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REVIEW

Prevalence of *Giardia lamblia* with or without diarrhea in South East, South East Asia and the Far East

Hassan H. Dib · Si Qi Lu · Shao Fang Wen

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Abstract This article is a review of the latest information on the prevalence of *G. lamblia* in South Asia, South East Asia and Far East, characterizing the current endemic situation within these regions. Around 33 published papers from 2002–2007 were collected on *G. lamblia*. The included countries were Nepal, Bangladesh, India, Cambodia, Vietnam, Malaysia, Philippines, Indonesia, Thailand, Republic of Korea, and China. Only five published papers were discarded because data was extracted before 2002–2007 or they are not included within our regions, emphasizing more on *G. lamblia* in animals, or performed at extensive molecular level. The prevalence of *G. lamblia* varied markedly between studies illustrating higher levels in the urban than in the rural areas, more among poor communities, slightly higher in males than in females with age range of 2–5-year-old children, and among university students, old-aged people, HIV-positive patients, and gastric carcinoma patients. Though *G. lamblia* is not a life-threatening parasite, nevertheless, it is still considered as the most common water-borne diarrhea-causing disease. It is important to understand the etiology, frequency, and consequences of acute diarrhea in children. Routine surveillance such as bi-annual follow-up treatments, treating *G. duodenalis* cysts and other protozoa oocysts detected in ground water sources, and continuous health education are the most preventive measures.

H. H. Dib
School of Public Health, Health Policy and Management,
Peking University Health Science Center,
Beijing 100083, China
e-mail: dibhassan@hotmail.com

S. Q. Lu (✉) · S. F. Wen
Department of Parasitology, School of Basic Sciences,
Capital Medical University,
10# Xi Tou Tiao, You An Men Wai,
Beijing 100069, China
e-mail: wdxlsq42@yahoo.com.cn

S. F. Wen
e-mail: wenshf1980@sohu.com

Introduction

The spread of various types of protozoal infections including *G. lamblia*, or what is known as *G. intestinalis*, is a worldwide phenomenon mostly common in developing than in developed countries. Infection from *G. lamblia* remains the leading water-borne diarrhea-causing disease (WHO 2007; Karanis et al. 2007; WHO Seminar Pack 1995) among child care workers, children attending day care centers and school aged children, international travelers, hikers, campers, swimmers (Bureau of Public Health Division of Public Health Government of Wisconsin 2001; Pond-WHO 2007), either when people drink accidentally or swallow water from contaminated or untreated sources (no heat inactivation, filtration, or chemical disinfection). This disease afflicts many homosexual men and immunocompromised patients such as HIV-positive and HIV-negative individuals or attracted by immunocompetent patients (variable immunodeficiency; Koru et al. 2006; Mak 2004) and subjected to children with x-linked agammaglobulinemia (Lane and Lloyd 2002; Alzueta and Matamoros 2001; van der Meer and Zegers 1994; Lavilla et al. 1993).

The purpose of this review article is to shed light on the prevalence of *G. lamblia* among populations within three regions in Asia characterizing their current endemic situation.

Materials and methods

We collected 33 research articles published from 2002 to 2007 on the prevalence of *G. lamblia* infections. Data search was performed through Databases of Pubmed, Unbound Medline, Info-trieve Medline, Galenicom, WHO web, as well as several Chinese-translated articles on the prevalence of *G. lamblia*. We divided the countries according to their geographical locations. South Asia: Nepal (three cross-sectional and one retrospective study), Bangladesh (one birth-control and one case-control study), India (four cohort and four cross-sectional studies); South East Asia: Cambodia (three cross-sectional studies), Vietnam (one cross-section study), Malaysia (two retrospective study), Philippines (two cross-sectional studies), Indonesia (one cross-sectional study), Thailand (five cross-sectional studies); and Far East: Republic of Korea (one cohort study), China (one cross-sectional studies). Only five published papers were discarded because their data was extracted before our set-up time frame, not included within our regions, or more emphasizing on *G. lamblia* in animals, or performed at the extensive molecular level.

Prevalence of *G. lamblia* in South Asia or Sub-Indian continent (Nepal, Bangladesh, India)

Nepal

Nepal is still considered as one of the world's poorest countries due to its geographical location in the subtropics and altitude level; thus, making this country prone to natural disasters and to the spread of many diseases including parasites (Cotruvo et al. 2004). The highest prevalence of *G. lamblia* reached to 73.4% (141/192) in Western Nepal (Easow et al. 2005) and 9.1% (31) in rural areas of Kathmandu Valley (Rai et al. 2005); while in North-eastern rural areas of Kathmandu (Sharma et al. 2004), *G. lamblia* consisted 23.1% of the total protozoal infection Table 1.

