analyses, and subjects with confirmed Giardia lamblia infection identified under the microscope were chosen for further testing. The research was also aimed to find helicobacter pylori infection and specific biochemistry and immunology parameters in the study participants.

2.2 Sample collection

Sterile disposable screw capped plastic containers were used for the collection of stool samples from the participants for the laboratory assays. All stool samples were given appropriate identification tags before being sent to the Parasitology Laboratory for tests.

The stool samples were subjected to direct examination through wet mount technique for detecting the presence of G. lamblia cysts or trophozoites.

2.3 Blood collection and serum preparation

The participants were subjected to the collection of approximately 5 mL of blood from their veins using a sterile disposable syringe. The collected blood was inserted into sterile serum separator tubes which contained gel clot activator. The blood was allowed to clot before being centrifuged for 5–10 minutes at 3000 rpm. The resultant serum was transferred into four sterile Eppendorf tubes to avoid repeated freeze–thaw cycle.

2.4 Inclusion criteria

This study included children between the ages of 1 and 13 who were referred to the hospital with abdominal pain and/or diarrhea and had not received specific treatment for either parasites or H. pylori before sample collection.

2.5 Exclusion criteria

Children outside the specified age range and those who had received antiparasitic treatment or treatment for H. pylori before sample collection and those suffering from known chronic diseases, acute systemic illnesses, or other conditions that would affect the laboratory parameters being studied were excluded from the study.

2.6 Laboratory measurements

The immunologic parameters (IL-6, IL-10 and TNF-α), and oxidative stress indicators (MDA and GSH) were determined by enzyme-linked immunosorbent assay (ELISA) kits (SUNLONG, China) using the sandwich ELISA technique. In short, the plates were coated with antibodies to the cytokine of interest. Following this, the ELISA kit standards, controls and serum samples were added and incubated according to the manufacturer's directions. Subsequently, a detection antibody marked with horseradish peroxidase was added to each well. After incubation, the plate was washed to remove the unbound elements. The substrate tetramethylbenzidine (TMB) was then added showing a color change only in the wells containing the analyzed cytokine. The reaction was halted by the addition of the stop reagent which caused another color change. The optical density of each well was measured at 450 nm using a spectrophotometer. The concentration of each cytokine was calculated based on the standard curve provided by the ELISA kit's manufacturer.

2.7 Statistical analysis

Statistical analysis was conducted utilizing Minitab statistical software. Continuous variables were reported in the form of mean ± standard deviation (SD), wherever relevant. Scientific comparison of measured values between different study groups was carried out using a one-way analysis of variance (ANOVA). If ANOVA indicated a significance level of a comparison, appropriate post-hoc comparisons were carried out in order to investigate differences between groups. A P value of <0.05 was taken to be significant.

3. Results

3.1 Sample distribution

Out of the total number of examined samples, the percentage of examination which is 13 (8.67%) turned out to be positive for G. lamblia infection, while 21 samples tested positive for H. pylori infection. Co-infections with G. lamblia and H. pylori were recorded in 7 children (4.67%). The remaining 109 samples were reported to have negative results for both the diseases under investigation, meaning that overall negative samples accounted for the highest share of the study population followed by H. pylori infection, then G. lamblia infection, and lastly co-infections after that, Table 1.

Table 1. Distribution of study group according to results

Procedures	Samples	Positive samples			Negative sample
		G. lamblia	*H. pylori*	Co-infection	
Results	150	13(8.67%)	21(14.0%)	7(4.67%)	109(72.67%)

In Table 2, the sex ratios of study groups with positive findings are presented. Out of the children who tested positive for G. lamblia, 10 (76.92%) children were of the male sex

and 3 (23.08%) children were of the female sex. With respect to H. Pylori, 15 children (71.43%) were male and 6 (28.57%) were female. Finally, the number of children co-infected with both G. lamblia and H. Pylori comprised 5 boys (71.43%) and 2 girls (28.57%).

