Open Access Research Journal of
Biology and Pharmacy
Journals home page: https://oarjbp.com/
ISSN: 2782-9979 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(RESEARCH ARTICLE)

Association between intestinal parasitic infections and biochemical markers of malnutrition among pediatric patients

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Open Access Research Journal of Biology and Pharmacy, 2026, 16(02), 105-113

Publication history: Received on 05 March 2026; revised on 05 April 2026; accepted on 08 April 2026

Article DOI: https://doi.org/10.53022/oarjbp.2026.16.2.0034

Abstract

Intestinal parasitic infections are still a pressing public health issue for children around the world, but especially in underdeveloped areas. Intestinal parasitic infections can cause malnourishment and stunt growth. They can interfere with the metabolism and absorption of nutrients which could then affect levels of essential nutrients such as hemoglobin, serum iron, ferritin, albumin, total protein, vitamin D and zinc. The aim of the present study was to determine the relationship between the presence of intestinal parasites and levels of biochemical markers associated with malnutrition in young children. This was a cross-sectional study involving 298 young children who were screened for intestinal parasites via stool samples at the Kirkuk Children's Hospital. Microscopic examination revealed that *Entamoeba histolytica* and *Enterobius vermicularis* were the two most frequent types of parasites present in the children. We also measured the following biochemical parameters: hemoglobin, serum iron, ferritin, albumin, total protein, vitamin D and zinc in the infected versus uninfected children. The study demonstrated that infected children have lower levels than uninfected children in all of the measured markers. In summary, the study demonstrated that intestinal parasitic infections have a direct negative impact on levels of biochemical markers associated with nutrition status of children. Early detection and treatment of parasitic infections may help prevent malnutrition and improve child health outcomes.

Keywords: Intestinal parasitic infections; *Entamoeba histolytica*; *Enterobius vermicularis*; Malnutrition; Biochemical markers

1. Introduction

Intestinal parasitic infections (IPIs) continue to be a significant public health concern around the globe, with some nations, such as those with little sanitation or poor hygiene and those with low access to clean water, being the most affected by this problem [1]. Due to their poor immune systems and being frequently exposed to dirty conditions, children are at a higher risk for developing these types of infections [2]. According to the World Health Organization (WHO), an estimated 1.5 billion people (or 24% of the world's population) currently suffer from IPIs [3].

Some individuals who have a long-term intestinal parasite infection can start to experience severe health problems resulting from malnutrition, such as malabsorption of nutrients, iron-deficiency anemia, vitamin deficiency and impaired physical and cognitive development. Children with chronic intestinal parasite infections may also experience long-term effects on their growth, nutritional status and performance in school, which will ultimately affect their overall health and quality of life [4]. Malnutrition continues to be one of the leading global health concerns for children. Around one-third of all child deaths (under five years of age) are attributed to undernutrition. As a result, it has a negative impact on how well you digest or absorb food, cause you to lose a greater amount of the nutrients in your food, and may also reduce your appetite, which will lead to nutrient deficiency [5]. Intestinal parasites live alongside gut bacteria, indicating that the gut microbiota may play a role in affecting the pathophysiology of intestinal parasitic infections (IPIs) [6]. The gut microbiota is vital for sustaining balance and overall health in the body, significantly influencing immune system development and cellular metabolism [7], the gut microbiota aids in defending against opportunistic pathogens,

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supports the formation of new blood vessels, assists in repairing damage to epithelial cells, regulates energy metabolism, and helps in acquiring essential nutrients [8]. The impact of intestinal parasitic infections (IPIs) on the microbial environment of the human gut remains largely unclear. Most studies investigating these relationships have been conducted using animal models [9], recent research involving human subjects has indicated that intestinal parasites can alter gut microbial communities [10]. The presence of specific intestinal parasites in the gut can lead to changes in gut composition that may be either beneficial or harmful, depending on the type of parasite involved [11].

