EPIDEMIOLOGY AND PUBLIC HEALTH IMPORTANCE OF FOODBORNE PROTOZOAN DISEASES

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Abstract

Food-borne illnesses comprise a broad spectrum of diseases and are responsible for substantial morbidity and mortality worldwide. It is result from consumption of food containing pathogens such as bacteria, viruses, parasites or the food contaminated by poisonous chemicals or bio-toxins. Many parasitic infections are associated with poor sanitation, contaminated food and water, overcrowding, under nutrition, and other poverty-related factors. Current estimates showed that at least more than one-quarter of the world's population is chronically infected with intestinal parasites and that most of these infected people live in developing countries. Foodborne parasitic zoonoses include both helminthic and protozoan infections. Foodborne and waterborne protozoan diseases caused by *Cryptosporidium parvum*, *Cyclospora caytanesis, Giardia lamblia, Entamoeba histolytica, Balantium coli, Sarcocystis spp.* and *Toxoplasma gondii* affect many millions of people worldwide. Food borne protozoan infections have been recently identified as an important public health problem having considerable economic impact in terms of morbidity, loss of productivity and health care costs. Control of such foodborne protozoan infections is being improved by mass chemotherapy approaches using donated drugs. Education of consumers, food handlers, and food producers particularly regarding basic hygiene, sufficient cooking, and avoiding cross-contamination have all had an impact on food borne transmission of pathogens and remain imperative to food safety. It is important to strengthen veterinary services to enhance efforts to control infections in livestock.

Key words: Epidemiology, Foodborne protozoan infections, Public health, Zoonoses**Introduction**

Foodborne diseases include wide variety of illnesses and are considered as a growing public health problem worldwide. Causative factors include ingestion of foodstuffs contaminated with wide variety of organisms and chemicals. The contamination of food may occur at any stage in the food production process, which starts from harvesting in the field and ends in the consumer's plate. Though gastrointestinal symptoms are the most common clinical presentation of foodborne diseases, neurological, gynecological, immunological symptoms and even multiorgan failure are also peculiar to certain foodborne infections. These foodborne diseases represent a considerable burden of morbidity and mortality. It is difficult to determine the exact magnitude of mortality associated with foodborne illnesses (Helms *et al.,* 2003); however, an estimated 2 million deaths occurred worldwide due to gastrointestinal illness, during the year 2005 (Fleury *et al.,* 2008). More than 250 different foodborne illnesses are caused by various pathogens or by toxins (Linscott, 2011).The consumption of food containing pathogens such as bacteria, viruses, parasites or the food contaminated by poisonous chemicals or bio-toxins result in foodborne infections (WHO, 2011). Although majority of the foodborne illness cases are mild and self-limiting, severe cases can occur in high risk groups resulting in high mortality and morbidity in this group. The high risk groups for foodborne diseases include infants, young children, the elderly and the immunocompromised persons (Fleury *et al.,* 2008). While parasitic infections have received less attention than those caused by bacteria (Cox, 2002), they are among the dominant contributors of morbidity and mortality and, hence, major public health problem worldwide.

Many parasitic infections are associated with overcrowding, poor sanitation, contaminated food and water, lack of nutrition, and other poverty-related factors. The parasitic diseases continue to be a significant health problem in both developed and developing countries. Current estimates showed that

more than 1/4th population of world is chronically infected with intestinal parasites; most of them live in developing countries (Chala, 2013). Foodborne parasitic zoonoses include both helminthic and protozoan infections. Amongst 1500 known infectious agents for human being, 66 are protozoa and 287 are helminths (Chomel, 2008) and only around 100 species are known to be foodborne (Orlandi *et al.*, 2002). The incidence of food borne and water borne protozoan diseases have also increased (Slifko *et al.*, 2000). Therefore, this review is aimed to provide current epidemiological status of foodborne protozoan diseases and their public health significances.

Foodborne Protozoan Diseases

Toxoplasmosis

It is an important global protozoan zoonosis, which is caused by a protozoan parasite, *Toxoplasma gondii* (Pal, 2007). Organisms are obligate intracellular parasites and their infectious stages are tachyzoites, bradyzoites and the oocysts. They can be found in any organ but are common in skeletal muscles, cardiac muscles and brain (Parija, 2009). Clinical signs range from mild to severe pain due to invasion of muscle, brain and eyes. Toxolpasmosis can cause lymphadenopathy, fever, anorexia, malaise, headache, myalgia, or chorioretinitis (Pal, 2007).

