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Predominance of gastrointestinal protozoan parasites in children: A brief review

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Abstract
Intestinal parasitic infections are among the major diseases of concern to public health throughout the world (WHO, 1987). About 25% of world's population suffers from one or more kinds of intestinal parasitic infections (helminthes/protozoa). Children because of their complex nutritional requirements and less developed immune systems are observed to be the principal sufferers of these parasitic infections (Scrimshaw, 1994). Moreover they have an extremely delicate physiology which can result in severe upsetting of their biochemical and physiological processes associated with these infections. Intestinal protozoan parasites can affect children in a variety of ways; they cause mal-absorption, reduced growth, increased risk for protein energy malnutrition, reduced psychomotor development and anaemia. This report addresses *Cryptosporidium, Giardia,* and *Entamoeba* as the main parasitic protozoa of concern among children worldwide.

Keywords: Immune systems, protozoan parasites, *Cryptosporidium, Giardia,* and *Entamoeba*

Introduction
Intestinal parasitic infections caused by intestinal helminths and protozoa are among the most common human infections endemic throughout the world especially in tropical and subtropical countries including India. About 3.5 billion persons are infected with intestinal parasites and nearly 450 million suffer from clinical morbidity (WHO, 2000) [75]. The protozoan parasites are the more common cause of gastrointestinal disorders compared to helminthes especially in developing countries. A number of intestinal protozoan parasites are reported in different parts of the world like *Giardia lamblia, Dientamoeba fragilis, Entamoeba histolytica, Blastocystis homini, Isospora belli, Cyclospora cayetanensis* and Microsporidia. Among them *Entamoeba, Giardia* and *Cryptosporidium* are the major protozoan parasites of global public health concern. Protozoan parasites being single celled can rapidly multiply inside the body leading to the development of the serious infection. Most of the protozoan infections tend to be asymptomatic. However the common symptoms associated with it include abdominal discomfort, vomiting and dysentery (Schunk *et al*., 2001) [62]. When burden of infection is pronounced, it may cause several complications like diarrhea, malaise, bloating, fatigue, epigastric discomfort, malnutrition, mal-absorption, intestinal ulceration, gastroenteritis, weight loss, abscesses, mental retardation and even death. Protozoan infections can also lead to structural and functional abnormalities of small intestines in humans and can be misdiagnosed as appendicitis or other inflammatory diseases of gastrointestinal tract. Children are the primary victims of gastrointestinal protozoan parasites. So the disease control interventions need to be focused towards the pediatric group.

Giardia lamblia
It is a flagellated protozoan parasite of phylum Sarcomastigophora that colonise and reproduce in small intestines of humans, causing disease Giardiasis. *Giardia* is most frequently reported as a cause of diarrhea worldwide. Giardiasis can be responsible for severe malabsorption syndrome causing malabsorption of fat, proteins, folic acid, Vitamin A and vitamin B12 and these nutritional deficiencies in turn may lead to serious organ damage (Ali *et al*., 2003) [2]. *Giardia intestinalis* results in stunted growth and poor psychomotor development of children

(Simsek *et al*., 2004). *Giardia* infection also results in reduced Hb level (Monajemzadh *et al*., 2008) [50] and hypoalbuminemia (Neva and Brown, 1994; Solomons, 1982). It sometimes infects gall bladder leading to jaundice and colic.

Global Burden

Giardia lamblia is the most prevalent protozoan parasite worldwide currently infecting about 200 million people (Ignatius *et al*., 2012). *G. lamblia* is known to infect 2% to 5% of population in developed countries and 20-40% in developing countries, majority of which are children (Ortega *et al*., 1997; Ali *et al*., 2003; Meyer, 1985) [56, 2, 44].