Table 2. Distribution of study group according to gender

Gender	Positive samples			Total
	G. lamblia	*H. pylori*	Co-infection	
Male	10(76.92%)	15 (71.43%)	5(71.43%)	30(73.17%)
Female	3(23.08%)	6(28.57%)	2(28.57%)	11(26.83%)
Total	13(31.71%)	21(51.22%)	7(17.07%)	41(100.0%)

The data provided in Table 3 shows the vaccination rates among age groups who tested positive for different forms of study groups. Among those affected, the highest proportion of G. lamblia infections was noticed among children from 7 – 9 age (38.46%) with 5 cases followed by children in the 4-6 age (30.77%) with 4 cases and in the age of 10 – 12 (23.08%) with the lowest incidence rate being among children in the 1 – 3 age group with 1 case (7.69%). The same holds true for H. pylori; the highest ratio was recorded in the 4-6 age group with 10 cases (47.62%) among children infected with *H. pylori* followed by outbursts registered in the 7 -9 (33.33%) age group containing 7 cases. The least cases (9.52%) were recorded both in the both 1-3 years and the 10-12 age groups with 2 cases each. It is worth mentioning co-infections among those affected as well. The highest incidence rate was reported in the age group of the 7 – 9 children (57.14%). Additionally, the age group of 10-12 years demonstrated that the proportion of co-infected children was 28.57%, while the proportion of infected children still remained very low in the age group of 4-6. No cases were reported among children belonging to the 1-3 age group.

Table 3. Distribution of study group according to age

Age (year)	Positive samples			Total
	G. lamblia	*H. pylori*	Co-infection	
1-3	1(7.69%)	2(9.52%)	0(0.0%)	3(7.32%)
4-6	4(30.77%)	10(47.62%)	1(14.29%)	15(36.59%)
7-9	5(38.46%)	7(33.33%)	4(57.14%)	16(39.02%)
10-12	3(23.08%)	2(9.52%)	2(28.57%)	7(17.07%)
Total	13(31.71%)	21(51.22%)	7(17.07%)	41(100.0%)

3.2 Interleukins

The control group showed the lowest mean concentration of IL-6 (16.29 ± 2.47 pg/mL), whereas children infected with G. lamblia had a markedly higher concentration (65.14 ± 4.65 pg/mL). The mean IL-6 concentration in children with H. pylori infection was 31.19 ± 4.28 pg/mL, while the highest concentration was observed in the co-infection group, reaching 85.14 ± 7.39 pg/mL. The control group had a mean IL-10 concentration of 5.83 ± 0.12 pg/mL. This concentration increased to 15.91 ± 1.19 pg/mL among children with G. lamblia infection and to 9.22 ± 0.71 pg/mL among those with H. pylori infection. The co-infection group showed the highest mean IL-10 concentration (16.42 ± 2.81 pg/mL). The control group had the lowest mean concentration (23.19 ± 2.68 pg/mL), followed by the H. pylori group (48.42 ± 5.28 pg/mL). Higher concentrations were observed in children with G. lamblia infection (83.17 ± 9.21 pg/mL), while the co-infection group demonstrated the highest mean concentration (92.11 ± 7.41 pg/mL).

Table 4. The concentrations of interleukins in patient groups compared with control

Parameter	Control	Patients			P value
		G. lamblia	*H. pylori*	Co-infection	
IL-6 pg/ml	16.29± 2.47 d	65.14± 4.65 b	31.19± 4.28 c	85.14± 7.39 a	0.001
IL-10 pg/ml	5.83± 0.12 c	15.91± 1.19 a	9.22± 0.71 b	16.42± 2.81 a	0.001

Parameter	Control	Patients			P value
		G. lamblia	*H. pylori*	Co-infection	
TNF-α pg/ml	23.19± 2.68 c	83.17± 9.21 a	48.42± 5.28 b	92.11± 7.41 a	0.001

3.3 Oxidative stress

A statistically significant difference was observed in serum malondialdehyde (MDA) concentrations among the studied groups (P = 0.001). The control group showed a mean MDA concentration of 12.16 ± 3.12 pg/mL; this value rose significantly in children infected with G. lamblia to 36.13 ± 2.42 pg/mL. Similarly, the mean MDA concentration in children infected with H. pylori was 34.84 ± 2.42 pg/mL. The highest mean MDA concentration was recorded in children with a dual infection, reaching 42.18 ± 2.20 pg/mL. For GSH, The control group recorded the highest mean concentration of reduced glutathione (GSH), at 48.48 ± 1.41 pg/mL. The mean concentration decreased to 17.12 ± 1.95 pg/mL in children infected with G. lamblia and to 20.53 ± 2.47 pg/mL in those infected with *H. pylori. The lowest mean GSH concentration was observed in the dual-infection group, at 14.29 ± 1.55 pg/mL.