Numerous research studies illustrate that intestinal parasite infection is correlated with an increased risk for having insufficient nutritional status in children. Commonly reported intestinal parasites among young children living in developing countries include *E. histolytica*, *Giardia lamblia*, *Ascaris lumbricoides*, and *E. vermicularis*. These parasites can interfere with the absorption of nutrients through the intestines, which can result in deficiencies in key biochemical indicators of timely growth and development (e.g., hemoglobin, serum iron, ferritin). Other necessary micronutrients are also affected by this group of intestinal parasites [12].

Evaluating nutritional status in children requires biochemical markers. The evaluation of several parameters including hemoglobin, serum iron, ferritin, albumin, various vitamin levels, and trace elements (such as zinc) is used to assess anemia, protein status, and other micronutrient deficiencies (such as vitamin A). Children affected by chronic inflammatory and parasitic infections, along with associated intestinal damage, will have low levels of these biochemical markers due to malabsorption [13]. Therefore, the present study aims to investigate the association between intestinal parasitic infections and biochemical markers of malnutrition among pediatric patients.

2. Materials and Methods

2.1. Study Design, Setting and Population

This cross-sectional analytical study was conducted at the Children's Hospital in Kirkuk, Iraq, to examine the correlation between intestinal parasitic infections and biochemical indicators of under-nutrition in children. Data and samples were collected from emergency rooms and consultative laboratories during the period from January 14, 2024, to July 23, 2024. The study population comprised 298 pediatric patients aged between 4 months and 5 years. The participants included 155 males and 143 females who attended the hospital during the specified study period.

2.2. Sample Collection and Parasitological Examination

All participants' stool samples were obtained from each participant in a sterile container, and following collection were delivered to the laboratory to be tested. Microscopic examination was conducted to identify intestinal parasites found within the stool sample, with *E. histolytica* and *E. vermicularis* being the parasites detected in the study.

2.3. Blood Sample Collection and Biochemical Analysis

Blood samples from participants were taken aseptically for biochemical evaluation of nutrition-related biochemical markers such as hemoglobin, serum iron, ferritin, albumin, total protein, and vitamin D and zinc levels in order to assess nutritional status and diagnose potential deficiencies related to parasitic infections.

2.4. Laboratory Analysis

Quantitative measurements for hemoglobin, ferritin, serum iron, serum zinc, albumin, total protein, and vitamin D were evaluated in this study for all participants. Hemoglobin concentration was measured using an automated CBC hematology analyzer (SPAINREACT, Spain). Ferritin concentration was determined using a fluorescence immunoassay analyzer (FIA meter, FINCARE, China). Serum iron and serum zinc levels were measured using a spectrophotometer (Human Diagnostics, Germany). Serum albumin and total protein were measured using an automated clinical chemistry analyzer based on bromocresol green and biuret methods, respectively. Serum vitamin D levels were determined using an automated immunoassay analyzer based on enzyme linked fluorescent assay (ELFA). All tests were performed according to the manufacturers' instructions.

2.5. Statistical Analysis

Using the Statistical Package for the Social Sciences (SPSS) software, data was entered and subsequently analyzed. Biochemical parameters were summarized utilizing descriptive statistics such as their mean and standard deviation. The independent samples t-test was used to compare the means of blood markers analyzed (hemoglobin, serum iron, ferritin, albumin, total protein, vitamin D, and zinc) between children who were infected compared to those who were not. The Chi-square statistic was used to analyze frequency data when appropriate. A p-value of less than 0.05 was considered to be statistically significant (P < 0.05).

The necessary ethical approval for this research project was acquired from the proper institution's ethical committee, and we conducted all of our procedures in accordance with the ethical standards for conducting research with human participants, including maintaining the confidentiality of all patient-identifiable information throughout the study.

3. Results

3.1. Data Characteristics of the Study Population

The data of the population who were participants in this study can be found in Figure 1. A total of 298 children aged 4 months to 5 years old were included in the total number of children. The total number of male children was 155 (52.0% of the 298) and the total number of female children was 143 (48.0% of the 298). Most of the children who participated in this study, 218 children in total, were between 1 and 5 years of age and 80 of them were younger than 1 year.

