

# A Systematic Review of Waterborne Protozoan Pathogens in South Asia: Cases of Human Infections

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## ABSTRACT

**Aim/Background:** Waterborne protozoan parasites, which include *Giardia*, *Cryptosporidium*, and *Entamoeba*, are considered important intestinal parasites around the world due to their high rates of morbidity and mortality. It aims to provide a clinical picture of the current status of infection of WBPP in humans in South Asian countries through documented cases. **Materials and Methods:** Epidemiological studies that focus on the isolation and identification of cases caused by waterborne protozoans between 2010 to 2020 in South Asia were searched systematically in PubMed and Google Scholar databases to provide an updated prevalence on the current status of the prevalence of waterborne protozoan infections in humans in South Asia. **Results:** A total of 19, 718 articles in PubMed and Google Scholar databases provide an updated prevalence on the current status of the prevalence of waterborne protozoan infections in humans in South Asia. 92 articles are considered in this study coming from 6 South Asian countries. **Conclusion:** Establishing the prevalence of waterborne protozoan pathogen infection is considered an important tool in public health mitigation programs and setting up health intervention protocols to prevent future infections. Also, the existence of surveillance studies for these waterborne protozoan pathogens is an important step in assessing the health of the population as a whole.

**Keywords:** *Cryptosporidium* spp., *Entamoeba histolytica*, *Giardia* spp., South Asia, WBPP.

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## INTRODUCTION

Waterborne protozoan pathogens (WBPP) are considered an emerging global health concern.<sup>[1]</sup> The World Health Organization has stated that diarrheal outbreaks around the globe are due to infections caused by WBPPs. Among the WBPPs that pose severe to fatal health conditions to humans include: *Giardia* sp., *Cryptosporidium* sp., organisms belonging to the Free-Living Amoeba (FLA) group, *Cyclospora*, *Toxoplasma* spp.,

*Isoospora*, and *Entamoeba histolytica*. *Giardia lamblia* causes chronic diarrhoea described by loose watery stool that is normally transmitted to humans via ingestion of contaminated municipal drinking water, unfiltered water from recreational pools and contact with recreational water used by wildlife.<sup>[2]</sup> In addition, giardiasis is considered one of the most common enteric protozoan pathogen infections on a global scale with approximately of 33% of the population of developing countries infected, from this number, the younger age group (0-4) has the largest population.<sup>[3]</sup> In the case of *Cryptosporidium* spp., this coccidian causes cryptosporidiosis, like giardiasis, the condition is described as a mild form of diarrhoea but may appear to be life-threatening to lower age group populations (0-5 age group) and to those considered immunocompromised.<sup>[4]</sup> Unlike *Giardia* spp., *Cryptosporidium* spp. is linked to several water<sup>[5-8]</sup> and food<sup>[9]</sup> outbreaks in history.

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The risk of infection from WBPPs and cases of disease manifestation brought about by consequential health risks are seen among poor populations in developing countries.<sup>[10]</sup> Unfortunately, while outbreaks surveillance from developed countries exists for WBPPs such as *Giardia*,<sup>[11,12]</sup> *Cryptosporidium*,<sup>[13,14]</sup> *Cyclospora*,<sup>[15]</sup> *Toxoplasma gondii*,<sup>[16]</sup> *Isospora*,<sup>[17]</sup> and *Entamoeba histolytica*,<sup>[18,19]</sup> These surveillance studies may not be true in developing countries, where these pathogenic organisms are abundant due to industrial and biological pollution.

South Asian countries such as Afghanistan, Pakistan, India, Nepal, Bhutan, Bangladesh, Maldives, and Sri Lanka are considered havens for foreigners due to the attractions that these countries offer to travellers around the world.<sup>[20]</sup> Further, a number of South Asian countries have experienced economic growth in the last decade due to the rapid industrialization of their cities.<sup>[21]</sup> This growing economy, coupled with the problem of overpopulation, has resulted in a severe problem in the pollution of its natural freshwater sources due to biological and industrial waste. For this reason, South Asian countries are considered tinder boxes for a potential WBPP outbreak considering these factors: overpopulation, contamination of natural water sources from WBPPs, and the increasing number of travellers in this part of the world. This reasons, warrant surveillance studies in the region to understand the prevalence and extent of impact of WBPP contamination and infection in this part of the world. This review aims to provide a clinical picture of the current status of infection of WBPP in humans in South Asian countries through documented cases.