Table 5. The concentrations of MDA and GSH in patient groups compared with control

Parameter	Control	Patients			P value
		G. lamblia	*H. pylori*	Co-infection	
MDA pg/ml	12.16± 3.12 c	36.13± 2.42 b	34.84± 2.42 b	42.18± 2.2` a	0.001
GSH pg/ml	48.48± 1.41 a	17.12± 1.95 b	20.53± 2.47 b	14.29± 1.55 c	0.001

4. Discussion

In the present study, the prevalence of Giardia lamblia was found to be 8.67%, which is lower than the pooled prevalence of the disease in children reported in an earlier study conducted by Kalavani[19]. The difference in the two studies could be attributed to factors such as differences in region of study and sample population, exposure to the environmental factor and the use of different diagnostic techniques. The prevalence of H. pylori was recorded at 14.00%, with co-infection being found in 4.67% of the children. Our findings regarding G.-H. pylori co-infection are consistent with the findings of Ankarklev and El-Badry, who also reported such co-infection in children. The presence of co-infection in our population implies the possibility of having simultaneous infections in children infected with gastrointestinal pathogens, especially in places where the environmental and hygienic conditions are favorable for the transmission of the disease. However, differences in the prevalence rates in studies can also be the result of demographic factors such as age of the population, clinical conditions, size of the sample group, and methods of diagnosis.

In our study, male patients were predominant among positive cases, consistent with the studies of Kalavani who observed higher frequency of Giardia infection in male children, and in terms of age group, Giardia and H. pylori infections were more often seen in children aged 7-9 years and 4-6 years, respectively, which is in general accord with older pediatric studies showing differences in infections among children of different ages. Such age-related differences may be attributed to differences in exposure to contaminated food and water, person-to-person transmission, and differences in susceptibility of children to infections. However, the age data of our study show the distribution of positive cases rather than their age-specific prevalence.

The cytokine-related results achieved in this study were in accordance with the data reported in previous studies. The values of IL-6 and TNF-α were found to be significantly higher in infected children. For instance, the findings reported by Cascais-Figueiredo[20] suggested that there were the changes in the levels of pro-inflammatory cytokines in giardiasis-infected children, while Michalkiewicz reported on elevated levels of these cytokines in children infected with H. pylori. Data related to the increase in IL-10 levels in our infected children was also aligned with the study by Michalkiewicz. Even though

the rise in IL-10 and TNF-α levels was insignificant when comparing the groups of patients infected with Giardia and patients infected with two parasites, it is possible to say that the fact that both the pro-inflammatory and regulatory cytokines were increased suggests that both inflammatory and compensatory immune mechanisms are triggered by the infection. Finally, the elevated levels of IL-6 found in the children infected with two parasites may be an indicator of the presence of higher inflammatory burden, although it should be interpreted within the framework of association and not as proving synergistic interaction.

The outcomes related to oxidative stress corroborated earlier studies. For instance, the levels of MDA have significantly increased as well as the levels of Glutathione (GSH) have significantly decreased among children with parasitary infection. Notably, this finding corroborates Ismail statement, claiming that oxidative stress has increased among children contaminated with giardiasis and corroborates Hagag et al. conclusions[21] regarding the evidence of an increased concentration of MDA and decreased concentration of GSH in children suffering from H. pylori infection. Hence, using this evidence reveals the existence of inflammation and oxidative imbalance in kids suffering from both infections. In this case, elevated levels of MDA indicate that lipid peroxidation was increased, and the reduced levels of GSH point out to the depletion of the significant antioxidant mechanism.

5. Conclusion

According to the results obtained from the study considered, it was discovered that among the tested sample of children, there existed the presence of G. lamblia and H. pylori infections as evidenced by the obtained positivity rates of 8.67% and 14.00%, respectively, whereas the history of dual infections among the study population accounted for 4.67%. It is noteworthy that both infections correlate with significantly pronounced changes in cytokine concentrations and oxidative stress indicators as defined by the increase in IL-6, IL-10, TNF-α levels, and MDA as well as the decrease in GSH level. Moreover, it was found that the dual infection group experienced even more notable alterations showing the highest values of IL-6, TNF-α, and MDA levels along with the lowest level of GSH.

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