In Nepal, the prevalence of *G. lamblia* among the elderly people showed very low infection rates in concurrence with other researchers' findings (Shakya et al. 2006), i.e., with advancing age, there is a decrease of risk in attracting *G. lamblia* infection (Laupland and Church 2005) as a result of humoral and cellular immune responses, making elderly people have lower attack rates than other groups through the development of some protection from re-infection (Oda and Sherchand 2002). However, other researchers in other developing countries reported a greater prevalence of *G. lamblia* among people ≥40 years, but these countries are situated outside our chosen regions (Rahman 1993; Feng et al. 2001; Sayyari et al. 2005).

In Nepal, the most infected age group were from preschool age up to 19-year-old students, with similar prevalence in gender distribution; but the study on parasitism among the elderly (≥60 years of age) revealed slightly higher difference of infection in males than in females. The prevalence of *G. lamblia* among family and family sizes were nearly the same, and among races was marginally higher in positive rate among Dalits children compared to Tibeto-Burmans, and higher in Indo-Aryans living in rural areas of Kathmandu than in the North Eastern rural areas (Sharma et al. 2004). The utilization of various types of toilet facilities among children showed no significant increase in the difference of prevalence rate. Slightly higher positive rates existed when associated with drinking water from shallow wells compared to the natural spouts, piped water, and rivers. Children were infected despite of their awareness concerning safe water and geographic distribution (Rai et al. 2005).

Methods of diagnosis from Nepal studies

Diagnosis ranged from one study to another by filling out questionnaires regarding hygiene and sanitation, evaluating the predisposing factors to parasitic infections, and collecting fecal samples while attending hospitals (Easow et al. 2005), or obtained from schools (Rai et al. 2005; Sharma et al. 2004). The stool samples were examined by formal–ether concentration technique. In the 'elderly' study, stool samples were collected from government elderly homes, private elderly homes, and households in rural communities and were examined with formal–ether sedimentation and Sheather's sucrose flotation followed by Kinyoun's modified Ziehl–Neelsen staining (Shakya et al. 2006).

Bangladesh

In Bangladesh, there is a disparity between health prevention and health spending. The Dhaka study performed within the urban slum areas had identified the prevalence of *G. lamblia* in 11% of diarrheal stool specimens (Haque et al. 2003), Table 1. Factors contributing to the increase in diarrheal episodes were: large family size per household, illiteracy among female mothers (64%), very low annual income (72%), absence of appropriate and hygienic methods for transporting drinkable water, presence of many households near tolatrines (18%) and drains (27%), use of pit latrines (2.5%), and 27% of houses contained mud floors. Water storage is another contributing factor for water contamination either due to high temperature or due to the spread of the disease through the fecal–oral route. Furthermore, the youngest children were the most who experienced diarrheal episodes, with overall higher morbidity among male than female children. Researchers recognized that the prevalence rate of diarrhea in children with blood group A was less than it was seen in children with blood groups O and AB, but the relationship of blood grouping to infected agent(s) was not investigated thoroughly by

Table 1 Prevalence of *G. lamblia* in South East Asian countries

	Total no.	Age	*Giardia* prevalence	Parasitic prevalence[a]	Mix infections[b]
Nepal					
Western Nepal (Easow et al. 2005)	n=1790	Pre-school and school-going children	73.4%	No prevalence of parasites	No mixed infections
Rural area of Kathmandu Valley (Rai et al. 2005)	n=340	School children, boys: 177, girls: 163	9.1% (31)	71.2% children	71.2% (242)
northeastern part of Kathmandu Valley (Sharma et al. 2004)	n=533	Aged 4 to 19 years, school children, girls=269, boys=264	23.1%	66.6% (395/533)	53.8% (191/355)
Kathmandu Valley (Shakya et al. 2006)	n=235	Government elderly home=122; private elderly home=66; households rural community=47	1.5% (2)	41.7% (98)	30.6%
Bangladesh					
Mirpur, an urban slum in Dhaka (Haque et al. 2003)	n=289 n=252 households	n=221 followed for 36 months 2–5 years old. n=147 boys n=142 girls	11.08% (99/893) diarrheal stool specimens	No prevalence of parasites	No mixed infections
Hospital of the international center for diarrheal disease research, Dhaka (Haque et al. 2005)	n=2534 n=1305 diarrhea cases n=1229 non-diarrheal cases	All Ages	12.7% & 7.7% Giardia infection rate with diarrhea 18% Asymptomatic Giardia infection rate	No prevalence of parasites	No mixed infections
India					
Chandigarh, North India (Bansal et al. 2004)	n=550	No age specified in literature	(6.0%) 33	19.3%	No mixed infections
In and around the union Territory, Chandigarh, India (Khurana et al. 2005)	n=600	18% (108 cases) Children	5.5% (33 cases)	14.6%	No mixed infections
Delhi–India study (Kaur et al. 2002)	n=127	Children	11% (14 cases)	No prevalence of parasites	46.5% (59 cases)
Rural and urban areas in and around Chennai (S. India) (Fernandez et al. 2002)	n=324 children, a. rural areas n=125, b. urban settings n=199	No age specified in literature	a.16%, b.22.6%	a.91%, b.33%	No mixed infections
Northern India (HIV) (Mohandas et al. 2002)	n=120	Adults 94.2% (113) Youngsters 5.8% (7)	8.3% (10/120) & 4/10(40%) with diarrhea	30% (36/120) & 27 (75%) with diarrhea	No mixed infections
Center for related Diseases, National Institute of Communicable Diseases, Delhi (Dewivedi et al. 2007)	Total n=100 n=25 excluded n=50 with diarrhea n=25 without diarrhea (control)	Males=57 (76%) Females=18 (24%) Median age 34 males vs. 31.5 yrs females Heterosexual (45, 60%) Homosexuals (18, 24%) Transfusion recipients 16% (12) From Slums 36% (27) Rural 33.3% (25) Urban 30.7% (23)	9.8 /75 (13.3%) & 8/50 (16%) with diarrhea 4/25 (8%) without diarrhea	62.7% (47 cases) & 72% (32 cases) diarrhea 44% (20.68 cases) without diarrhea	36.2% (17/47)
Cancer biopsy (Misra et al. 2006)	a. Gastric Ca n=54, b. Antral biopsies n=100	Adults	a.14.9% (8), b.20% (7/35)	No prevalence of parasites	No mixed infections
Northern India—Malabsorption study (Ranjan et al. 2004)	n=99	Adults, mean age 34.6 years old, males=59, females=40	8.08% (8)	No prevalence of parasites	No mixed infections