## MATERIALS AND METHODS

### Literature Search Strategy

Epidemiological studies that focus on the isolation and identification of cases caused by waterborne protozoans between 2010 to 2020 in South Asia were searched systematically in PubMed and Google Scholar databases to provide an updated prevalence on the current status of the prevalence of waterborne protozoan infections in humans in South Asia. The search term used to obtain the relevant studies were: “*Blastocystis*”, “*Cryptosporidium*”, “*Entamoeba*”, “*Giardia*”, “diarrhoea”, and “water”. To maximize the number of included studies and to prevent any missing studies during the searches of the main database, country-specific searches to countries within the region of South Asia were made and the reference list of accepted articles was searched for any additional articles to be included.

### Eligibility criteria

The inclusion criterion for this study involves reported cases and isolation of waterborne protozoans in humans in South Asia. The exclusion criteria however were: (1) Reviews and mini-reviews, (2) studies of isolation of intestinal helminths in humans and other protozoan of non-waterborne transmission, (3) studies that focus on method evaluation, (4) Intervention studies, and (5) articles not written in English. Screening of articles was done in two rounds; the first round of screening was done by MP while the final screening of accepted article was performed by GM.

### Data Extraction

Data such as country location, year of study, isolated organism, type of sample used, percent of isolated organisms, methods used for identification, title and authors were extracted from the included articles for the purpose of standardization. Data extraction was done by both authors (MP and GM) and was checked by one author for accuracy (GM).

## RESULTS

A total of 19, 718 articles were screened using the keywords used in this study. Fourteen thousand eight hundred ninety-seven (14, 897) articles were removed and are considered duplicate titles. A further 4,696 articles were removed due to the following reasons: 302 are articles not written in English, 72 articles are studies done outside South Asia, 25 are review articles, 90 involve non-human cases articles, 22 do not have available full text, and 4218 studies involve organisms considered not waterborne in transmission (Figure 1). After the exclusion of non-qualified articles, 92 articles are considered in this study coming from 6 South Asian countries (Table 1).

Among the waterborne protozoan organisms causing infection in South Asia, *G. lamblia* is considered a common protozoan causing intestinal diseases with a total prevalence of 11, 573 (65.7%) from documented clinical cases in the region. This was followed by *E. histolytica* with 2,993 (17.0%) isolation cases, and *Cryptosporidium* spp. with 1, 896 (10.8%) cases. The less common waterborne protozoan organisms in the region include *Blastocystis* spp (679; 3.8%), *E. dispar* (222; 1.3%), *E. coli* (122; 0.7%), *Cyclospora* spp. (85; 0.5%), and *Cytoispora* spp. (46; 0.3%)(Figure 2).

Geographical distribution of waterborne protozoan isolated in South Asia showed that Pakistan had the