Figure 1 Visual Distribution of Study Population by Gender and Age Groups

Figure 1 shows the breakdown of participants according to age category; most of the subjects fall into the (1-5) year age category, making up a sizeable majority of total children studied; however, fewer were as young as 1 year old. The fact that there is a higher concentration of younger children at pediatric health care facilities suggests that young children may be at increased risk for developing intestinal parasitic infections and also highlights that this age group represents a significant time period in which to conduct studies regarding intestinal parasitic infections.

3.2. Prevalence of Intestinal Parasitic Infections

Figure 2 summaries the rates of observed intestinal parasitic infections seen in children. Microscopy, performed on child's stool specimens, found that 183 (61.4%) were infected with *E. histolytica* followed by *E. vermicularis* at 115 cases (38.6%).

These findings indicate that E. histolytica was the predominant intestinal parasite among pediatric patients in this study.

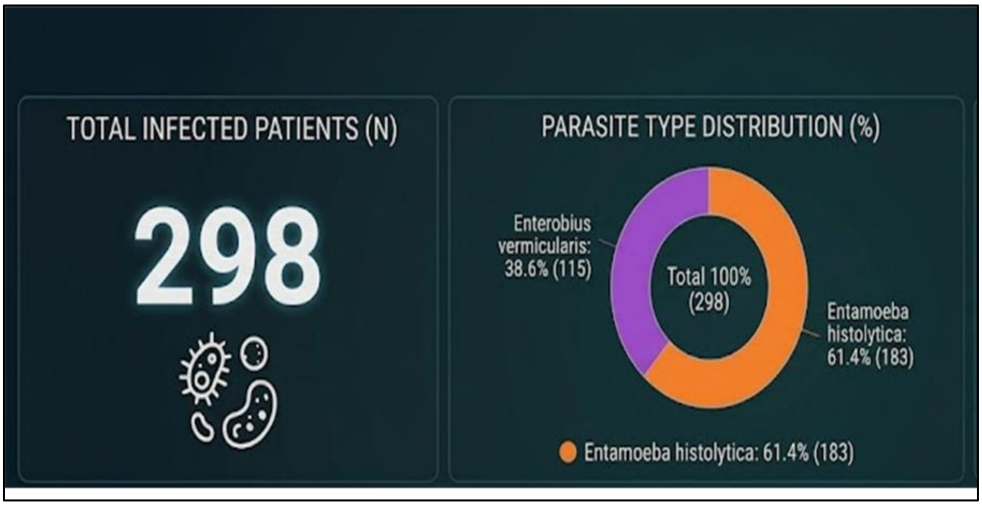


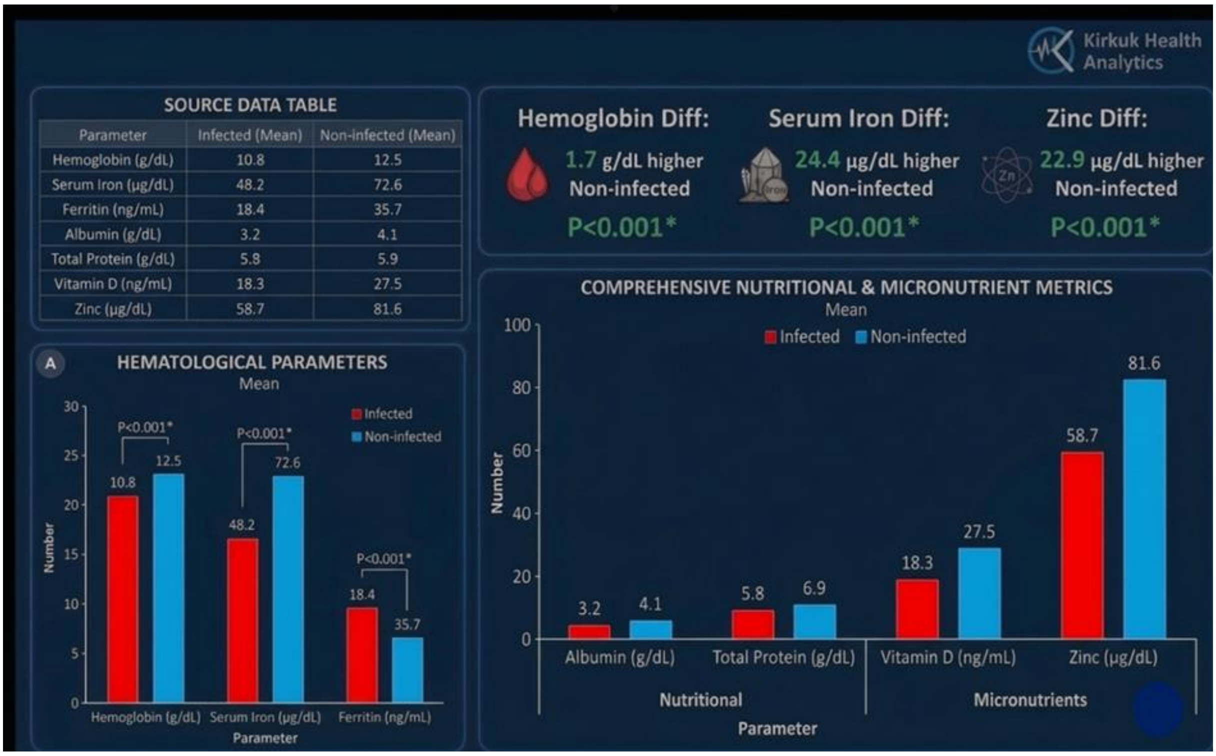
Figure 2 Visual Analysis of Detected Intestinal Parasite Distribution and Percentages

