

Prevalence and risk factors of parasitic diseases among Saudi children

An updated review

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ABSTRACT

عدوى الطفيليات المعوية هي مشكلة صحية عالمية آخذة في الانخفاض. ومع ذلك، في أجزاء معينة من العالم، لا يزال يتم التقليل من سوء الفهم القائل بتجنب بعض الأمراض بسبب وجود استراتيجيات وقائية وأدوية وتكرار حملات التوعية. أفادت الدراسات الحديثة في المملكة العربية السعودية عن معدلات انتشار عالية لعدوى الطفيليات المعوية؛ ومع ذلك، فإن الانتشار في المملكة العربية السعودية يختلف من مدينة إلى أخرى ومن فئة عمرية إلى فئة عمرية. علاوة على ذلك، تختلف الأنواع المسببة الأكثر انتشاراً في مناطق مختلفة من المملكة العربية السعودية بسبب الاختلافات في خصائص السكان الناشئة. كما تم ربط انتشار عدوى الطفيليات المعوية بعوامل خطر متعددة، مثل العمر والجنس والوعي الصحي والعادات الصحية والحالة الاجتماعية والاقتصادية. في الختام، ينبغي إيلاء المزيد من الاهتمام لمبادرات عدوى الطفيليات المعوية في المملكة العربية السعودية ويجب معالجة عوامل الخطر بشكل أفضل لمراقبة وتقليل انتشار عدوى الطفيليات، خاصة بين الأطفال الأصغر سناً.

Intestinal parasite infection (IPI) is a declining global health problem. However, in certain parts of the world, the misconception that certain diseases are avoided owing to the existence of prevention strategies, medication and the frequency of awareness campaigns remains underestimated. Recent studies in Saudi Arabia have reported high prevalence rates for IPI; however, the prevalence in Saudi Arabia varies from city to city and from age group to age group. Moreover, the most prevalent causative species vary in different areas of Saudi Arabia due to differences in the characteristics of emerging populations. The prevalence of IPI has also been correlated with multiple risk factors, such as age, gender, health awareness, health habits and socioeconomic status. Therefore, more attention should be given to IPIs in Saudi Arabia and the risk factors should be better addressed to monitor and reduce the spread of parasite infections, particularly among younger children.

Keywords: Prevalence, intestinal parasite infection, Saudi children, age, gender

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According to the World Health Organization (WHO), foodborne illnesses are a significant concern worldwide.¹ Precise epidemiological analyses are crucial to better understand the burden of foodborne diseases for determining the effects of food security interventions and advising decision-makers on the cost-effective use of sometimes restricted resources. However, to date, there is a lack of reliable and clear global knowledge on most foodborne agents or pathogens.²

Intestinal parasites are the largest source of chronic infectious illness worldwide, with reports that at least one-fifth of the world's population is contaminated.³ Intestinal parasites are a significant health problem in developed countries. Approximately 80% of all the deaths that occur annually in these countries are due to infection-related diseases and parasites; protozoa and helminthic parasitic infections, which are types of intestinal parasite infections (IPIs), affect 3.5 million people globally, most of them children.⁴

The occurrence of these parasites is generally associated with unsanitary living conditions. In some countries, the existence of more intestinal parasites was connected to disease, particularly in children.⁵ In Saudi Arabia, an unusually high prevalence rate of parasites has been reported, making IPI a common health problem⁶ that impacts the country's rapid economic growth, despite an overall improvement in health care.

The number of people worldwide with a specific link to parasite-infected children has been thought to increase.³ Even with the overall increase in sanitation and the quality of life in Saudi Arabia, intestinal parasites are common in the country.³

This study aimed to an updated summary of recent evidence regarding the prevalence and risk factors of IPI and the causative organisms and features of these infections.

