

## Review

*Cryptosporidium* and cryptosporidiosis: The Asian perspectiveMohammad-Reza Mahmoudi<sup>a</sup>, Jerry E. Ongerth<sup>b,\*</sup>, Panagiotis Karanis<sup>c,\*</sup><sup>a</sup> Department of Parasitology and Mycology, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran<sup>b</sup> Civil, Mining, and Environmental Engineering, University of Wollongong, Wollongong, Australia<sup>c</sup> State Key Laboratory of Plateau Ecology and Agriculture, Qinghai University, Center of Biomedicine and Infectious Diseases (CBID), Academy of Animal Science and Veterinary Medicine, Qinghai University, Xining 810016, China

## ARTICLE INFO

## Article history:

Received 22 March 2017

Received in revised form 17 July 2017

Accepted 17 July 2017

## Keywords:

*Cryptosporidium*

Cryptosporidiosis

Epidemiology

Asia

## ABSTRACT

This review discusses findings of *Cryptosporidium* and cryptosporidiosis research in Asia and highlights the current situation of *Cryptosporidium* epidemiology, genetic diversity and distribution, and transmission throughout Asia taking into account all the available papers published for *Cryptosporidium* research in Asian countries since 2000. This effort will facilitate future research approaches and further developments in the understanding of *Cryptosporidium* epidemiology in Asia. The intent is to contribute to improvement in protection measures for mitigating the burden associated with this illness in the future.

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## 1. Introduction

The literature published in peer reviewed journals on the protozoan parasite *Cryptosporidium* and its host species is extensive providing details on the occurrence and distribution in most regions of the world. Asia has generally been neglected in previous literature summaries. Accordingly, this review has compiled the discoverable literature and summarized information on *Cryptosporidium* and cryptosporidiosis in 37 countries comprising the land areas of Asia. These countries include a total population of 4238 million nearly 60% of the world population.

Although cryptosporidiosis is a significant cause of diarrheal disease in both developing and industrialized countries, epidemiological studies have shown that *Cryptosporidium* is more common in developing countries (5% to >10%) than in developed countries (<1%–3%) (Areeshi et al., 2007). In developing countries, this protozoan is one of the agents causing diarrhea in children under 5 years of age that is thought to be responsible for 30–50% of childhood mortality (Checkley et al., 2015; Kotloff et al., 2013; Ochoa et al., 2004; Platts-Mills et al., 2015).

This protozoan has a complex life cycle concentrated principally in epithelial cells in the digestive tract of a wide variety of hosts which includes humans, livestock, companion animals, wildlife, birds, reptiles, and fishes (O'Donoghue, 1995).

*Cryptosporidium* is responsible for moderate to severe opportunistic infection in both immunocompetent and immunocompromised individuals, the latter group being more susceptible

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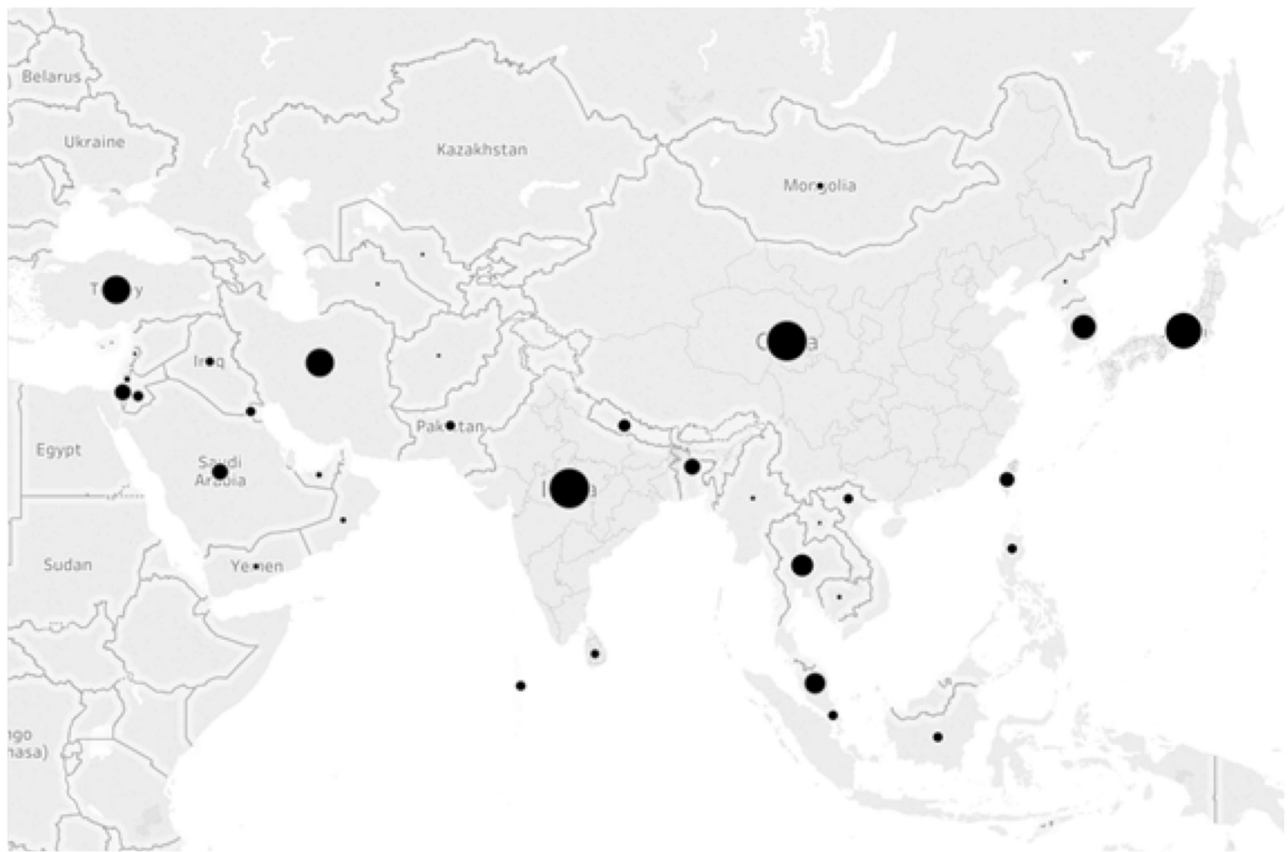