Humans become infected by ingesting cysts (from undercooked meat/viscera), or oocysts released from the definitive host (the domestic cat) that contaminate food, water or the environment. Two outbreaks of acute toxoplasmosis involving 8 adult patients in Korea were linked to eating uncooked pork (Choi *et al.*, 2004). An outbreak of toxoplasmosis in one household linked to a common source of infected meat was described by Masur and co-workers (1978). Six of seven members of a household investigated for toxoplasmosis demonstrated high antibody titer consistent with recent infection; five of these members (83%) were symptomatic. The most common manifestations were fever and lymphadenopathy, which developed from seven to 18 days (mean 11 days) after a common source ingestion of infected meat. Similarly, De Silva and investigators (1984) reported a family outbreak of toxoplasmosis involving five members of a Lebanese family in Australia that was linked to consumption of Kibbi, a traditional Lebanese dish, which can occasionally incorporate raw meat. In case of milk, contradictory data are observed within risk assessment of its consumption and toxoplasmosis occurrence. Some papers reported positive correlations between drinking milk and infection transmission to humans, while others stated non significant influence of milk or milk products consumption (Boughattas, 2015). However, Sacks and others (1982) described raw goat's milk as vehicle of *Toxoplasma gondii* in a large family from Northern California.

The proper heating and freezing meat are the most efficient method to kill *T. gondii* tissue cysts. However, interventions to prevent mixing of infected meat into the food chain would be technically feasible in countries where the meat chain is well organized. Monitoring of farms and farm management can play an important role in the control of *Toxoplasma* infection (Kijlstra and Jongert, 2009).

Cryptosporidiosis

Cryptosporidiosis is an emerging food and waterborne protozoan zoonosis of global significance (Pal *et al.*, 2016).There are about 20 species of *Cryptosporidium*, seven of which have zoonotic significance (Fayer, 2004). But the vast majority of human cases of illness are caused by *C. parvum,* which has both human and animal reservoirs (Chalmers and Davies, 2010). Recently, molecular techniques demonstrated 2 distinct genotypes of *C. parvum:* genotype 1 (also known as the human or anthroponotic genotype), which appears to infect only humans, and genotype 2 (the bovine or zoonotic genotype), which infects humans, cattle, and other mammals (Xiao *et al.*, 1998). It is prevalent worldwide with a prevalence rate of 0.6% to 20% in western countries and 5 to 10% in Asia and Africa (Garcia, 2001). *Cryptosporidium* is also major cause of diarrhoeic disorders in man all over the world. The disease transmission occurs through contaminated water and food. Infected animals act as the major source of infection especially in patients that are immune-suppressed, suffering with HIV and suffering with chronic diseases. In immunocompetent patients, cryptosporidiosis is usually a self-limiting disease (Smith *et al.*, 2007).

Common symptoms of disease in humans are watery diarrhea, malaise, nausea, fever, anorexia, abdominal pain, and dehydration (Pal, 2007). The disease lasts longer than most bacterial gastrointestinal infections, usually 1–2 weeks. In immunocompromised individuals, the disease may be much more severe and persistent, with invasion of other organ systems including the lungs and the bile duct, and it is life threatening (Farthing, 2000).

Raw food items are often incriminated as a source of infection in cryptosporidiosis outbreak. A food-borne outbreak of cryptosporidiosis among guests and staff at a hotel restaurant in Stockholm county of Sweden in September 2008 was occurred due to consumption of bearnaise sauce containing chopped fresh parsley acted as vehicle of etiological agent (Insulander *et al.*, 2008). Similar outbreak occurred across England and Scotland was found to be associated with consumption of fresh pre-cut salad leaves (McKerr *et al.*, 2015). Yoshida and co-investigators (2007) reported outbreak of gastroenteritis caused by *C. parvum* genotype II (bovine) amongst 4 members from the same company who had eaten raw meat dish called "Yukke", a Korean style beef tartar and raw liver in Sakai City of Japan.

Cyclosporiasis

Cyclosporiasis is an emerging foodborne disease, caused by coccidian parasite *Cyclospora cayetanensis* (Pal and Boru, 2010). *Cyclospora* oocysts do not multiply outside the host. After fecal excretion, they do not sporulate and become infectious for days to weeks (Ortega *et al.*, 1993). Infection occurs via the fecal-oral route by ingestion of contaminated water or food (Pal and Boru, 2010). Human-to-human infection is made less likely because of the long sporulation time (at least 7 days) after shedding in feces. Most cases occur in tropical and subtropical countries. Cyclosporiasis is endemic in Nepal, Peru and Haiti (Herwaldt, 2000). It is a self-limiting infection in an immunocompetant host. This infection is associated with watery diarrhea, cramps, nausea, bloating, flatulence, weight loss and fatigue (Garcia, 2001).