Prevalence of IPIs in the Kingdom of Saudi Arabia (KSA). Previous studies have reported that the prevalence rates of IPIs in the KSA range from 9.5% to 47.4% in children that are either symptomatic or asymptomatic.^{3,6} In Yemen, a neighboring KSA country, approximately 30-53% of all stool samples sent to public health hospitals suggested IPIs.⁷ Documented reports from several Middle East countries reveal higher rates of IPIs among children; 31.5% in Egypt,⁸ 27.6-53% in Gaza,⁹ 26% in Tunis,¹⁰ 21% in Lebanon,¹¹ 38.7% in Oman,¹² and 34.8% in Bahrain.¹³

Multiple studies have indicated the presence of different intestinal parasites in numerous Saudi Arabian cities. A study conducted in Makkah estimated that the prevalence of IPI was 6.2 % in 2011.¹⁴

Bolbol et al¹⁵ stated a prevalence of 20.8% in Riyadh City,¹⁵ and Al-Eissa et al¹⁶ reported a prevalence of 21.2% in Al-Baha City, and there was no statistical discrepancy relative to more recent information. In a more recent study, Al-Braiken et al³ documented a higher prevalence (33.8%) of IPI in the Jeddah Region, which was also higher than the prevalence observed in the Eastern province (9.3%) reported by Qadri et al.¹⁷

Moreover, the prevalence of IPI is far lower in KSA than other countries, such as Yamoussoukro, which

Mathurin et al¹⁸ reported to have a prevalence of 47.4%. In Morocco, the prevalence was reported to be 51%;¹⁸ it was reported to be 89.6% in Argentina¹⁹ and 93% in Nicaragua.²⁰

In contrast, Al-Megrin et al²¹ estimated a higher and more statistically meaningful incidence of diarrheal symptoms (15.7%) in the infected community, which is significant relative to the non-infected population. This is consistent with recent evidence reported by Mathurin et al,¹⁸ Hawash et al,²² and Hegazi et al²³ on the association between IPI and diarrheal symptoms. In the past, the diarrheal symptoms dissociated from IPI symptoms negatively affected the prevalence tracking; this can explain the prevalence difference between previous and recent studies, especially between children ranging in age from 7 months to 6 years.¹⁵

Various studies have shown that the majority of IPIs are caused by protozoa rather than intestinal worms,²⁴ such as research conducted by Al-Megrin et al,²¹ which showed that approximately 95% of IPIs are caused by protozoa and approximately 5% are caused by other parasites. It has been commonly documented that *Blastocystis hominis* (*B. hominis*), *Entamoeba histolytica/dispar* (*E. histolytica/dispar*) and *Giardia lamblia* (*G. lamblia*) first emerged as the most prevalent parasites triggering the majority of intestinal infections in KSA.⁴ In a cross-sectional study conducted in 2008 in Jeddah, KSA, the subjects were from outpatient clinics, there was a high prevalence of these parasite-induced infections, but this was not statistically significant in comparison to other gastrointestinal infection-inducing parasites.³ Amer et al²⁶ reported on data obtained from a 5-year retrospective survey by King Fahad Medical City, Riyadh, KSA; the study found that the most prevalent parasites in Riyadh were *E. histolytica* (0.27%), *Cryptosporidium sp.* (0.1%), *G. lamblia* (0.07%), and *Trichuris trichiura* (0.03%). According to Al-Braiken et al,³ *B. hominis* was found to be prevalent in 9% of the infected cases. The latest findings indicate that a parasite is linked with some intestinal conditions and that immune responses modulate the impact, suggesting that the cause is an opportunistic parasite.²⁷ In comparison, the occurrence of watery diarrhea has an important correlation.³ Al-Braiken et al³ suggested that *B. hominis* occurs periodically between parasite faunas, in line with the observation that in 6% of the cases *E. histolytica* has been reported for this parasite and comparable reports have also been reported for this parasite. In KSA, the prevalence range is 1.2-14% in different regions.²⁸ In 2020, Wakid¹⁸ evaluated infections of middle school boys in Jeddah, KSA finding that 46 students (17.4%)

Table 1 - Summary of the prevalence of intestinal parasite infection in different Saudi cities.