[a] Prevalence of parasitic infection are shown here just to provide the reader an overview
[b] Prevalence of mixed infections are shown here just to provide the reader an overview

correlating specific parasites to certain blood groups, or revealing the influential factors of parasites possessing more or lesser effects on different blood groups among infected populations. Also, there was absence of any data on the total infection rate of *G. lamblia*, blood grouping ratio, as well as age and gender distribution.

At Dhaka International Research Center for Diarrheal Disease, researchers associated the prevalence of *G. lamblia* and the genotype of this protozoan at the alloenzyme and DNA sequencing through recognition of 'assemblage A' and 'assemblage B' genotypes.

The prevalence of *G. lamblia* infection reached to 12.70%, where 7.7% had diarrhea while 18% had no diarrhea (Table 1) with higher odds ratios for diarrhea between assemblage A and A2 infections, and with a higher overall prevalence observed in assemblage B infections (Haque et al. 2005).

Methods of diagnosis from Bangladesh studies

Stools were examined for ova and parasites by direct microscopy to identify *G. lamblia* and other helminthic and protozoa parasites. Blood type analysis, ABO and Rh blood typing were performed by traditional methods (Haque et al. 2003). Stool analysis included erythrocytes, leukocytes, ova/parasites as well as detection of *G. lamblia* and other parasites antigens. Genotyping of *G. lamblia* was determined by microscopy or antigen-positive using Scorpion probe-real time polymerase chain reaction (qPCR; Haque et al. 2005).

India

In India, the prevalence of intestinal parasitic infections still varies from one region to another due to the variation in the socio-economic levels, ages and gender, between rural and urban, and the population distribution,

G. lamblia in patients without HIV in India

The prevalence rate of *G. lamblia*, within the rural and urban populations in and around union Territory, Chandigarh India (Fig. 1), reached to 5.5% with the highest prevalence rate existed in the slum areas (24.6%), and the most commonly affected group were children (18%; Khurana et al. 2005); while the study from Chandigarh area—(N. India) from a low socio-economic population the prevalence rate of *G. lamblia* reached to 6% (33) Table 1, (Bansal et al. 2004). In the absence of proper sanitation and hygiene as a result of poor health education and absence of continuous surveillance, the Delhi study showed higher prevalence rate of *G. lamblia* infection among residents living in high condensed suburbs of Delhi (India). *G. intestinalis* and other protozoa were present in 14 (11%) cases each (Kaur et al. 2002). Comparison of the two urban studies, i.e., within and around the Chennai area—South India and the Delhi–India study (Fig. 1), the latter showed lower prevalence of *G. lamblia*, which could be related to the sample size and/or related to a higher socio-economic level (Table 1).

However, detection of intestinal parasites was noticeable among children attending schools from rural and urban areas in and around Chennai—Southern India (Fernandez et al. 2002). The prevalence of *G. lamblia* was lower, among all protozoa infections, in the rural areas (16%) than in the urban areas (22.6%), while the prevalence of parasitic infection was higher in the rural areas (91%) than in the urban areas (33%), most probably the majority of children might have had a higher prospect of exposure to contaminated soil and/or fecal–oral contamination (Table 1).

