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ORIGINAL ARTICLE

Spatial distribution of *Giardia lamblia* infection among general population in Mazandaran Province, north of Iran

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Abstract *Giardia lamblia* is the most prevalent intestinal parasites of humans in Iran and other in the world although information on geographical distribution of giardiasis plays significant role in identifying communities at high risk, little attention has been paid to study human giardiasis using geographical information system. Therefore, the aim of the current study was to determine temporal and spatial patterns of human giardiasis distribution to identify possible high risk areas and seasons in northern Iran. A total of 4788 people referred to health centers in the Mazandaran Province of northern Iran were surveyed January to December 2015. From each person stool sample and questionnaire with socio-demographic data were collected. *Giardia* infection was diagnosed using direct wet mount, formalin ether concentration and trichrome staining. The results were analyzed using Moran Local Indicators of spatial association and geographically weighted regression. The overall prevalence of *Giardia* infection was 4.6% (222/4788), and was significantly higher among those aged 5–9 years compared to their older peers ($P < 0.0001$). Our data showed a significant dependency between the prevalence of *G. lamblia* and age, job, residence, season and height from the sea ($P < 0.0001$). The results of this study provided a precise and specific spatial and temporal pattern of human giardiasis distribution in the Mazandaran Province, Iran. These evidences should be considered for proper control of disease decisions and strategies.

Keywords *Giardiasis* · Geographical information system · Infectious disease · Iran

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Introduction

Giardia lamblia, is a cosmopolitan protozoan parasite of mammals which causes illness of the host intestinal tract (Sedighi et al. 2015). Giardiasis has variable clinical symptoms ranging from asymptomatic to acute or chronic diarrhea, dehydration, abdominal cramps, nausea, vomiting, weight loss, disaccharide intolerance and malabsorption. In addition, *G. lamblia* affects growth and cognitive functions of infected children (Jethwa et al. 2015). This parasite transmitted by its cyst form through contaminated food or water (Fecal–Oral). The encysted stage of the organism is relatively resistant to chlorination and ozonolysis can remain viable for several weeks. Humans are considered as the most significant reservoir hosts for human giardiasis (Adam 2001; Al-Mekhlafi et al. 2013), with outbreaks occasionally occurring due to mass exposure to insanitry water and food containing cysts of the

parasite and direct contact with infected individuals, particularly in child care centers (Gholami et al. 2016). *Giardiasis i*s of particular concern in developing countries with a prevalence ranging from 20 to 60% compared to 2–7% in industrialized countries (Faraji et al. 2015; Yakoob et al. 2005). In Iran, the prevalence of the disease was reported 14.7% (Fakhar et al. 2014). *Giardiasis* can be acquired at any age, it is most prevalent in children living in unhygienic conditions and areas of high population density (Jethwa et al. 2015). Estimated about 200 million people have symptomatic giardiasis across Asia, Africa, and Latin America with 500,000 new reported cases annually, despite current monitoring programs (Al-Mekhlafi et al. 2013; Rayani et al. 2014; Abasian et al. 2013).

A recent study in Tonekabon, west of Mazandaran Province, has shown that *Giardia* protozoa with prevalence 3% was one of the most important pathogens in the protozoan group (Shahdoust et al. 2016).

Due to the notably high degree of infection rates presented above, the collection of a comprehensive dataset and its analyses are necessary to better manage prevention and control strategies for giardiasis. One of these strategies uses geographical information system (GIS) which can prepare geographical patterns in disease distribution and helps develop early warning systems for infectious diseases (Zhou et al. 2009). Currently, GIS has been well documented as an important tool to collect, retrieve, organize, and display public health information (Croner et al. 1996). In addition, it has become a commonly applied platform to visualize and analyze diseases. This powerful tool can run simulative and predictive models required for complex dynamic processes of transmission concerning infectious diseases (Thomas et al. 2002). Therefore, the aim of the current study was to study temporal and spatial patterns of human giardiasis distribution and find possible risk factors in the Mazandaran Province, northern Iran.

Materials and methods

Study area

This study was done in Mazandaran Province, located in south of the Caspian Sea, north of Iran (lat. 35°47″36°35″, long. 50°34″54°10″). This province has 19 cities and populace of around 3,073,943 people. The mean yearly relative humidity is 80%, with rainfall happening in all seasons of the year, and the mean temperature is 18 °C.