City	Prevalence (%)	Study
Jeddah	33.8	Al-Braiken et al ³
	17.4	Wakid et al ¹⁸
Al-Baha	21.2	Al-Eissa et al ¹⁶
Riyadh	20.8	Al-Megrin et al ¹⁹
		Bolbol et al ¹⁵
Eastern province	9.3	Qadri et al ¹⁷
Makkah	6.2	Zaglool et al ¹⁴

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were contaminated with intestinal parasites, including 7 protozoa: primarily *Blastocystis spp.*, *G. lamblia*, *E. histolytica/dispar* and 3 parasites of helminth, including *Hymenolepis nana*, *Ascaris lumbricoides*, and *Trichuris trichiura*.¹⁸

In standard diagnostic laboratories, the detection of amoebiasis by microscopic recognition of stool parasites remains insensitive, since it cannot be differentiated from non-pathogenic amoeba. A number of research studies have been conducted in the Middle East to determine the prevalence of *G. lamblia* infection.⁹ Indeed the prevalence of *G. lamblia* in children in this analysis might indicate that there is no infection or intermittent cyst excretion, as cysts may pass at 2-3 day intervals and often at 7-8 day intervals, and sometimes the prevalence in this sample is far lower than the prevalence found for this organism in Jeddah, KSA.²⁹ The failure to diagnose *G. lamblia* infection in children for the duration of the study can indicate that cysts are either missing or are sporadic, since cysts may pass after 2-3 days or even 7-8 days, and even repeated microscopic tests sometimes do not reveal that parasites are present in the stools in patients who have giardiasis.²⁹

Another literature analysis indicated that *Cryptosporidium* infection was reported in 2.6% of Saudi infants.³ Provided that certain laboratories only test for the presence of *Cryptosporidium* in stools on a physician's order, cryptosporidiosis is generally undiagnosed in the field. In this study, the prevalence for *Cryptosporidium* infection was consistent with the findings reported in other studies from the Middle East.³⁰ However, the prevalence of *Cryptosporidium* was lower (32%) and asymptomatic (4.7%) in 2000 in Jeddah, KSA and it was 69% in infants in the same study. The prevalence of *A. lumbricoide* diseases, along with *Trichuris trichiuria*, hookworm, and other worms, was found to be minimal.^{6,28} Al-Megrin et al¹⁹ reported that among preschool children in Riyadh, KSA, *G. lamblia* was the most prevalent parasite contributing to intestinal infections (37.8%), followed by *E. histolytica* (24.4%), then *B. hominis* (20%) and *Cryptosporidium parvum*. A few cases were diagnosed with *Cyclospora cayetanensis* (4.4%), *A. lumbricoides* (2.2%), and *H. nana* (2.2%). These findings confirm what has been mentioned in earlier reports, such as the one by Al-Eissa et al¹⁶ and the more recent one in Saudi Arabia by Al-Braiken.³ This update coincides with more recent studies from numerous locations worldwide, such as those conducted by Sharif et al³¹ and Mbae et al,³² particularly for children aged 5 years and younger. *G. lamblia* is the most widespread parasite

contributing to intestinal infections, in accordance with other studies from Riyadh, KSA by Alkhalife,⁴ from Jeddah, KSA by Zakai,⁶ and from Al-Baha by Al-Eissa et al.¹⁶ Compared to the afore-mentioned findings, it is worth noting that this report found an increase in the prevalence rate of *G. lamblia* in Riyadh City and Jeddah City.³ Many studies from other countries in the Middle East reported that *G. lamblia* infections are the most common infections induced by protozoa in children.³³ Al-Megrin et al¹⁹ finding that *E. histolytica* is the second most prevalent parasite contributing to intestinal infection among children in Riyadh City, is compatible with the results from Al-Baha City¹⁶ and Jeddah City²⁸ and in accordance with the findings reported by Hegazi et al.²⁴ However, a lower prevalence was documented in Taif, a city in western Saudi Arabia,³⁴ and in the city of Côte d'Ivoire, as reported by Mathurin et al.²⁰ Moreover, *B. hominis* infections (20%) were ranked third by Al-Megrin et al.¹⁹ This finding is comparable to the results reported in previous research that explored the prevalence of the same organism in various areas of Saudi Arabia.³⁵ Furthermore, *C. parvum* was reported to have a prevalence of 8.9%.^{19,36} However, that percentage is considerably less than that reported by Sanad and Al-Malki in 2007.³⁷ They reported the prevalence of cryptosporidiosis to be 69.7% in children (69.7) younger than the age of 2 who have compromised immunity.³⁷ Another study conducted on children of Jeddah reported that 32% of the infected cases were symptomatic and 4.7% of the cases were infected but clinically silent.²⁸