Methods of diagnosis from Indian studies without Human immunodeficiency virus (HIV)

Stool samples were collected in all studies, where Bansal et al. (2004) examined them macroscopically and microscopically; Khurana et al. (2005) used cluster sampling technique and examined the stools samples microscopically; Kaur et al. (2002) applied direct smears to diagnose different types of parasites; and Fernandez et al. (2002) examined the stool samples microscopically using normal saline, Lugol's iodine preparation, and saturated sodium chloride flotation technique.

G. lamblia among HIV patients in India

Several studies have already been published about protozoa and other parasitic infections among HIV sero-positive patients (Reynolds 2003). Comparing the Northern India HIV study (Mohandas et al. 2002) and the Delhi HIV study (Dwivedi et al. 2007), the prevalence of *G. lamblia* in HIV sero-positive patients in North India reached to 8.3% (10/120) and in the Delhi study to 13.3% (9.86/75), Table 1. Around 75% (27cases) in Northern India study and 72% (32 cases) in the Delhi study had diarrhea, where in North India study 40% (4/10) of HIV sero-positive patients had diarrhea with CD4 count lower than 30 cells/mm^3, while in the Delhi study 16% (8/50) specifically had diarrhea as a result of *G. lamblia* with a mean CD4 count at 166 cells/mm^3. As for the prevalence of *G. lamblia*, infection in patients without diarrhea had reached to 8% and the mean CD4 count reached to 479 cells/mm^3 (Mohandas et al. 2002). Thus, *G. lamblia* associated with diarrhea in 8% of normal controls proved that this parasite does not occur at higher levels in HIV-positive than in HIV-negative individuals, but rather, is maintained at a rate range between 1–11% (Janoff et al. 1988).

Fig. 1 Sub-Indian continent map including countries in our study (India, Nepal Bangladesh, part China)

Methods of diagnosis from Indian studies among HIV patients

Mohandas et al. (2002) and Dwivedi et al. (2007) both collected and examined fecal samples by using 10% buffered formalin clean wide-mouthed plastic containers placed in a formalin–ethyl acetate sedimentation concentration technique. Specimens were examined on wet saline mounts and iodine preparation was used for the detection of protozoan ova, cysts, and helminthic eggs and larvae (Mohandas et al. 2002). Any other protozoa samples having positive or doubtful results were further reconfirmed by direct immunofluorescence assay (IFA). Dwivedi et al. (2007) utilized a modified trichome stain to confirm the presence of microsporidia.

G. lamblia among cancer patients and with duodenal ulcers in India

Protozoal infection have had extended beyond the norm of spread to those suffering from gastric carcinoma and patients with history of duodenal ulcer (Misra et al. 2006). Around 14.9% (8 cases) with gastric carcinoma patients found to be harboring *G. lamblia* trophozoites (8/8), and 20% (7/35) revealed the presence of *G. lamblia* in patients who were on treatment for duodenal ulcer.

Also, another study in Northern India had identified the presence of *G. lamblia* while searching for the causative factors responsible for the sporadic of malabsorption syndrome in adults (Table 1). The precipitating causes for the prevalence of *G. lamblia* were found among eight patients; however, the age distribution and gender were not investigated. Further data were needed to clarify the spread of *G. lamblia* among these patients (Ranjan et al. 2004).

Methods of diagnosis of G. lamblia from other Indian studies

In India, Misra et al. (2006) based their diagnosis on identifying *G. lamblia* by gastric and antral biopsies from subjects with stomach carcinoma and in patients who were on treatment for duodenal ulcer. Only after the second and third trials of biopsies researchers were successful in identifying the presence of *G. lamblia*. As for patients suffering from malabsorption syndrome, Ranjan et al. (2004) based their diagnosis on duodenal or jujenal biopsies in identifying *G. lamblia*. Six patients were diagnosed by duodenal or jujenal biopsies, while the other two patients were detected as a response to follow up.

Prevalence of *G. lamblia* in South East Asia (Cambodia, Vietnam, Malaysia, Philippines, Indonesia, Thailand)

The major causes of diarrhea in developing countries is the lack of unsafe water as well as proper sanitation that could provide appropriate niche for the growth of bacterial, parasitic and viral transmission (Karanis et al. 2007). With the rapid growth rate of urbanization in Africa and Asia, the level of safe water supply is diminishing, making these locations vulnerable to higher risk of water-related diseases (Cotruvo et al. 2004—WHO Waterborne Zoonoses; Boonyakarnkul et al. 2004—WHO; WHO/UNICEF 2000).