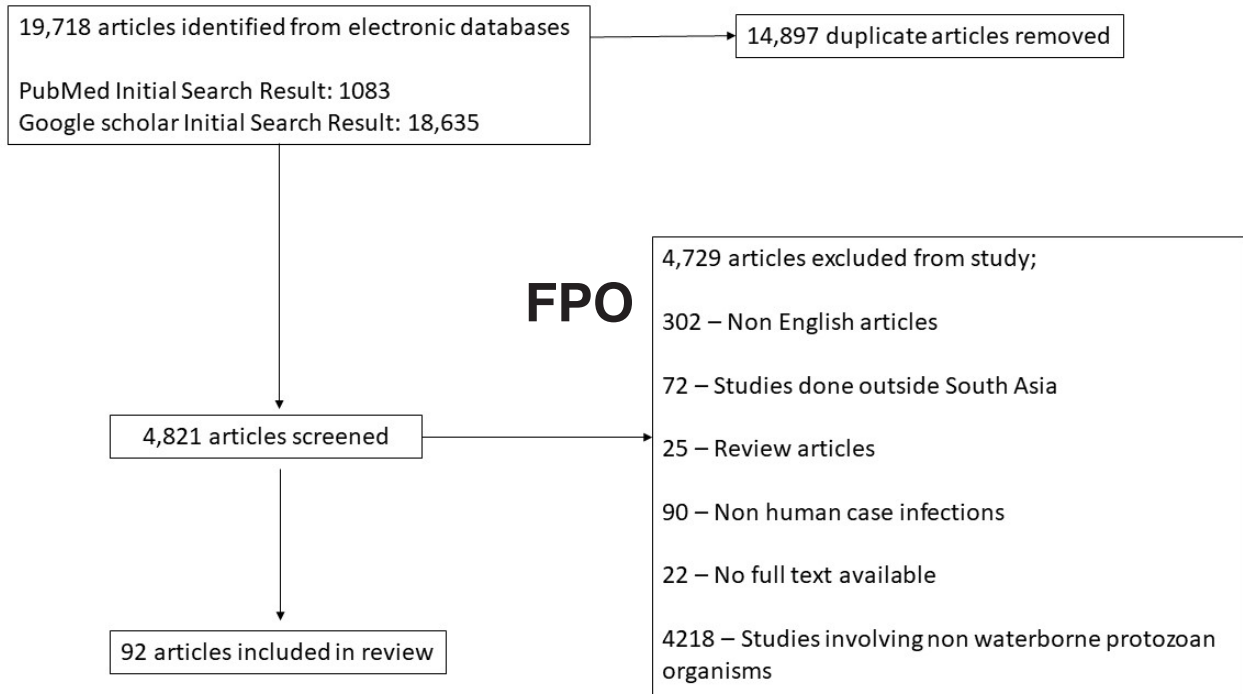


Figure 1: Flow diagram of study selection process for including articles in the study.

Table 1: List of qualified articles from 6 South Asian countries was included in the study.

Country	Count	References
Afghanistan	6	[22-27]
Bangladesh	13	[28-40]
India	44	[41-84]
Nepal	14	[85-98]
Pakistan	12	[99-110]
Sri Lanka	3	[111-113]

most number of reported and documented cases of infections. This was followed by India and Afghanistan, while Sri Lanka had the least number of documented reports of waterborne protozoan pathogens in the region (Figure 3).

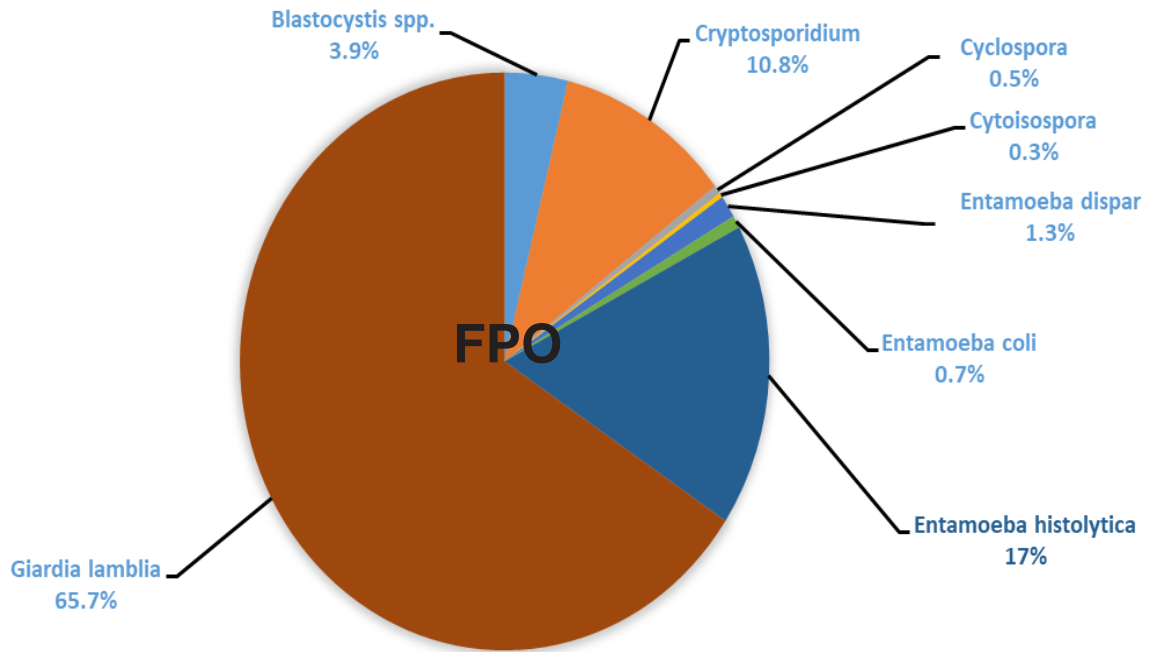
## DISCUSSION

Waterborne protozoan parasites which include *Giardia*, *Cryptosporidium*, and *Entamoeba* are considered important intestinal parasites around the world due to their high rates of morbidity and mortality.<sup>[114]</sup> For this reason, surveillance studies involving the prevalence of these pathogenic protozoans in several drinking sources is a major public health priority, especially in to developing countries. South Asia is identified as a region where