Foodborne outbreaks of cyclosporiasis have been reported in the United States since the mid-1990s and have been linked to various types of imported fresh produce, including raspberries, basil, snow peas, mesclun lettuce and cilantro but not due to any of the frozen produce (Anonymous, 2017). Retrospective cohort study involving 94 of the 101 guests who attended a wedding reception at a restaurant in Boston, USA was conducted by Fleming and others (1998). Their findings concluded that it was a point source outbreak due to *C. cayetanensis*, with berries as the vehicle of transmission. Insulander and others (2010) reported an outbreak of *C. cayetanensis* infection involving 12 laboratory-confirmed and 6 probable cases in Stockholm County, Sweden. Imported sugar snap peas from Guatemala were the suspected vehicle, based on information obtained from patient questionnaires.

Amoebiasis

Among the *Entamoeba* species that infect humans, *Entamoeba histolytica* stands out as a pathogenic amoeba that can cause invasive intestinal and extra-intestinal disease worldwide (Stark, 2008). The main source of transmission is the chronically infected human who pass stools infected with cysts of *E. histolytica* that may contaminate fresh food or water through poor personal hygiene (Obadiah, 2012). Humans are the primary known reservoir for *E. histolytica*. The main source of transmission is the chronically infected human. Stools infected with the cyst form of the parasite may contaminate fresh food or water. The incubation period of intestinal amebiasis can vary, ranging from a few days to months or years, but is generally 1 to 4 weeks. The wide spectrum of intestinal infection ranges from asymptomatic to transient intestinal inflammation to a fulminate colitis with an array of manifestations that may include toxic megacolon and peritonitis (Tanyuksel and Petri, 2003).

Entamoeba histolytica is of highest clinical importance and considered as the only amoeba parasitic in the intestine of human beings. Mao and others (2009) studied the epidemiological aspect of an outbreak of amoebic dysentery in Jiangshan City of Zhejiang Province and observed 31 cases with *E. histolytica* with 74.2% (23 cases) of students and preschool children.

Of 160 travellers from various regions in Italy who had taken part in a five-day organized trip to Phuket, Thailand, and been accommodated in the same luxury hotel, 17 showed either amebic abscess or colitis. Overall, parasitological examinations were negative in eight (13.8%) patients, and 50 out of 58 (86.2%) were found to be positive. The prevalence of *Giardia lamblia* and *E. histolytica* infections was 67.2% and

72.4%, respectively, and 28 subjects (48.3%) were stool-positive for both of these protozoa. the consumption of drinks with ice, ice cream and raw fruit in ice was significantly associated with *E. histolytica* and/or *G. lamblia* infections (de Lalla *et al.*, 1992).

Contamination of food and water with human faeces must be prevented.Treatment of asymptomatic cyst passers is suggested to check the spread of infection. Boiling of water kills *E. histolytica* cysts and should be encouraged, especially in endemic developing nations. Uncooked foods, including salads and vegetables should be properly washed and treated with vinegar before consumption (Escobedo *et al.*, 2003; Pal,2007).

Sarcocystosis

Sarcocystosis is a foodborne protozoan zoonosis, which has been reported in humans from Asia, Europe South America and North America (Pal, 2007). The life-cycle is heteroxenous with herbivores primarily acting as intermediate hosts, containing sarcocysts and carnivores including humans, serving as definitive hosts (Macpherson *et al.*, 2000). There are two known species of *Sarcocystis* that can infect humans. *Sarcocystis hominis* produces diarrhea, stomachache and nausea following consumption of raw beef that contains muscle cysts. *Sacrocystis suihominis* produces more severe but similar clinical signs following ingestion of uncooked pork containing muscle cysts (Olson and Guselle, 2000).

Sarcocystis involves pig-man cycle (*Sarcocystis suihominis)* and cattle-man cycle (*Sarcocystis hominis*), in which man act as definitive host. The sporulated oocysts are passed out through faeces and intermediate host (pig) gets the infection through ingestion of contaminated food and water. Numerous species of *Sarcocystis* infect cattle, sheep, pigs, horses, camels, buffalo and wild game animals. Heavy infections in these intermediate hosts may cause abortion, anorexia, fever, anaemia and reduced live weight gain (Macpherson *et al.*, 2000).