Prevalence of *Giardia* worldwide

Country	Area of study	Prevalence (%) reported	Reference
Bangladesh	ICDDRB Hospital, Dhaka	0.37	Alam *et al*. (2013) [6]
Egypt	Damanhur city,	14.8	Hegazy *et al*. (2014) [26]
Ethiopia	NorthGondar,	41.9	Ayalew *et al*. (2011) [9]
Ghana	Kumasi,	0.2	Walana *et al*. (2014) [72]
Iraq	Abu-Malah & Harer, Basrah	45.16 & 18.7	Jarallah *et al*. (2012) [32]
Iraq	Kadhmiyah hospital, Baghdad	1.77	Ibrahim and Qays *et al*. (2012)
Iraq	Erbil/Kurdistan	13.13	Hama & Rahemo *et al*. (2014) [27]
Iran	Abyek, Qazvin	3.0	Akhlaghi *et al*. (2013) [8]
India	Aurangabad	55	Jain *et al*. (2015) [33]
India	Barabanki, UP	19.13	Chaudhary *et al*. (2012) [15]
	Buea, Cameroon	21.4	Mbuh *et al*. (2010) [48]
India	Chandigarh	7.96	Sehgal *et al*. (2010) [64]
India	Gujarat	5	Jethwa *et al*. (2015) [34]
Kenya	Thika District,	6.9	Ngonjo *et al*. (2012) [53]
Libya	Sebha Province	3.19	Bernawi *et al*. (2013) [13]
Malaysia	Inanam sabah	35.48	Mahsol *et al*. (2006) [46]
Mexico	Coacalco-de Berriozabal	18	Diaz *et al*. (2003) [17]
Nepal	Dadeldhura	7.47	Tiwari *et al*. (2013) [67]
Nepal	Dharan	6.8	Sah *et al*. (2013) [59]
Nigeria	Delta and Edo States	0.51 & 3.1	Omorodion *et al*. (2012) [55]
Oman	Dhahira	10.5	Patel *et al*. (2006) [57]
	Gaza, Palestine	10.3	Alhindi *et al*. (2008) [3]
Philippines	Metro Manila	11.6	Baldo *et al*. (2004) [11]
Pakistan	Muzaffarabad	11.8	Chaudhary *et al*. (2012) [15]
Pakistan	Quetta	32	Wadood *et al*. (2005) [71]
Rwanda	Kigali,	3.6	Emile *et al*. (2013) [20]
Thailand	Thai	1.56	Songserm *et al*. (2012) [66]
Tajikistan	Western	26.4	Matthys *et al*. (2011) [45]

Entamoeba histolytica

It is a protozoan parasite of phylum Sarcomastigophora that colonises and reproduces in large intestines of humans, causing disease Amoebiasis. The disease may remain restricted to intestinal lumen or invade intestinal lining causing Amoebic dysentery. It not only causes severe diarrhea but can also result in extra intestinal manifestations including rectal bleeding, ameboma, toxic megacolon, pneumatosis coli, peritonitis and abscesses in the intestine, liver, lung and other organs. *Entamoeba histolytica* is reported to be responsible for deaths of approximately 1, 00,000 persons per year, second only to another protozoan infection, malaria (WHO, 1997) [74].

Global Burden

Nearly 10% of the world's population is infected with *E. histolytica*, the majority being in developing countries (Vandenberg *et al*., 2006). Most of the infected individuals tend to be asymptomatic while the minority of cases develops clinically apparent disease. *E. histolytica* is known to result in 50-100 million cases of colitis or liver abscesses per year and up to 100,000 deaths annually (Ayeh-Kumi *et al*., 2001) [10]. Amoebiasis is the third leading cause of death from parasitic diseases world-wide with its greatest impact on people of developing countries.