Samples collection

This cross-sectional study was performed on 4788 people referring to health centers of Mazandaran Province from January to December 2015. Stool specimens were collected after receiving consent from the individuals and filling out the questionnaire. The specimens were preserved in polyvinyl alcohol (PVA) and carried to the Parasitology Laboratory of Mazandaran University of Medical Sciences.

Stool examination

All specimens were examined using normal saline (0.85% NaCl) for observed of trophozoites and Lugol's iodine staining for detect of the *Giardia* cysts under the light microscope by 40× objective magnifications. Then, Formalin-ether concentration technique and trichrome staining were done for all samples (Fig. 1).

Geographical data

In our study, data related to height (three groups: less than 500, 500–1000 m and above 1000 m) and distance from the sea (three groups: less than 10,000, 10,000–20,000 m and more than 20,000 m) were obtained from Google Earth software (version 16). Ecological data (such as temperature, rain, humidity, height and distance from the sea) were collected from the Mazandaran Metrological Organization.

Statistical analysis procedure

The obtained results were analyzed by the SPSS 16.0 and using Moran Local Indicators of Spatial Association to determine the distribution of human giardiasis in different areas of the province. Furthermore, geographically weighted regression (GWR) was used to study the geographical relationship of prevalence of human giardiasis and associated important variables including precipitation and temperature.

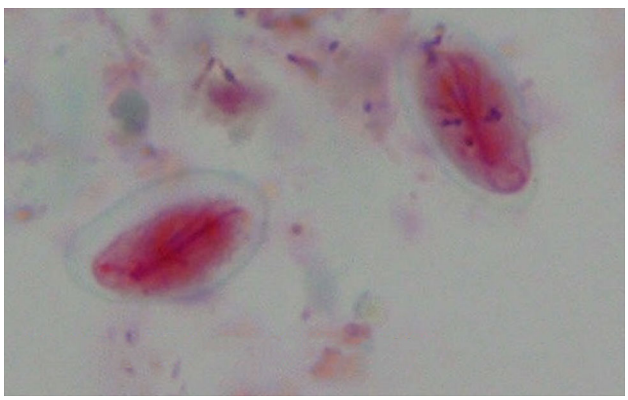

Fig. 1 Cyst from of Giardia stained with trichrome (×100)

Results

The overall prevalence of giardiasis was 4.6% (222/4788). 53.9% (2579) were male and 46.1% (2209) female. The mean of ages was 32.39 ± 17.75 years (range 1–77 years old).

A significant association was found between the prevalence of *G. lamblia* with age, season, job, residence and education ($P < 0.05$) (Table 1).

Our results showed that the prevalence rates of *G. lamblia* were as follow: < 500 m, 3.5% (61/1710); 500–1000 m, 5.1% (152/2954); and > 1000 m, 7.2% (9/124). Among metrological risk factors, only height 500–1000 m prevalence of *G. lamblia* showed a significant difference according to the height from the sea ($P < 0.05$). According to mapping prevalence of *G. lamblia* indicated that Amol (9.3%) and Galugah districts (1.8%) had the highest and lowest prevalence rate in Mazandaran Province (Fig. 2).

Discussion

Giardia lamblia is a major human pathogen with a worldwide distribution. Prevalence of infection is higher in countries that lack proper sanitation and hygienic conditions (Hakim et al. 2011). Although *Giardia* was added to the 'WHO Neglected Diseases Initiative' in 2004, it continues to be a common and problematic human parasite (Savioli et al. 2006).

In the present study, the prevalence of *G. lamblia* infection among the general population in the Mazandaran Province of Iran was 4.6%. The prevalence of *G. lamblia* is high in some countries such as Amman, Jordan (78%), Western Nepal (73.4%), Malaysia (44.1%), Latin America (24%) (Shakkoury and Wandy 2005; Easow et al. 2005; Noor Azian et al. 2007; Reinthaler et al. 1998). Different studies in Iran have shown infection rates of 1.4–39.5%. It appears that changes in the prevalence of *G. lamblia* infection should be due to different factors including seasons of sampling, kind of consumed water, different laboratory tests, climate and environmental factors.