Humans acquire *S. hominis* by consumption of uncooked beef containing zoitocysts. *Sarcocystis hominis* is only mildly pathogenic in humans, causing stomach pains, nausea and diarrhea. Sporocysts begin to be passed in the faeces after 14 to 18 days (11 to 13 days after infection with *S. suihominis*). *Sarcocystis suihominis* is acquired by eating zoitocysts in undercooked pork. *Sarcocystis suihominis* is more pathogenic than *S. hominis*, causing stomach pains, nausea, diarrhoea and dyspnoea within 24 hours of infection (Macpherso *et al.*, 2000).

Prevention and Control

Control of several parasitic diseases is being improved by mass chemotherapy approaches. Also notable is the need for very long term and consistent application of strategies with full community involvement and critical appraisal of barriers to success as disease control programs (Hotez *et al.*, 2007).

Communication and educational campaigns aimed at different target groups such as consumers, food producers, parents, children, food handlers, and street vendors will play an important role in the prevention of foodborne diseases. Disinfection of drinking water, cleaning and washing of vegetables and fruits, sewage treatment, pasteurization of milk, freezing, retort canning, proper cooking of fish and sea-foods, sanitation in food establishments, periodic examination of food handlers, protection of food and water contamination from faecal matter, strict meat inspection of food animals and the use of antimicrobial compounds have all reduced the prevalence of food borne pathogens and, consequently, food borne diseases (Pal, 2007). In developed countries, surveillance of foodborne disease has become a fundamental component of food safety systems (Gervelmeyer, 2008).

Conclusion

Foodborne illnesses comprise a broad spectrum of diseases and are responsible for substantial morbidity and mortality throughout the world. It is a growing public health problem in developing as well as developed countries and difficult to determine the exact mortality associated with foodborne illness. Foodborne illnesses can occur following the consumption of food containing pathogens or bio-toxins or poisonous chemicals. A plethora of factors are associated with foodborne and waterborne protozoan

diseases. Sanitation, personal hygiene and public health education are of pivotal significance in combating food and water related protozoan infections. Attempts should be made to develop safe, potent, and cost effective vaccine to prevent the protozoan diseases.

References

Anon. (2017). U.S. Foodborne Outbreaks of Cyclosporiasis- 2000-2015. Available at https://www.cdc.gov/parasites/cyclosporiasis/outbreaks/foodborneoutbreaks.html.

Boughattas, S. (2015). Toxoplasma infection and milk consumption: Meta-analysis of assumptions and evidences. Crit Rev Food Sci Nutr. DOI: 10.1080/10408398.2015.1084993

Chala, B. (2013). A retrospective analysis of the results of five-year (2005-2009) parasitological examination for common intestinal parasites from bale-Robe Health Center, Robe Town, Southeastern Ethiopia. ISRN Parasitol., doi: 10.5402/2013/694731.

Chalmers, R. and Davies, A. 2010. Mini review: clinical cryptosporidiosis. Exp. Parasitol., 124: 138-146.

Choi, W.Y., Nam, H.W., Kwak, N.H., Huh, W., Kim, Y.R., Kang, M.W., Cho, S.Y. and Dubey, J.P. (1997). Foodborne outbreaks of human toxoplasmosis. J Infect Dis. 175: 1280-1282.

Chomel, B.B. 2008. Control and prevention of emerging parasitic zoonoses. Internat. J. Parasitol., 38: 1211-1217.

Cox, F.E. 2002. History of human parasitology. Clin. Microbiol. Rev., 15: 595-612.

de Lalla, F., Rinaldi, E., Santoro, D., Nicolin, R. and Tramarin, A. (1992). Outbreak of *Entamoeba histolytica* and *Giardia lamblia* infections in travellers returning from the tropics. Infect., 20: 78-82.

De Silva, L.M., Mulcahy, D.L., Kamath, K.R. (1984). A family outbreak of toxoplasmosis: a serendipitous finding. J. Infect., 8: 163-167.

Escobedo, M.A., Homedes, N., Aldana, V., Alt, K.V., Serrano, B.N. and Garcia, R. (2003). Assessment of parasitic diseases in children in five communities in the border region of Far West Texas. Texas Department of Health Office of Border Health (TDH), pp 120.

Farthing, M.J.G. (2000). Clinical aspects of human cryptosporidiosis. In: Petry, F. (Ed.), Cryptosporidiosis and Microsporidiosis, Contrib. Microbiolo. 6. pp. 5074.

Fayer, R. (2004). Cryptosporidium: a water-borne zoonotic parasite. Vet. Parasitol., 126: 37-56.

Fleming, C.A., Caron, D., Gunn, J.E. and Barry, M.A. (1998). A foodborne outbreak of *Cyclospora cayetanensis* at a wedding: Clinical features and risk factors for illness. Arch Intern Med. 158:1121-1125.