3.3. Distribution of Intestinal Parasites Among Pediatric Patients

The finding is that *E. histolytica* is of greater prevalence than *E. vermicularis* in the study population. In the study, both infections were found in all study participants in their different age groups and genders.

3.4. Comparison of Biochemical Markers Between Infected and Non-infected Children

As can be seen in Figure 3, there is a report on the differences in blood biochemistry between infected and non-infected children. Those who were infected had lower average values of many important nutrients than those who were not infected, such as hemoglobin, serum iron, ferritin, albumin, total protein, vitamin D and zinc.



P-values were calculated using independent samples t-test. A value of P < 0.05 was considered statistically significant.

Figure 3 Comparative Visual Analysis of Biochemical Profiles and Micronutrient Status in Infected and non-infected

Hemoglobin levels were significantly reduced in children with intestinal parasites (mean = 10.8±1.3 g/dl) compared to children without parasites (mean=12.5±1.1 g/dl). Infected children also had significantly lower serum iron levels (mean= 48.2±9.5 µg/dL) than uninfected children (mean=72.6±10.3 µg/dL) and ferritin levels (mean=18.4±6.2 ng/mL) than non-infected children (mean = 35.7+/-7.9 ng/mL). In addition, infected children had significantly lower means for albumin (mean=3.2 +/- 0.5 g/dld) and total protein (mean = 5.8 +/- 0.6 g/dl) than uninfected children (mean=4.1±0.4 g/dL and 69.5, 0.5 g/dL, respectively). Infected children's mean micronutrient levels were also significantly lower than uninfected children's; for example, vitamin D's mean level was 18.3±4.1 ng/mL for infected children compared with 27.5±5.2 for non-infected children, and for zinc, the means were 58.7±8.3 µg/dL versus81.6±9.4 µg/dL, respectively.

4. Discussion

4.1. Prevalence of Intestinal Parasitic Infections Among Pediatric Patients

In the present study, we explored the relationship between biochemical markers of malnutrition and intestinal parasites infections in children who attended the Children's Hospital in Kirkuk, Iraq. The results of our investigation found that intestinal parasites were prevalent within this patient population, with *E. histolytica* being the most highly prevalent parasite among patients tested; *E. vermicularis* was the second most highly prevalent intestinal parasite identified. The predominance of *E. histolytica* in this study agrees with other epidemiological studies conducted on the same issue in developing nations, and supports the idea that sanitation, access to safe drinking water, and lack of hygienic practices are significant contributors to the transmission of intestinal parasites [14,15].

According to Figure 1, Most of the subjects that participated were in the age range of (1 – 5). Youngsters in this age group are typically more vulnerable to intestinal parasitic diseases due to their higher level of contamination in their environments, an immature immune system and developing hygiene practices. All of these factors increase the likelihood that young children become infected with parasites and suffer from related nutritional deficits [16].