In this study, the most prevalence rate of *G. lamblia* was found among individuals aged 5–9 years (9.3%), and this is in agreement with previous studies in India, Malaysia and Iran (Jethwa et al. 2015; Choy et al. 2014; Arani et al. 2008). This could be attributed to the higher exposure of young children to a lot of infection sources, which could be due to having lower standards of personal hygiene when compared to old children and adults. In this study prevalence of giardiasis in males were 4.7% and in females 4.5%. The results were similar to study of Al-Saeed 2006 in Iraq (Al Saeed and Issa 2006). Another study carried out in Palestine and Mexico reported a higher rate (24%) of giardiasis among males than in females (Al-Zain and Al-Hindi 2005; Quihui et al. 2006). This high rate of prevalence in male that may be they are more exposure to sources of parasites or exposed to unhygienic conditions in fields during outdoor activity while females may be remain indoors (Khoshnood et al. 2015; Wani et al. 2010). Residential areas play an important role for prevalence of giardiasis. In the present study, the relationship between the prevalence of infection and the residential area was statistically significant and similar to a study in South Khorasan (Taheri et al. 2011; Mahni et al. 2016; Tork et al. 2016; Rahimi-Esboei et al. 2013). The prevalence of infection in this work was higher in rural areas (6.4%) rather that urban region (3.0%), which can be explained by low levels of sanitation knowledge, lack of healthy drinking water reservoir in some villages, more contact with soil, unpleasant environmental conditions and large numbers of family members (Rahimi-Esboei et al. 2013).

A significant association was observed between the educational level of people referred to health centers and parasitic infection, as infection rates in illiterate people (6.2%) was greater than those of educated people (1.9%) which shows close agreement with finding of other studies (Heidari and Rokni 2003; Al-Megrin 2015).

Our study shows a seasonal pattern with infection rates peaking in the summer, which is in agreement with other studies (Martin et al. 2003; Yoder et al. 2010; Robertson and Gjerde 2001). The high number of infection cases in this season is probably due to more consumption of contaminated vegetables and fruits which leads to higher number of patients referring to laboratory diagnosis. Additionally, the moist and warm climate of Mazandaran in the summer provides proper conditions for survival of the cyst.

In our study, there was a significant relationship between job and rate of infection the prevalence rate of giardiasis among farmers (7.1%) was more than other jobs. This increase in the prevalence of these can be more exposure to soil or contaminated water (Feng and Xiao 2011).In this work, GWR was used to study geographical relationship of the prevalence of human giardiasis in relation with some important variables including precipitation, temperature and livestock. The results show that 61 and 68% of prevalence of human giardiasis are contributed to rainfall and contact to domastic animals, respectively. This fact highlights the great impact of these two major variables.

It is noteworthy to mention that Mazandaran Province annually attracts a great number of tourists, immigrants and refugees owing to its high potential regarding of holidays, job-seeking and financial activities. Travelers' diarrhea is considered to be a great threat for tourists and *G. lamblia* is

Table 1 Frequency of *G. lamblia* in Mazandaran Province by demographic data and risk factors

Risk factors	No. specimens examined	No. positive (%)	OR (95% CI)	*P* value
Age				
< 5	648	25 (3.8%)	1	–
5–9	828	78 (9.4%)	0.3 (0.2–0.6)	< 0.0001
10–14	722	36 (4.9%)	0.7 (0.4–1.3)	0.3
15–24	988	31 (3.1%)	1.2 (0.6–2.1)	0.4
25–39	913	29 (3.1%)	1.2 (0.6–2.1)	0.4
≥ 40	689	23 (3.3%)	1.1 (0.6–2.1)	0.6
Sex				
Male	2579	122 (4.7%)		
Female	2209	100 (4.5%)	1.04 (0.7–1.3)	0.7
Residence				
Rural	2273	146 (6.4%)		
Urban	2515	76 (3.0%)	2.2 (1.6 – 2.9)	< 0.0001
Consumed water				
Tab water	3984	186 (4.7%)	1	
Shaft water	308	9 (2.9%)	1.6 (0.8–3.6)	0.1
Mineral water	496	27 (5.4%)	0.8 (.5–1.3)	0.4
Job				
Student	1587	71 (4.4)	1	–
Private business	1085	52 (4.7)	1.09 (0.7–1.5)	0.6
Housewife	1139	43 (3.7)	1.2 (0.8–1.7)	0.3
Government employee	348	11 (3.1)	1.7 (0.9–3.7)	0.07
Agriculture	629	45 (7.1)	0.06 (0.04–0.1)	< 0.0001
Education				
Illiterate	943	58 (6.2%)	1	–
Primary	1477	85 (5.8%)	0.6 (.4–1.1)	0.7
High school	1646	65 (3.9%)	0.5 (0.3–0.8)	0.01
University	722	14 (1.9%)	0.8 (0.5–1.3)	< 0.0001
Contact to domestic animals				
Yes	2427	121 (4.9)	1.2 (0.9–1.5)	0.1
No	2361	101 (4.2)		
Season				
Winter	1167	39 (3.3%)	1	–
Spring	1196	59 (4.9%)	0.6 (0.4–1.1)	0.06
Summer	1256	76 (6.1%)	0.5 (0.3–0.8)	0.002
Autumn	1169	48 (4.1%)	0.8 (0.5–1.32	0.4
Anti parasitic drug consumption				
Yes	1086	46 (4.2%)	0.8 (0.6–1.2)	0.5
No	3702	176 (4.8%)		