Cambodia

The Cambodian health system is underway to recovery after suffering from long decades of international conflicts; nevertheless, parasitic infection remains a major concern for the Cambodian Health Bureau (Lanjouw et al. 1999). In Table 2, the prevalence of *G. lamblia* ranged from 4.2% of the total parasitic infections in villages bordering Tonle Sap Lake (Chhakda et al. 2006) to 3.2% (eight) in Kampongcham City—northeast of Cambodia (Lee et al. 2002), reaching 2.9% (18) in Bat Dambang, southeast of Cambodia (Park et al. 2004). In Kampongcham City, the prevalence of *G. lamblia* infection among males and females was nearly equal as well as the distribution among different school classes, but the highest level was observed in grade 2 schools (Lee et al. 2002). However, in Bat Dambang (Cambodia), *G. lamblia* infection was higher in males than in females with nearly equal distribution in different classes (Park et al. 2004).

Methods of diagnosis from Cambodian studies

In Kampongcham City and Bat Dambang area (Cambodia), fecal samples were examined by formalin–ether sedimentation technique for the detection of parasitic infections, while in villages bordering Tonle Sap Lake, the fecal samples were examined by Kato–Katz, SAF concentration, Baermann technique, and accompanied with some short clinical examinations (Chhakda et al. 2006; Lee et al. 2002; Park et al. 2004).

Vietnam

Vietnam is ranked as 13th most populated and poorest country in the world despite urbanization and development. It is still predominantly an agricultural country with nearly 80% of the population living in the rural areas. Vietnam's health care system was shattered for several years between the 1950s and 1970s due to the international conflicts they experienced. Despite the adoption of renovation policy by the government in 1986, the majority of people do not have proper access to health care (Ha Nguyen et al. 2002). Notwithstanding absence of a good distribution of health resources, expensive health treatment, absence of health coverage for nearly one third of the population, intestinal parasitic infections remain a major government concern. Also there is a huge lack of information on the prevalence of parasitic infections with limited or absence of appropriate diagnosis. In the Mountainous Northern–Western Vietnam, investigation concentrated on the prevalence of parasitic infections among six ethnic groups (Table 2): Muong, Kinh, Dao, Thai, Tay and Hmong. *Giardia* cysts were found among 4.1% (103) and the adjusted prevalence of *G. lamblia* infection was estimated at 3.2%, which is comparatively low in prevalence to other countries (Verle et al. 2003).

Methods of diagnosis from Vietnam studies

All households were evaluated clinically and 90% of them filled-up the standardized questionnaires. Stools samples were collected from 84% of households and blood samples from 89% (Table 2). Formalin–ether concentration technique was used by examining one smear per sample, and for each blood sample, a blood film was produced; and hemoglobin concentration levels were measured using the Lovibond Comparator method (Woodliff et al. 1966).

Malaysia

In Malaysia, parasitic infections including *G. lamblia* infection still occupy an important part of Malaysian health care. The prevalence of four main protozoan infections were reviewed in one study (Table 2), and showed six out of 1,350 stool samples were infected with *G. lamblia*, with children making up 66.7% of the total patients; nevertheless, it is still low in comparison to other Asian countries (Nissapatorn et al. 2005). Also, among Orang Asli children in Selangor, Malaysia, the relationship between *G. lamblia* infection and protein-energy malnutrition, vitamin A deficiency, and iron deficiency anemia was evaluated. The prevalence of *G. duodenalis* infection among children was around 24.9% (Table 2), higher than the previous study. This might be attributed to geographical location, socio-economic level, and unsafe water resource, or due to the study design (Al-Mekhlafi et al. 2005).