access to safe and potable water is a challenge. Here, we have identified cases caused by waterborne protozoan pathogens.

### Giardiasis in South Asia

Considered by the CDC as one of the most common water-transmitted pathogens causing high morbidity in populated cities. In the United States alone, 181 out of 242 outbreaks by *Giardia* spp. from waterborne sources have been documented from 1971-2011.<sup>[23]</sup> The vast cases of waterborne transmission of *Giardia* in South Asia may be explained by considering the phenotypic characteristics of the organism. Being moderately chlorine resistant, *Giardia* spp. may be able to withstand a number of water pretreatment processes, reason for the organism to escape into water being delivered to households for drinking.<sup>[115]</sup> Although this may be true for developing countries, it may be otherwise for developed ones. Another reason for the high transmission rate of protozoans in water is that, most often, water in different parts of the world is heavily polluted with human faecal organisms.<sup>[116]</sup> This argument is validated by several studies conducted in the South Asia region providing evidence of high human fecal contamination in water sources.<sup>[117,118]</sup> Our results showed the same epidemiologic picture which may ascertain the cause of the high morbidity cases

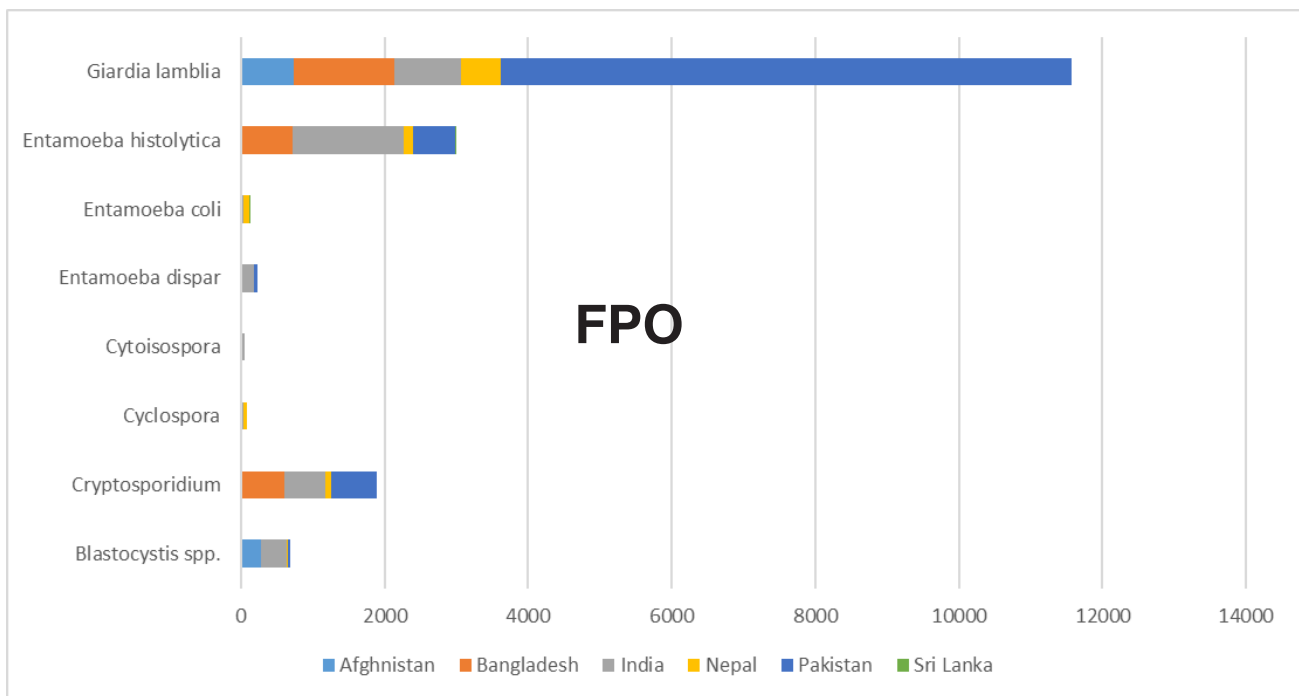


**Figure 2: Percent isolation of different waterborne protozoan in South Asia from included studies. Pie graph showing *G. lamblia* as the most common waterborne protozoan isolated in the region.**

of Giardiasis in the region. Considering the facts as presented by the studies mentioned.