Children are particularly vulnerable to infections caused by intestinal parasites because of the unique behavioural and immunological features that children exhibit. Young children often play in contaminated environments and can ingest eggs or cysts of parasites from unwashed hands, contaminated food or drinking-water. In addition, their immune systems are not yet fully developed, meaning that children are at a greater disadvantage than adults in resisting infections from these parasites [17]. This study's data on the high prevalence of intestinal parasites in children continues to demonstrate the substantial public health burden associated with infections caused by parasites in children, especially in populations living in areas where there are poor conditions of environmental sanitation and hygiene.

4.2. Association Between Parasitic Infections and Anemia

The current study's most significant conclusion is that children who are infected with intestinal parasites have significantly lower hemoglobin levels than children who are not infected. Hemoglobin indicates anemia and overall nutritional status; therefore, the low hemoglobin levels in children with intestinal parasitic infections indicate that they may be at increased risk for anemia as a result of their intestinal parasitic infection [18].

This relationship can be explained by several biological mechanisms. Intestinal parasites can cause chronic inflammation of the intestinal mucosa, which leads to a decreased absorption of essential nutrients needed for red blood cell formation. Certain parasitic infections can also cause chronic intestinal bleeding or destruction of red blood cells, both of which contribute to the development of anemia. Children who are infected with these parasites have a reduced appetite, which reduces their food intake and further exacerbates both iron deficiency and anemia. All of these biological mechanisms explain the association between intestinal parasitic infections and reduced hemoglobin levels as found in this study [19].

4.3. Impact of Parasitic Infections on Iron Status

Infections in young children, as demonstrated in previous studies, can also lower serum iron and ferritin. Both measures represent the availability of iron in a child's body (serum iron) and the amount of iron stored (ferritin). Children with reduced serum iron and ferritin have decreased iron stores and, as such, compromised iron metabolism [20].

There are many pathways that connect parasites in the intestinal tract to iron deficiency. For example, the intestinal parasite may compete for nutrients with the host; therefore, the number of available nutrients will be reduced. In cases where an intestinal parasite is causing chronic intestinal inflammation, that inflammation can result in alterations to the metabolism of iron by increasing the concentration of regulatory hormones like hepcidin, which inhibits the absorption of iron from processed foods as well as the release of iron from the body's stored manner into circulation [21]. Therefore, it is possible for children who have been infected with an intestinal parasite to be diagnosed with either iron deficiency or decreased ferritin level, which can develop into iron-deficiency anemia.

4.4. Effects of Parasitic Infections on Protein Metabolism

Children who had infections in this research had lower levels of albumin and total protein than children that did not have infections. Albumin is a key protein in the plasma that is reflective of both nutritional status and liver function [22]. Total protein is an overall measure of the circulating proteins in the body.

These lowered proteins may be due to various mechanisms related to parasitic infections. For example, damage to intestinal mucosa as a result of parasitic infections may impair the ability to digest and absorb dietary sources of protein. Therefore, with chronic infections, the body will have greater demands for metabolism and thus also will undergo greater protein catabolism; therefore, circulating protein levels will be lower [23]. In children, prolongs protein deficiency may result in adverse effects upon normal growth, immune function and overall development.

4.5. Micronutrient Deficiencies in Infected Children

The present study also revealed lower levels of vitamin D and zinc among children infected with intestinal parasites. Micronutrients play a critical role in immune function, metabolic regulation, and growth [24]. Deficiencies in these nutrients may significantly compromise a child's ability to resist infections and maintain normal physiological functions [25].

Vitamin D plays an important role in regulating immune responses and maintaining bone health [26]. Vitamin D has been linked together with immunity; it's not a coincidence that low Vitamin D levels result in a weakened immune system, as well as increase the risk of infections [27]. Vitamin D is also required for several other processes within the body and is necessary for many other nutrients to work properly [28]. Zinc can also contribute to multiple enzymatic reactions and helps develop and function the immune system, and Zinc deficiency can lead to poor immune responses, delayed wound healing, and increased susceptibility to infectious disease, all of which we see in this study's results when we looked at Vitamin D and Zinc levels in children with parasitic intestinal infections [29]. Thus, we see that the effects of intestinal parasitic infections on nutritional status are evident when comparing Vitamin D and Zinc levels in infected children in this study [30].