Risk factors for IPIs and their influence on the prevalence based on different Saudi cities. The risk factors for IPIs varied. Some risk factors are behavioral, others are demographic and subjective. This section presents an overview of these risk factors.

a. Attending awareness campaigns. A survey by Al-Saad et al³⁸ conducted in 2018 in Jeddah, KSA reported that 92.7% of the participants did not attend awareness campaigns. A study conducted by Al-Ain in the United Arab Emirates (UAE) suggested the benefit of coordinating public awareness campaigns to disseminate information on IPI processes, signs and alert signals to reinforce the significance of receiving medical advice and to inform people regarding the measures they can take to protect themselves from contracting certain infections.³⁹ The Emairati recommendation was presented to all 6 of the Gulf Cooperation Council (GCC) countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE), which are recognized as high-income countries and have accepted community preventive medical services by WHO.⁴⁰

b. Previous history of IPIs. In their 2018 report, Al-Saad et al³⁸ stated that the majority (75.5%) of their participants have no history of IPIs. However, 80.9% of the signs, including abdominal discomfort, vomiting, diarrhea and nausea, were reported. A study carried out in Jeddah showed that the diagnosis of parasite infections, such as amebae, through microscopic stool detection, is insensitive.³⁸ That study also addressed the scarcity of precise data on amoebiasis and other parasitic bowel infections.³⁸ In 2010, a study conducted in Al-Ahssa found that there was a strong probability of infection owing to a prior history of previous IPIs among family members, contributing to a 24.5% likelihood of re-infection.⁴¹ Another study found that, in restaurants where 94% of the participants are at high risk of contracting IPIs, transmission of disease through food sources is an ongoing global problem.⁴²

c. Health behaviors. In their 2004 study, Nematiana et al⁴³ estimated that 80% of Tehran's population washed fruits and vegetables that had a high risk factor for IPIs before they were consumed by using detergents, salts and antiseptics thereby decreasing contamination; however, these substances do not eradicate the bacterial and parasite counts. Another cross-sectional study conducted by Gelaw et al⁴⁴ in 2013 established a statistically significant correlation between hand hygiene practices and parasitic infection rates among Ethiopian primary school children, suggesting that bad hand hygiene practices substantially increased the infection rates. However, a different association has been reported in numerous Saudi studies. For example, in a 2013 study conducted in Al-Ahssa, KSA, 67.7% of the participants had strong hand hygiene practices, but 90% still had parasitic infections.³⁸ Moreover, a recent study conducted in Jeddah stated that hand washing with water alone was a statistically significant risk factor for IPI transmission.⁴⁵

d. Food and water sources. Many studies researched the role of the water and food supply in many countries including KSA.⁴⁶ Food servers, such as chefs, can be a major cause of infection if they are sick. They may be a direct source of illness, or they can also be a silent carrier that transfers the parasite, and thus the disease, to someone later.⁴² In Al-Ahssa in 2018, 95% of the population under investigation reported having frequently dined in restaurants, putting them in direct danger of experiencing this threat.³⁸ Furthermore, the community's source of drinking water was proposed to be a major factor in predicting the parasite infection.³⁸ Al-Saad et al³⁸ suggested that approximately 34.5% of the subjects in their study in Jeddah that used water from tanks were at a greater risk of multiple parasitic

infections. Moreover, farm animals are considered to be a major component of the transmission chain of numerous diseases,⁴⁷ which represents a severe challenge to public health.⁴⁸ However, in an Al-Ahssa study of 500 people in 2008, 33.8% of whom tested positive for parasitic infections, nearly 85.5% of the participants reported a lack of direct contact with livestock, which was expected to reduce their chance to developing a parasitic gastrointestinal tract infection.³⁸