considered as a one of major causative agents of diarrhea (Feng and Xiao 2011). Therefore, there is a danger of acquiring *Giardia* infection for tourists in these areas. Considering to these facts, a regular monitoring program should be undertaken to decrease the prevalence of giardiasis in this province.

Conclusions

This for the first time this study identified and introduced a vital spatial and temporal pattern of human giardiasis distribution in the Mazandaran Province of northern Iran. These visual and statistical evidences for spatial clustering

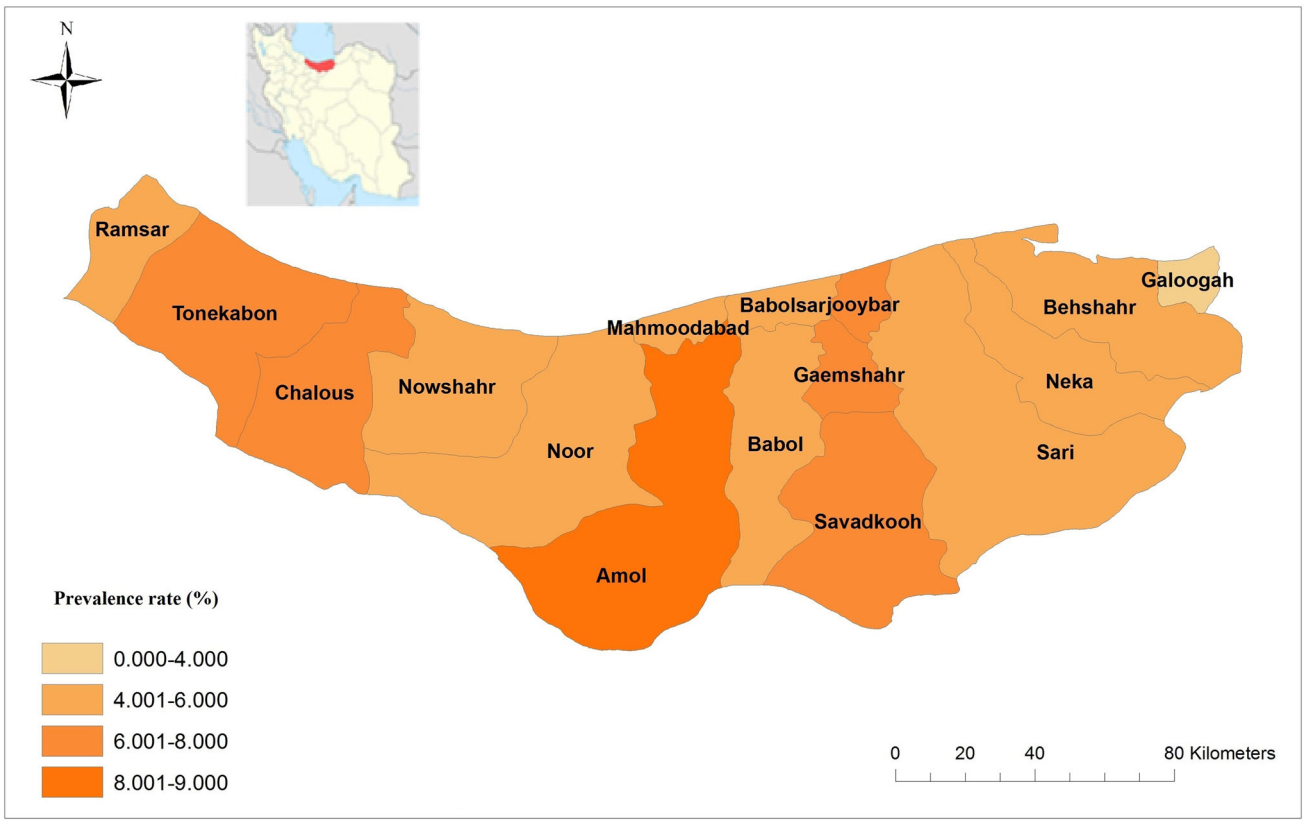

Fig. 2 Geographic distribution by GIS-based map of estimated prevalence rates of giardiasis in Mazandaran Province, north of Iran