Table 2 Prevalence of *G. lamblia* in South East Asian countries

	Total no.	Age	*Giardia* prevalence	Parasitic prevalence[a]	Mixed infections[b]
Cambodia					
Northeast Cambodia (Lee et al. 2002)	n=251	No age range mentioned in literature	3.2% (8), females (4) 3.3%, males (4) 3.1%	54.2%, males 57.3%; females 50.8%	16.7%
Southeast of Phnom Penh (Park et al. 2004)	n=623	Kindergarten and schoolchildren	2.9% (18) M: 15(4.4%) F: 3 (1.1%)	25.7%, males 26.2%, females 25.1%	No mixed infections
Tonle Sap Lake, Cambodia (Chhakda et al. 2006)	n=1616	School-aged children	4.2% (67)	No prevalence of parasites	No mixed infections
Vietnam					
Mountainous Northern–western Vietnam (Verle et al. 2003)	n=526 households or n=2997 individuals	All ages	3.2%	88%	No mixed infections
Malaysia					
(Nissapatorm et al. 2005)	n=297	All ages Children	2.02% (6/297), Males=5, Female=1	15.8%	No mixed infections
Orang Asli Selangor (Al-Mekhlafi et al. 2005)	n=281	2–15 years	24.9%	No prevalence of parasites	No mixed infections
Philippines					
Metro Manila (Baldo et al. 2004)	n=284	Highest among 10–14 years old 14.7% (11) lowest or absence of infection above 15 years old	20 (11.6%), Males higher prevalence 13.5% (12) than females 9.6% (8)	62.0%	34.2%
Roxas City, Mindoro (Kim et al. 2003)	n=301	1–16 years old and above	Total absence of *G. lamblia*	64.5% males 56.6% females 72.5% infectivity	No mixed infections
Indonesia					
Simadibrata et al. 2004	n=207	Not specified	3.62%	66.7% (138)	No mixed infections
Thailand					
Pathum Thani Province (Saksirisampant et al. 2003)	n=106	10–82 months old, males=60, females=46	37.7% (40), males=45, females=41	86 (81.1%)	No mixed infections
Mountains area North of Thailand Karen hill-tribe, Doi Inthanon region, Mae Chame district, Chiang Mai Province (Saksirisampant et al. 2004)	n=781	3–19 years, males=325, females=456	2.21% (17.26)	42.06% (328), male=46.87% (366), female=38.82% (303)	No mixed infections
Central Thailand including Ang Thong, Ayudthaya, and Suphanburi Provinces (Saksirisampant et al. 2006)	n=1037	Primary schools 3–12 years, males=540, females=497	1.25% (13)	4.24% (44)	No mixed infections
Sangkhlaburi, a rural district in the west of Thailand (Wongstitwilairoong et al. 2007)	n=472	Pre-school children 3–60 months Males=233 Females=239	From cases (n=236) 13.6% (32), from control (n=236) 23.3% (55)	22.7% (107)	3.8% (18)
Northeast Thailand (Surin Province) Central Thailand (Samut Sakhon Province) (Wongjindanon et al. 2005)	n=3358 n=656	Surin Province volunteers of any age, Samut Sakhon Province children 5–7 years old	Rural areas 2.2% (75), 30 cases, <10 years old Sub-urban 6.5% (43)	No prevalence of parasites	No mixed infections

[a] Prevalence of parasitic infection are shown here just to provide the reader an overview

[b] Prevalence of mixed infections are shown here just to provide the reader an overview

Methods of diagnosis from Malaysian studies

Structured questionnaires, anthropometric measurements, and laboratory analysis of blood and fecal samples were performed. Nissapatorm et al. (2005) collected blood and stool samples from 297 subjects, while Al-Mekhlafi et al. (2005) performed structured questionnaires interviews, anthropometric measurements, and laboratory analysis of blood and feces.

Philippines

The Philippines is greatly affected with widespread poverty, and 36.8% out of 81 million people are still living under the national poverty line, with communicable diseases remaining a major public health concern despite the great efforts by the Ministry of Health to tackle these problems (Catacutan 2005). Only the Metro Manila study (Baldo et al. 2004) showed absolute high prevalence of *G. lamblia*: 11.6% (20) of street children housed in different NGOs, government-managed shelters, children living in street communities (i.e. communities adjacent to a road, highway, or street), or staying in their own homes in Metro Manila (Baldo et al. 2004). This might have been attributed to highly condensed population and absence of hygiene. While in the Roxas City study, there was total absence of *G. lamblia* infectivity and is most probably related to a less-condensed population or having better water resources (Kim et al. 2003).

Methods of diagnosis from Philippines studies

Both studies used the same method of diagnosis by examining stool samples with formalin–ether concentration for the detection of any parasitic ova and cysts (Baldo et al. 2004; Kim et al. 2003).

Indonesia

In Indonesia, there is 27% of the population (210 million) under the national poverty line, and accessibility to clean water is still the main health problem. The country is still suffering from water-borne diarrhea-causing diseases, and diarrhea is considered among the ten leading causes of mortality (WHO/UNICEF 2000; Fig. 2). One study had investigated diarrheal cases as a result of chronic infectivity over a 6-year-period duration. The infectivity was attributed to bacterial and protozoan causes. *G. lamblia* was the third leading cause of diarrhea, contributing only to the prevalence around 3.62% of the total chronic infectivity (Simadibrata et al. 2004); chronic infective diarrhea was detected in 66.7%.