Although waterborne giardiasis from water reservoirs is the most common source of infection, there are cases when contamination of groundwater occurs, such as the case in outbreak of giardiasis from 4 villages in Korea

which involved 25 people to which the source of infection came from groundwater.<sup>[119]</sup> This may have been caused by further contamination of groundwater due to sewage overflows, sewage systems that are not working properly, polluted stormwater runoff, agricultural runoff, and most importantly, flooding.<sup>[120]</sup> According to a study



**Figure 3: Distribution of different waterborne protozoan in South Asia per country showing Pakistan with the most reported cases of waterborne protozoan infection.**

that discusses flood data in the region between 1976-2005, there is an increase in the frequency of severe flooding in the South Asia region where it accounts for 33% of the recorded floods in Asia.<sup>[30]</sup> With this in mind, it can be argued that the current trend of the high morbidity of giardia infection can be associated with the current problem of the region in terms of flood control. This problem consequently contributes to the eventual contamination of both ground and surface water sources in the region that explains the high rates of documented cases of giardiasis.

Having been said, it is now important to note that more than the available treatment regimens and access to medical care, effective environmental control programs on flooding and waste management are important key points to mitigate flood problems in the region if not to totally prevent it. This may eventually ripple to a positive outcome by lowering the cases of giardiasis in the region.

### Amoebiasis in South Asia

Like *Giardia* spp., *Entamoeba histolytica* is an enteric protozoan frequently transmitted via freshwater contaminated with human faeces.<sup>[31]</sup> Although the mode of transmission is the same, the mechanism and pathophysiology of *E. histolytica* infection are different and more severe compared with giardiasis. Other than intestinal pathology, amoebiasis is documented to cause extra-intestinal pathology such as cutaneous,<sup>[121]</sup> liver abscess<sup>[122]</sup> and brain abscess.<sup>[123]</sup> For this reason, amoebiasis has been tagged by some researchers to be an emerging parasitic disease of our time due to its ability to cause extra-intestinal pathology. The challenge is to assess the real burden of *E. histolytica* infection in the region has been a challenge for two reasons: the use of conventional diagnostic tools other than molecular methods as well as the existence of morphologically similar species such as *E. dispar* and *E. moshkovski* as reported by studies in the region.<sup>[34]</sup> These reasons alone may have been the challenge to establish the true number of cases of amoebiasis in the region, considering the possibility of underreported cases.

### CONCLUSION

Establishing the prevalence of waterborne protozoan pathogen infection is considered an important tool in public health mitigation programs and setting up of health intervention protocols to prevent future infections. Also, the existence of surveillance studies for these waterborne protozoan pathogens is an important step to assess the health of the population as a whole.

Although data acquired in this study is limited in terms of the surveyed scholarly databases, the authors have provided a baseline picture on the current problem and status of waterborne protozoan pathogen infection in South Asia.

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### PATIENT CONSENT

Not Applicable.

### CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

### ABBREVIATIONS

**WBPP:** Waterborne protozoan pathogens; **EPA:** Environmental Protection Agency.

### SUMMARY

WHO has stated that diarrheal outbreaks around the globe are due to infections caused by WBPPs. This research article is an epidemiological study that focuses on the isolation and identification of cases caused by waterborne protozoans between 2010 to 2020 in South Asia. A total of 19, 718 articles provide an updated prevalence on the current status of the prevalence of waterborne protozoan infections in humans in South Asia. 92 articles are considered in this study, coming from 6 South Asian countries. Establishing the prevalence of waterborne protozoan pathogen infection is considered an important tool in public health mitigation programs and the setting up of health intervention protocols to prevent future infections. Also, the existence of surveillance studies for these waterborne protozoan pathogens is an important step in assessing the health of the population as a whole.

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