e. Age. School-aged children were shown to have a significant predictive effect on intestinal parasite infections; they were more likely to be infected than children that do not attend schools. Minor children usually play in open fields, and the result may clarify their own mouth.⁴⁹ There is a clear correlation between intestinal parasite infection, particularly *G. lamblia*, and diarrhea in pre-school-age children in Riyadh, KSA in comparison to infants.¹⁴ In contrast, the same research in Riyadh, KSA, showed that children between the ages of 3 and 5 tend to have the highest rate of infections (23.3%) relative to other experimental categories. In 2018, Gebretsadik et al⁵⁰ reported the same average for this age group. This result supports what Ghiwot et al⁵¹ suggested in 2014 in that children that are 4 years of age are the typical age group with the highest frequency rate of infection. However, Wongstitwilairoong et al⁵² reported the highest prevalence rate for children between the ages of 2 and 3, which was slightly lower than the average median prevalence age in other studies.

f. Gender. It is stated in the literature that gender-associated disparities in susceptibility to parasites and the effect of testosterone (T) on immunosuppression make women more susceptible to parasite infections.⁵³ This paradigm indicates that, in reaction to parasites, sexual dimorphism is largely controlled by the host's immune system, which fails to recognise that such parasites may clearly respond to their female and male hosts' distinct sex steroidal hormone profiles.⁵⁴ Hypothesizing that women are more immune to parasites than men, causing prudent simplification precautions, has been considered the 'feminine dominant theory' in practice for over half a century. This hypothesis confirms that the increased mortality rate in human males relative to females is due to their susceptibility to infectious agents.⁵⁵ Women's relative resistance to infection was correlated with discrepancies between sex life history, including mates, social hierarchy,⁵³ sexual activity and resource spending to establish a reproductive parasite immune response.⁵⁶ Immune responses in males and females are triggered by microbes and are mostly attributable to ligand-specific receptors in or within the immune cell bioplasm.⁵⁷

While sexual steroids hormones have a consistent effect on immune cell functioning, these gender differences are highly prevalent and they depend on the parasite-host framework. Although gamma interferon (IFN- γ) concentrations are higher in female mice than male mice in malaria infection,⁵⁸ female mice produce less IFN- γ and tumor necrosis factor alpha (TNF- α) than male mice in reaction to *Toxoplasma gondii*.⁵³ In *Taenia crassiceps*, a parasite with a higher IFN- γ response in females than males, females have a higher interleukin 10 (IL-10) response than females with IL-6 and IL-12.⁵³

In this case, females have a lower IFN- γ response than males. In hamsters, males develop deeper lesions after infection with *Leishmania panamensis*.⁵⁹ Male hamsters also have higher IL-4, IL-10 and transforming growth factor beta (TGF- β) concentrations than female hamsters, but levels of IL-12 and IFN- γ are not different based on gender.⁵³

In a study on the incidence of IPI among classes of adolescents, including pre-school boys and girls (below 6 years), the prevalence was found to be approximately 20.4% in boys and approximately 15.9% in girls, suggesting no statistically relevant difference between the genders ($p > 0.05$).¹⁹ This finding is consistent with the results reported in a study from Thailand,⁵² which showed a prevalence of 18.5% for boys and 16.1% for girls, a study in Italy, where 17.1% of the boys and 12.1% of the girls were infected⁶⁰ and in a study in Morocco where 63.5% of the boys and 60.4% of the girls were infected.⁶¹ These findings disagreed with the results reported in previous research indicating reversed incidence rates from Nepal, where the percentages were approximately 16.9% for boys and 22% for girls,⁶² and Ethiopia, where 32.1% of the boys and 35.9% of the girls displayed IPI features attributable to protozoal infection.⁴⁴

g. Immune status. In 2010, the incidence of IPIs among immune-compromised children in Riyadh, KSA, was nearly double that of previous studies conducted in Riyadh City during the same decade.⁶³ Immune status is widely thought to play a significant role in determining if an individual may contract a parasitic infection. Moreover, Frank's key publication on immunity and parasite infestation claimed that IL play a significant role as a parasite infection prognostic factor.⁶⁴ They especially found that IL-4 improved the prognosis and probability of complete recovery of cutaneous leishmaniasis, and higher levels of IL-10 and interferon gamma improved the prognosis and probability of recovery in visceral leishmaniasis. They linked immunoglobulin E and eosinophilic behaviors with schistosomiasis infection defence. That also

includes basophils and IL-4.⁶⁴ Furthermore, parasitic infections were associated with intestinal immunological conditions, such as irritable bowel disorder and irritable bowel syndrome;⁶⁵ the incidence of blastocystis is 67% in individuals with irritable bowel syndrome. They also observed a higher incidence of increased intestinal mucosa thickness after infection with *Giardia* species.⁶⁵ The precise mechanism behind these changes and the various associated implications is not yet understood.