Prevalence of *Entamoeba* worldwide

Country	Area of study	Prevalence(%) reported	Reference
Bangladesh	ICDDRB Hospital Dhaka	1.11	Alam *et al*. (2013) [6]
Cameroon	Buea	24.4	Mbuh *et al*. (2010) [48]
Egypt	Damanhur city	16.8	Hegazy *et al*. (2014) [26]
Ethiopia	NorthGondar	27.3	Ayalew *et al*. (2011) [9]
Ghana	Kumasi	8.5	Walana *et al*. (2014) [72]
Iraq	Sulaimani district	4.05	Raza *et al*. (2008) [58]
Iraq	Abu-Malah, & Harer, Basrah	23.87 & 30.93	Jarallah *et al*. (2012) [32]
Iraq	Kadhmiyah hospital, Baghdad	9.80	Ibrahim and Qays (2012)
Iraq	Erbil/Kurdistan	30	Hamad &Ramzy(2012) [25]
India	Barabanki, UP	28	Chaudhary *et al*. (2012) [15]
India	Bhopal	25.4	Kiran *et al*. (2014) [37]
Japan	Hanoi, Vietnam	2	Uga *et al*. (2005) [69]
Kenya.	Thika	14.6	Ngonjo *et al*. (2012) [53]

Lesotho	Qacha's Nek	24	Oguntibeju *et al*. (2003) [54]
Mexico	Coacalco-de Berriozabal	10	Diaz *et al.* (2003) [17]
Malaysia	Inanam sabah,	83.87	Mahsol *et al.* (2006) [46]
Nigeria	Nigeria	8	Ganiyu *et al*. (2012) [21]
Nepal	Dehran,	6.1	Sah *et al*. (2013) [59]
Philippines	MetroManila,	2.9	Baldo *et al.* (2004) [11]
Pakistan	Quetta	29	Wadood *et al.* (2005) [71]
Pakistan	Muzaffarabad,	5.9	Chaudhary *et al.* (2012) [15]
Rwanda	Kigali,	54.5	Emile *et al.* (2013) [20]
Tajkistan	Western Tajkistan	25.9	Matthys *et al.* (2011) [45]
Thailand	Thai	0.03	Songserm *et al.* (2012) [66]
Uganda	Kampala	2.5	Buzigi, E. (2015) [14]

Cryptosporidium parvum

It is a small coccidian protozoan parasite belonging to Phylum Apicomplexa that infects the microvillus region of epithelial cells of the digestive tract in humans. *Cryptosporidium* causes moderate to severe diarrhea in the immunocompetent individuals due to malabsorption and increased secretion. In the immunocompromised individuals, the condition can be prolonged and dangerous. *Cryptosporidium* infection of the intestinal epithelium is associated with villous atrophy, hyperplasia of intestinal crypt cells, and inflammation of the lamina propia. Cryptosporidiosis can sometimes lead to extra-intestinal complications like respiratory cryptosporidiosis, cholecystitis, hepatitis and pancreatitis (Arora *et al*.; 2005) [7].

Global Burden

Global statistics on prevalence of *Cryptosporidium parvum* shows that it infects 2-50% of population worldwide. (WHO, 2006; Percival *et al*., 2004). In Asia and Africa the infection rate ranges from 5-10% (Vandenberg *et al*., 2000)

Prevalence of Cryptosporidium worldwide			
Country	**Area of study**	**Prevalence(%) reported**	**Reference**
Bangladesh	ICDDRB Hospital, Dhaka	4.44	Alam *et al.* (2013) [6]
Ethiopia	Girar Jarso & Dera,	7.3	Wegayehu *et al*. (2013) [73]
Ethiopia	Pawi, northwestern Ethiopia	8.1	Tigabu *et al.* (2010) [68]
Egypt	Cairo	15.3	El-Helaly *et al.* (2012) [19]
Ghana	Kumasi	8.5	Walana *et al.* (2014) [72]
Ivory coast	Yamoussoukro	36.93	Koffi *et al.* (2014) [40]
Iran	Isfahan	4.6	Saneian *et al.* (2010) [60]
Iraq	Baghdad	2.3	Mahmud *et al*.(2006) [47]
India	Dehli	27.4	Bera *et al*. (2014) [12]
India	Uttar Pradesh	33.33	Kashyap *et al*. (2013) [36]
Jamaica	Kingston	4.3	Lindo *et al.* (1998) [41]
Kenya	Kenya	4	Gatei *et al.* 2006) [23]
Mexico	Coacalco-de Berriozabal	4	Diaz *et al*. (2003) [17]
Netherlands	Netherlands	21.8	Hove *et al.* (2007) [28]
Nigeria	Zaria	4.5	Gambo *et al.* (2006) [24]
Palestine	Gaza	16.3	Al-Hindi *et al.* (2007) [4]
Philippines.	Philippines.	1.9	Natividad *et al*. (2008) [51]
Saudi Arabia	Makkah	4.07	Al-Harthi (2004) [1]
Uganda	Kampala	1.5	Buzigi, E. (2015) [14]