and seasonal patterns should be considered for proper disease control decisions and strategies. In addition, there is a decreasing temporal trend in the distribution of giardiasis rates and Amol is major hot spot identified area. The results of this study also provided a precise and specific spatial and temporal pattern of human giardiasis distribution in the northern of Iran. These evidences should be considered for proper to control of disease decisions and strategies.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

References

Abasian L, Bazyar A, Shirbazo S, Sayehmiri K, Ahmad N (2013) Prevalence of *Giardia lamblia* in Iran: a systematic review and meta-analysis study. Res Med 36(5):111–116

Adam RD (2001) Biology of *Giardia lamblia*. Clin Microbiol Rev 14(3):447–475

Al Saeed A, Issa S (2006) Frequency of *Giardia lamblia* among children in Dohuk, northern Iraq. East Mediterr Health J 12(5):555–561

Al-Megrin WAI (2015) Assessment the prevalence of intestinal parasites and associated risk factors among preschool children in Riyadh, Saudi Arabia. Res J Parasitol 10(1):31–41

Al-Mekhlafi HM, Al-Maktari MT, Jani R, Ahmed A, Anuar TS, Moktar N et al (2013) Burden of *Giardia duodenalis* infection and its adverse effects on growth of schoolchildren in rural Malaysia. PLoS Negl Trop Dis 7(10):2516

Al-Zain B, Al-Hindi A (2005) Distribution of Strongyloides stercoralis and other intestinal parasites in household in Beit-lahia city, Gaza Strip, Palestine. Ann Alquds Med 1:48–52

Arani AS, Alaghehbandan R, Akhlaghi L, Shahi M, Lari AR (2008) Prevalence of intestinal parasites in a population in south of Tehran, Iran. Rev Inst Med Trop Sao Paulo 50(3):145–149

Choy SH, Al-Mekhlafi HM, Mahdy MA, Nasr NN, Sulaiman M, Lim YA et al (2014) Prevalence and associated risk factors of *Giardia* infection among indigenous communities in rural Malaysia. Sci Rep 4(4):6909

Croner CM, Sperling J, Broome FR (1996) Geographic information systems (GIS): new perspectives in understanding human health and environmental relationships. Stat Med 15(18):1961–1977

Easow JM, Mukhopadhyay C, Wilson G, Guha S, Jalan BY, Shivananda PG (2005) Emerging opportunistic protozoa and intestinal pathogenic protozoal infestation profile in children of western Nepal. Nepal Med Coll J 7(2):134–137

Fakhar M, Kialashaki E, Sharif M (2014) An overview on the present situation of Giardiasis in Iran and the world with emphasis on zoonotic aspects. J Mazandaran Univ Med Sci 24(113):235–251

Faraji R, Ahmadian F, Javadi GR, Barshahi PM (2015) Prevalence of Giardiasis among children in childcare centers in Kermanshah, Iran. Int J Res Med Sci 3(7):1717–1720

Feng Y, Xiao L (2011) Zoonotic potential and molecular epidemiology of *Giardia* species and giardiasis. Clin Microbiol Rev 24(1):110–140

Gholami S, Rahimi-Esboei B, Mousavi P, Marhaba Z, Youssefi MR, Rahimi MT (2016) Survey on efficacy of chloroformic extract of *Artemisia annua* against *Giardia lamblia* trophozoite and cyst in vitro. J Parasit Dis 40(1):88–92

Hakim GD, Kızıltaş Ş, Çiftçi H, Göktaş Ş, Tuncer I (2011) The prevalence of giardia intestinalis in dyspeptic and diabetic patients. ISRN Gastroenterol. https://doi.org/10.5402/2011/580793

Heidari A, Rokni M (2003) Prevalence of intestinal parasites among children in day-care centers in Damghan-Iran. Iran J Public Health 32(1):31–34

Jethwa D, Chaudhri U, Chauhan D (2015) Prevalence of Giardia infection in paediatric age group. Int J Curr Microbiol Appl Sci 4(8):907–911