Fig. 1. Distribution of *Cryptosporidium* and cryptosporidiosis literature reports in Asian countries, dot sizes proportional to percent of reports.

with potentially fatal consequences. The immunocompetent individuals usually experience self-limiting disease often manifested by acute profuse watery diarrhea accompanied by abdominal pain and other enteric symptoms including vomiting, low grade fever, general malaise, weakness, fatigue, loss of appetite, nausea, chills and sweats (<https://www.cdc.gov/parasites/crypto/illness.html>). No chemotherapeutic agents have been found that are effective for treatment of cryptosporidiosis although a normally functioning immune system will clear the human infection in 1–2 weeks (<https://www.cdc.gov/parasites/crypto/treatment.html>). In contrast, the disease may be chronic and even life threatening for undernourished infants (MacFarlane and Horner-Bryce, 1987) and severely immune deficient, e.g., AIDS patients (Manabe et al., 1998). Other groups at risk include the aged and individuals with chronic disease, malnutrition, chemotherapy and organ transplant patients, or other debilitating conditions that contribute to a compromised immune system. The significance of *Cryptosporidium* infection is compounded by the lack of curative therapy. While principally an enteric disease, respiratory infection has been reported in immune compromised humans and is a major site of infection in fowl (Fayer, 2004).

Transmission occurs principally through the faecal-oral route, following direct or indirect contact with *Cryptosporidium* oocysts via person to person, zoonotic, waterborne, foodborne or airborne contact (Fayer, 2004). Analysis of cryptosporidiosis epidemiology provides the most common risk factors including: interpersonal contact with an infected individual, typically an infant, contact with a pet or other household animals, poor sanitation in low economic living circumstances, lack of safe water supply and faecal waste disposal, travel to endemic areas, and ingestion of contaminated food or water.

## 2. Methods

The keywords used for searching relevant articles included both terms related to parasite name (*Cryptosporidium*) and country name. These keywords were combined. The search strategy was run in the medical databases of the multidisciplinary SCOPUS and Pubmed. Any field of publication was searched for keywords. The search was limited to studies until 2015. In a second step; selected abstracts were screened using the inclusion and exclusion criteria specified. The following data were extracted from the articles and included in Tables: Host; Sample; Sample size (No. of cases); Prevalence of *Cryptosporidium* spp.; *C. parvum*; *C. hominis*; Other species; Country.

## 3. Results and discussion

At least 1600 published reports address *Cryptosporidium* infections in Asian countries, with apparent differences geographically (Fig. 1), in the host and medium of occurrence, in the species of *Cryptosporidium* identified, and in apparent prevalence among hosts (Tables 1 and 2).

### 3.1. Geographic distribution

Literature has been compiled describing relevant information associated with *Cryptosporidium* and cryptosporidiosis in 34 countries of Asia (Table 3). The number of papers reported from China (221, 16%) and India (255, 19%) accounted for 35% of all reports, while Iran, Japan, Turkey, and other countries accounted for 14.5%, 9.5% and 8.5%, respectively, of reports (Table 3, Fig. 1). These five countries accounted for approximately 2/3 of reports from Asia on *Cryptosporidium* and cryptosporidiosis. The reports were uniformly

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