4.6. Public Health Implications

The findings of this study emphasize the significant relationship between intestinal parasitic infections and nutritional deficiencies among pediatric patients. This relationship highlights the importance of integrated public health interventions aimed at both controlling parasitic infections and improving nutritional status among children.

Improvements to access safe drinking water, infrastructure for sanitation, and hygiene education will help provide effective prevention measures. Screening children regularly for intestinal parasites is also valuable for the early identification of infection and its successful treatment. In addition, nutritional interventions that include micronutrient supplementation and refined dietary practices can help reduce the negative nutritional consequences of parasitic diseases.

4.7. Study Limitations

While the results of this research provide important information about how intestinal parasites can impact malnutrition biomarkers, the study had various limitations that must be recognized. First, due to the study being conducted in just one healthcare facility, the findings may not be representative of other populations or regions in the world; therefore, the results from this study cannot be applied or used to determine conclusions for any other population. In addition, since this was a cross-sectional study design, a direct cause-and-effect relationship between the presence of intestinal parasitic infections and the presence of nutritional deficiencies could not be determined. Thus, further longitudinal studies are recommended using larger populations to assist researchers in developing a better understanding of the long-term effects of intestinal parasites on child health and nutrition.

4.8. Summary of Findings

The current research indicates that there exists an association between intestinal parasites and reduced biochemical markers indicating nutritional status in children. In many cases, children who are infected with parasites have lower levels of hemoglobin, serum iron, ferritin, albumin, total protein, vitamin D, and zinc than those who do not have parasitic infections. This study reinforces the need for rapid detection and treatment of parasitic infections and the necessity of public health policies that provide comprehensive infection control and nutrition deficiency measures for the pediatric population.

5. Conclusion

The results suggest that intestinal parasitic infections continue to be a significant problem among children and that there is a substantial association between intestinal parasitic infections and decreased levels of a number of important biochemical indicators of nutritional status. The predominant intestinal parasites found in this population were *E. histolytica* and *E.vermicularis*; *E. histolytica* was the most frequently detected parasite. Children with intestinal parasitic infections exhibited significantly lower levels of hemoglobin, serum iron, ferritin, albumin, total protein, vitamin D and zinc as compared to children without intestinal parasitic infections. These changes in the biochemical markers may contribute to the development of anemia, protein deficiencies and micronutrient deficiencies in pediatric patients. The decrease in these biochemical markers indicates that parasitic infections can have a negative effect on the nutritional and physiological condition of children. Continued chronic intestinal parasitic infections may lead to impaired growth and development due to the manner in which these infections can negatively affect nutrient absorption, increase metabolic demands and negatively impact normal physiological functions. Consequently, intestinal parasite infections are a major concern for both infectious disease prevention and for exclusively contributing to the problem of malnutrition in children under five years of age. Timely detection of intestinal parasite infections can lead to improved health outcomes for children. Routine screening for intestinal parasites in children will allow for early detection of infection among children at high risk of infection when stool samples are routinely done. Additionally, access to clean drinking water, sanitation, and hygiene can assist with reducing parasite transmission in children. Nutritional supplementation, such as iron and/or other micronutrient supplementation, and nutritional education as it relates to antisocial dietary habits can reduce the impact of parasite infections in children. Integrated approaches to providing child health care include infection control measures and nutritional assistance programs that may effectively address both the problem of parasitic infections and nutritional deficiency in preschool children. The findings in this study indicate a need for comprehensive public health initiatives designed to reduce parasitic infections and improve the nutritional status of preschool children simultaneously. Promoting healthy development and growth in children requires addressing the issues of parasitic infections and socioeconomics together.

Compliance with ethical standards

Acknowledgments

The author would like to express their sincere appreciation to the staff of the Children's Hospital in Kirkuk for their cooperation and assistance during sample collection and laboratory analysis. The author also extend their gratitude to all participating children and their families for their cooperation and contribution to this study.

Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this research.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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