Khoshnood S, Saki J, Rafiei A, Alizadeh K (2015) Prevalence of intestinal parasitic infections among people in Baghmalek during 2013–2014. Jentashapir J Health Res 6(2):24792

Mahni MB, Rezaeian M, Eshrat Beigom K, Raeisi A, Khanaliha K, Tarighi F et al (2016) Prevalence of intestinal parasitic infections in Jiroft, Kerman Province, Iran. Iran J Parasitol 11(2):232–238

Martin SW, Michel P, Holt J, Middleton D, Wilson J (2003) Geographical and temporal distribution of human giardiasis in Ontario, Canada. Int J Health Geogr 2(1):5

Noor Azian M, San Y, Gan C, Yusri M, Nurulsyamzawaty Y, Zuhaizam A et al (2007) Prevalence of intestinal protozoa in an aborigine community in Pahang, Malaysia. Trop Biomed 24(1):55–62

Quihui L, Valencia ME, Crompton DW, Phillips S, Hagan P, Morales G et al (2006) Role of the employment status and education of mothers in the prevalence of intestinal parasitic infections in Mexican rural schoolchildren. BMC Public Health 6(1):225–232

Rahimi-Esboei B, Gholami S, Ghorbani Pasha Kolaei A, Pour Haji Baqer M, Hasannia H, Shaban R et al (2013) Laboratories performance after outsourcing in the hospitals of Shahid Beheshti University of Medical Sciences. Med Lab J 7(2):37–41

Rayani M, Unyah NZ, Hatam G (2014) Molecular identification of *Giardia duodenalis* isolates from Fars province, Iran. Iran J Parasitol 9(1):70

Reinthaler FF, Feierl G, Stünzner D, Marth E (1998) Diarrhea in returning Austrian tourists: epidemiology, etiology, and cost-analyses. J Travel Med 5(2):65–72

Robertson L, Gjerde B (2001) Occurrence of parasites on fruits and vegetables in Norway. J Food Prot 64(11):1793–1798

Savioli L, Smith H, Thompson A (2006) Giardia and Cryptosporidium join the 'neglected diseases initiative'. Trends Parasitol 22(5):203–208

Sedighi I, Asadi M, Olfat M, Maghsood AH (2015) Prevalence and risk factors of *Giardia lamblia* and *Blastocystis hominis* infections in children under ten years old, Hamadan, Iran. Avicenna J Clin Microbiol Infect 2(2):22713

Shahdoust S, Niyyati M, Haghighi A, Azargashb E, Khataminejad MR (2016) Prevalence of intestinal parasites in referred individuals to the medical centers of Tonekabon city, Mazandaran province. Gastroenterol Hepatol Bed Bench 9(1):75–79

Shakkoury W, Wandy E (2005) Prevalence of *Giardia lamblia* infection in Amman, Jordan. Pak J Med Sci 21(2):199–201

Taheri F, Namakin K, Zarban A, Sharifzadeh G (2011) Intestinal parasitic infection among school children in South Khorasan Province, Iran. J Res Health Sci 11(1):45–50

Thomas K, Friederike D, Jugen S (2002) New perspectives on the use of Geographical Information Systems (GIS) in environmental health sciences. Int J Hyg Environ Health 205:169–181

Tork M, Sharif M, Yazdani Charati J, Nazar I, Hosseini SA (2016) Prevalence of intestinal parasitic infections and associated risk factors in west of Mazandaran Province, Iran. J Mazandaran Univ Med Sci 25(134):81–88

Wani SA, Ahmad F, Zargar SA, Amin A, Dar ZA, Dar PA (2010) Intestinal helminthiasis in children of Gurez valley of Jammu and Kashmir State, India. J Glob Infect Dis 2(2):91–94

Yakoob J, Jafri W, Abid S, Jafri N, Hamid S, Shah HA et al (2005) Giardiasis in patients with dyspeptic symptoms. World J Gastroenterol 11(42):6667

Yoder JS, Harral C, Beach MJ, CfD Control (2010) Prevention. Giardiasis surveillance—United States, 2006–2008. MMWR Surveill Summ 59(6):15–25

Zhou X-N, Lv S, Yang G-J, Kristensen TK, Bergquist NR, Utzinger J, Malone JB (2009) Spatial epidemiology in zoonotic parasitic diseases: insights gained at the 1s[t] International Symposium on Geospatial Health in Lijiang, China, 2007. Parasites Vectors 2(10):1–16