Intestinal Protozoan Infections in Kashmir Valley

In Kashmir valley the studies conducted so far demonstrate the presence of protozoan parasites *Giardia intestinalis,* and *Cryptosporidium parvum* among children. Besides this a number of helminth parasites have also been reported especially *Ascaris lumbricoides, Trichuris trichiura, Enterobius vermicularis Taenia saginata Hymenolepis* and *Ancylostoma.* (Wani *et al.,* 2008*;* Lone *et al*., 2009; Jad *et al*., 2015) [31]

Prevalence of Gastrointestinal Protozoan Parasites in Kashmir				
Prevalence reported (%)			**Area of study**	**Reference**
Giardia	***Entamoeba***	***Cryptosporidium***		
9.20			Srinagar	Mir *et al.* (1979) [49]
12.28			Srinagar	Khan *et al.*(1994) [38]
7			Srinagar	Singh *et al*. (2012) [63]
		36	Srinagar	Masrat *et al.* (2012) [43]
73.5	17.35		Jammu	Jad *et al.* (2015) [31]

New approach for parasite Detection

Diagnosis of intestinal protozoa is made usually by microscopy after staining feacal smears with iodine or any other stain. This technique is being widely used for diagnosis of intestinal protozoa (Chaudary, *et al*., 2004; Wadood *et al*., 2005; Alzain *et al*.,2006; Raza, *et al*., 2008; Hamad *et al*., 2012; Sah *et al*., 2013) [16, 71 5, 58, 25, 59]. However nowadays molecular diagnostic tests are increasingly being used for both clinical as well as research purposes. They involve identification of specific antigen or DNA of parasite in stool or serum samples through Enzyme linked immunoassay (ELISA) (Kramar *et al*., 2003; Davies *et al*., 2009; Julio *et al.,*

2012) [39, 18, 35] or direct fluorescent antibody assay (Huma *et al*., 2013; Gracia *et al*., 1997; Mank *et al*., 1997) [29, 22, 42]. These molecular methods besides having high sensitivity for parasite detection help in differentiation of various species of parasite with the help of PCR.

Control and Prevention

In view of high prevalence of protozoan infection and the morbidity they cause, the measures aimed at their control and prevention need to be strengthened. Steps should be taken to reduce the infection rate to the levels at which they cease to be of public health significance. The prevention and control of protozoan diseases can be primarily achieved through improvement in personal as well as environmental hygiene. The most effective control can be achieved by involving the community to participate in its own disease control. For this purpose mass awareness programmes should be conducted to make the people aware about the various infectious agents and their modes of transmission, encourage hygienic practices, recommend use of safe drinking water, avoid defecation in open areas, and prioritize primary health care. Moreover, standard techniques should be used by clinical microbiologists for screening the stool samples to increase the chances of detection of parasites and chemotherapy option should be used for treatment of individuals diagnosed with protozoan infections.

Conclusion

Gastrointestinal disorders caused by various protozoan parasites impose a great burden on human populations in the developing world, particularly among children. The need of the hour is that we should have enough epidemiological information on the prevalence of gastrointestinal protozoan infections and their associated risk factors in different localities which are a prerequisite to develop quality control measures.

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