Fig. 2 Showing most of South East Asian countries included in our study (Malaysia, Thailand, Vietnam, Philippines, Indonesia

Table 3 Prevalence of *G. lamblia* in Far East Asian Countries

	Total no.	Age	*Giardia* prevalence	Parasitic prevalence[a]	Mix infections[b]
Korea					
R. Korea Guk et al. 2005	n=105	39.2±10.0 years a. n=67 61 men 6 women	a. 1.5% (1/67)	31.4% (33) a. 23.9%	No mixed infections
China					
Shandong Province (Yang et al. 2003)		a.1>14 years old and 80 years old higher rate among age range groups 10>14 years old, females (7.38%), males (5.92%)	Provincial 4.84%, a. 7.81%, b. males=5.06%, females=4.61%, c. province 8.67%~9.07%	No prevalence of parasites	No mixed infections
Wang zhu, Nanzhu, Qian ran villages, suburb of Jiaozuo City, Henan Province (Xu et al. 2003)	n=1722	Absence of age distribution, tested=1,557, males=829, females=728	4.62% or 23.23% of total parasitic infection	18.82% (293/1557) Wang zhu village, infection rate 19.58% (*Giardia*:23;103/526) Nazu village 16.09% (*Giardia*: 29;84/500), Qiang nan village 20.83% (*Giardia*20;106/509)	6.10%
University students Henan Province (Wang and Huang 2005)	5,038, males:1,926, females: 3,112		2.74%	15.28% (770/5038), females: 16.10% (501/3110), males: 13.97% (269/1926)	No mixed infections
Huai Nan Anhui Province students from kindergarten to university level (Fu et al. 2004)	n=1332 Age=4–26 years old Males=864 female=486	Kindergarten students n=365, primary school n=335,middle school n=322 university students n=310 residence urban areas: 1106 rural areas: 226	6.08%	No prevalence of parasites	No mixed infections

[a] Prevalence of parasitic infection are shown here just to provide the reader an overview
[b] Prevalence of mixed infections are shown here just to provide the reader an overview

Methods of diagnosis from Indonesian studies

Patients had undergone physical examination and laboratory tests, as well as colon enema X-ray, small bowel X-ray, colonoscopy, ileoscopy, and upper gastrointestinal endoscopy (Table 2).

Thailand

The Thai Health Care System experienced a great improvement in the past 30 years, and was reflected in the major health indicators such as birth rate, life expectancy, etc. The prevalence of *G. lamblia* varies from one region to another with the highest prevalence existing in the rural districts of western Thailand, ranging from 13.6% to 23.3% (Table 2), with higher prevalence in males than females, but was the opposite case among controls (Wongstitwilairoong et al. 2007). In Pathum, Thani Province (Thailand) the prevalence of *G. lamblia* reached to 37.7% with nearly equal gender distribution (Saksirisampant et al. 2003), while in studies performed from the central (Saksirisampant et al. 2006) and northern part of Thailand (Saksirisampant et al. 2004), the prevalence was very low, from 1.25% to 2.21%. The northeast (rural) and central (sub-urban) parts of Thailand study showed different prevalences of *G. lamblia*, 2.2% and 6.5% (Wongjindanon et al. 2005; Table 2), with the highest prevalence mostly existing among school children below 5 years old, and slightly higher difference among males than females (Saksirisampant et al. 2003).

Methods of diagnosis from Thai studies

After researchers collected stool samples, the simple smear and formalin–ether concentration was applied to detect *G. lamblia* and other protozoa infections (Saksirisampant et al. 2003, 2004, 2006); stool samples in all infected cases were classified according to six characteristics: formed, soft, loose, mucous, loose–watery, and watery. There was no recorded history of diarrhea symptoms among these orphans (Saksirisampant et al. 2003). However, in Sangkhlaburi, a rural district west of Thailand along the Thai–Myanmar border, stool specimens were collected from children with diarrhea and from asymptomatic children. The direct wet smear, modified acid fast stain, formalin–ethyl acetate sedimentation concentration technique, and trichrome stain were applied to process and examine each specimen. For the detection of *G. lamblia*, ProSpecT Microplate assays (Alexon-Trend, Lenexa, KS) were utilized (Wongstitwilairoong et al. 2007). Wongjindanon et al. (2005) collected stool samples from volunteers among all ages and from three secondary schools; samples were analyzed by both simple smear and normal saline concentration technique on fresh collected feces.

Prevalence of *G. lamblia* in the Far East (Korea and China)

South Korea

In industrialized countries including South Korea and Japan, *G. lamblia* infection is very common and is considered one of the main protozoa that causes diarrhea. One cohort study investigated the prevalence of parasitic infections among HIV-infected patients at Seoul National University Hospital, Korea (Guk et al. 2005). The study showed a low prevalence rate of *G. lamblia* 1/67 (1.5%), with a lower incidence of diarrhea than is observed in the HIV Delhi and Northern Indian HIV patients.

Methods of diagnosis from South Korean studies

Fecal samples were obtained from 67 patients fixed in 10% formalin, and processed using the formalin–ether sedimentation technique and observed under a light microscope (Guk et al. 2005).

People's Republic of China

As for China, with its huge population, large geographical area, and fast-growing economy, the health care sector started facing many challenges. A large number of the population were without any medical insurance coverage; the uninsured rural and urban population accounted for 79% and 44.8%, respectively, according to 2003 statistics (Dib et al. 2007; China Ministry of Health 1998; 2004).