However, according to Mohammadi et al,⁶⁵ several parasite infections interfere with the production of differentiation clusters, which play a major role in modulating and mediating a positive, balanced immune response.

h. Socio-economic status. According to WHO, socio-economic status has been recognized as one of the determinants of health that has an impact not only on the state of an individual's health, but also the type of disease that he/she is likely to develop;⁶⁶ thus, better control over parasitic infections is an essential determinant of health. Furthermore, some socio-economic factors subject people to diverse health inequalities.⁶⁷ There are various ways in which socio-economic levels in KSA could influence IPIs. For example, the educational background of parents has been reported to impact the prevalence of parasitic infections. In Riyadh, KSA, it was observed that cases of children with a higher prevalence of IPIs were correlated with families with lower education levels, suggesting a higher probability of infection in these children in comparison to those whose parents had higher education levels.⁶⁸ Furthermore, mothers' working status in Riyadh, KSA has also been recognized as a risk factor.

It is worth noting that, during this period, with the steady increase in the number of women employed at home with subsequent economic development, more housekeepers are being imported primarily from Asian countries, such as Indonesia, Bangladesh, India and Sri Lanka, and these workers are becoming increasingly important, offering valuable insight into the source and handling of household infections.⁶⁹ This process also triggers the importation of endogenous pathogens from their home country to KSA to reshape the public health of the country.⁷⁰ In Abha, KSA it was reported that 46.5% of the homes with Asian female housekeepers had at least one parasitic infection.⁶⁹ In comparison, low-income households and families listed as being poor were more likely to have children with IPIs (42.1%).⁷¹ Moreover, an increase in the prevalence of IPIs was found in places where humans reside near animals. It was apparent when 2 groups of households living in 2 different areas of southern Riyadh, KSA

screened positive for intestinal parasitosis (19.1% prevalence).¹⁹ However, in households in northern Riyadh, KSA, the prevalence was approximately 14.9%. Although the difference was not substantial, it confirms what Masoumeh et al³³ indicated in their 2012 study from Iran, which is that economic status and living area affect the occurrence of parasite infections. However, according to Hawash et al,⁷² infections could be more frequent in urban populations (76.2%) in comparison to rural communities (23.8%).

In conclusion, intestinal parasitic infection is a main type of chronic disease in KSA with several acute presentations. The risk factors associated with IPI have differing incidence rates in various areas of KSA. One of the risk factors, age, has a higher prevalence in younger people with a lower immune response, particularly children under the age of 5. Some organisms are more abundant in KSA than others; for example, *B homini*, *E. histolytica/dispar*, and *G. lamblia* are the most common parasites in KSA, representing the most parasitic infections from protozoa and non-worm infections. Boys are believed to be at higher risk than girls; however, more recent publications indicate a lower gender gap, thus, not reflecting a major differential. Moreover, while numerous reports have found that girls are at higher risk than boys for contracting parasitic infections, the differences between the genders are not statistically significant. Another aspect is having access to advertisements and health education/awareness programs. These programs are not yet sufficient to create a tangible degree of knowledge in the community. Additionally, health behavior remains a powerful risk factor, and it is not denied that people in KSA still engage in extensive unsafe behaviors that require urgent public health action. Among the people recently infected with parasites, the incidence of new infections has decreased. In contrast, communities in which the water is supplied from a lake and communities without direct access to clean water have much higher parasitic infection rates.

Socio-economic status is a major risk load. Low-income residents per capita had poorer access to health promotion services, leaving them more susceptible to infection. Higher-economic communities tend to employ migrant housekeepers from other countries that have different protozoa and parasites, which, in many cases, increase the incidence of infection. Moreover, food prepared in restaurants is often more vulnerable to these pathogens than food that is made at home.

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