In China, the prevalence of *G. lamblia* (Table 3) ranged from 4.84% at the provincial level (Shandong Province), and the infection rate reached to 7.81% among children as well as in ≥80 years old. The infection rate ranged from 8.67% ~9.07%, which were extracted from 13 areas out of 35 cities at the provincial level (Yang et al. 2003). A temporal study from three villages (Wang zhu, Nanzhu, Qian ran), a suburb of Jiaozuo City, Henan Province, the prevalence rate of *G. lamblia* among enrollees had reached to 4.62% (Xu et al. 2003), 2.74% from a cross-sectional study among 2nd-year university students enrollees in Henan Province, (Wang and Huang 2005), and 6.08% from another cross-sectional study of enrollee students from different educational levels (kindergarten, primary school, middle school, and university students) in Huai Nan, Anhui Province (Fu et al. 2004). The prevalence of *G. lamblia* infection rate was much higher, in general, in males than in females, 5.06% 4.61%, respectively, but within the age range groups, it was much higher among females 10∼14 years old, and the rates were 7.38% for females and 5.92% for males (Yang et al. 2003). In the Jiaozuo City study (Xu et al. 2003), there was absence of age and gender prevalence, while the study among 2nd-year students in Henan Province showed higher prevalence of infection rates of *G. lamblia* among females (16.10%) than males (13.97%), and the urban students had lower prevalence infection rates, 9.40%, than rural students, 18.34% (Wang and Huang 2005). In the Huai Nan, Anhui Province study there was no significant difference in the prevalence of *G. lamblia* infection rate between males and females, and the rural students had a higher prevalence of infection than urban students (Fu et al. 2004). However, one of the studies showed that the prevalence of *G. lamblia* infection rate decreased from 4.58% in 1993 to 2.74% in 2004, but remained to be the leading infectious parasite (Wang and Huang 2005). The linkage between the spread of *G. lamblia* infection to the water source factor was established in the four studies and the spread was directly related to the degree and nature of water hygiene.

Methods of diagnosis from Chinese studies

Yang et al. (2003) based their diagnosis on clinical signs and symptoms; they aspirated the gastric content and examined them microscopically; Xu et al. (2003) collected stool samples and applied iodine to observe all protozoa cysts after being placed in formalin–ether, while Wang and Huang (2005) collected stool samples from all university students then applied iodine to identify protozoa cysts after being placed on a wet saline, using the thick smear slide technique; also, natural precipitation for cysts, NaCl 0.9%, and direct smear was applied. As for Fu et al. (2004), they extracted their data based on students' disease history, living habits, and nature of the environment they were living in. Stool samples were collected and placed in formalin–ether and iodine, and were observed microscopically.

It is evident that the prevalence of *G. lamblia* varies markedly between studies in Asia. The prevalence varies between rural and urban areas depending on each country's economic level and social status. The prevalence of *G. lamblia* exists more among poorer communities, slightly higher in males than in females, with higher prevalence among 2–5-year-old children. Also, *G. lamblia* infection is observed more among university students, old-aged people, HIV-positive, and gastric carcinoma patients. *G. lamblia* has been transmitted most of the time through contaminated water due to lack of appropriate modern toilets within houses, absence of proper drinking sources, more of the disease is spread as a result to fecal–oral contamination, and lack of knowledge about swimming in unhygienic water. There is a marked difference in the prevalence of *G. lamblia* between the Korean HIV patients and Indian HIV patients and an unknown reason for the presence of *G. lamblia* among gastric cancer patients, patients on treatment for peptic ulcer disease, and among malabsorption syndrome patients.

In conclusion, though *G. lamblia* is not a life-threatening parasite; nevertheless, it is still considered as the most common water-borne diarrhea-causing disease in poor and urban slum areas due to the absence of proper hygiene and health education, and absence of appropriate surveillance. Prevention through continuous health education is one of the solutions to these problems by increasing awareness about food and water contamination, the avoidance of swimming in unclean water, and proper hygiene within nursing homes and preschool kindergarten students. It is important to understand the etiology, frequency, and consequences of acute diarrhea in children, which could aid in designing interventions to improve health education. Also, access to clean drinking water is a crucial concern for the governments. Routine surveillance and prevention programs including bi-annual follow-up treatments, treating *G. duodenalis* cysts and other protozoa oocysts detected in various ground water sources is necessary for the control of infections or outbreaks in the community. Furthermore, there is a need to acknowledge the importance of *G. lamblia* infections in patients with gastric carcinoma and duodenal ulcer disease, as they have been detected in high prevalence among those patients, which will pave the way for an emerging situation as it has been already confirmed with *cryptosporidiosis*, which resulted in provoking the development of polyps and carcinoma in mice.

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