Fleury, M.D., Stratton, J., Tinga, C., Charron, D.F. and Aramini, J. (2008). A descriptive analysis of hospitalization due to acute gastrointestinal illness in Canada, 1995- 2004. Canadian J. Publ. Hlth., 99 (6): 489-493.

Garcia, L.S. (2001). Diagnostic Medical Parasitology. 4th Edn., ASM Press, Washington DC.

Gervelmeyer, A. (2008). Developing the community reporting system for food borne, outbreaks. Euro. Surveill., 13: 45.

Helms, M., Vastrup, P., Gerner-Smidt, P. and Molbak, K. (2003). Short and long term mortality associated with foodborne bacterial gastrointestinal infections: registry based study. British Med. J. (Clinical Research Ed.), 326: 357.

Herwaldt, B.L. (2000). Cyclosporacayetanensis: A review, focusing on the outbreaks of cyclosporiasis in the 1990s. Clin. Infect. Dis., 31: 1040-1057.

Hotez, P.J., Molyneux, D.H., Fenwick., A, Kumaresan, J., Sachs, S.E. and Savioli, L. (2007). Control of neglected tropical diseases. New England J. Med., 35: 1018-1027.

Insulander, M., de Jong, B. and Svenungsson, B. (2008). A food-borne outbreak of cryptosporidiosis among guests and staff at a hotel restaurant in Stockholm county, Sweden. Euro. Surveill., 13: 19071.

Insulander, M., Svenungsson, B., Lebbad, M., Karlsson, L. and de Jong, B. (2010). A foodborne outbreak of Cyclospora infection in Stockholm, Sweden. Food-borne Patho. Dis., 7: 1585-1587.

Kijlstra, A. and Jongert, E. (2009). Toxoplasma-safe meat: close to reality. Trends. Parasitol. 25: 18-22.

Linscott, A. J. 2011. Food-Borne Illnesses. Clin. Microbiol. Newsl., 33: 41-45.

Macpherson, C.N., Gottstein, B. and Geerts, S. (2000). Parasitic food-borne and water-borne zoonoses. Rev. Sci. Tech. 19: 240-258.

Masur, H., Jones, T.C., Lempert, J.A., Cherubini, T.D., De Silva, L.M., Mulcahy, D. L. and Kamath, K.R. (1978). Outbreak of toxoplasmosis in a family and documentation of acquired retinochoroiditis. Am. J. Med. 64: 396-402.

Mao, L.X., Zheng, J.J., Wang, X.M., Yao, L.N., Cheng, H.L. and Zhu, Q.G. (2009). Epidemiological investigation on an outbreak of amoebic dysentery in Jiangshan city of Zhejiang Province. Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi. 27: 182-183.

McKerr, C., Adak, G.K., Nichols, G., Gorton, R., Chalmers, R.M., Kafatos, G., Cosford, P., Charlett, A., Reacher, M., Pollock, K.G., Alexander, C.L. and Morton, S. (2015). An outbreak of *Cryptosporidium parvum* across England and Scotland associated with consumption of fresh pre-cut salad leaves. PLoS One 10: e0125955

Obadiah, H.I. (2012). Review of the survey of *Entamoeba histolytica* in Children; a brief focus on Nigeria Situation: A review. J Phys. Pharm. Adv., 2: 150-157.

Olson, M.E. and Guselle. N. (2000). Are pig parasites a human health risk? Adv. Pork Prod., 11: 153.

Orlandi, P., Chu, D., Bier, J., Jackson, G., 2002. Parasites and the food supply. Food Technol. 56, 72-80.

Ortega, Y.R., Sterling, C.R., Gilman, R.H., Cama, V.A. and Diaz, F. (1993). *Cyclospora* Species: A new protozoan pathogen of humans. New England J. Med., 328: 1308-1312.

Pal, M. (2007). Zoonoses. Satyam Publishers, Jaipur, India.

Pal, M. and Boru, B.G. (2010). *Cyclospora cayetanensis*: An emerging food-borne pathogen. J.Natural History 6: 9-11.

Pal, M., Tefese,W.,Tilhan,G. and Anberber,M. 2016. Cryptosporidiosis: An emerging food and waterborne protozoan disease of global significance. Food Beverage World 43: 43-45.

Parija, S.C. (2009). A Textbook of Medical Parasitology. 3rd Edition. All India Publishers and Distributors, New Delhi, India.

Robertson, L.J. (2013). Have foodborne parasites finally become a global concern? Trends Parasitol. 29: 101-103.

Sacks, J.J, Roberto, R.R. and Brooks, N.F. (1982). Toxoplasmosis infection associated with raw Goat's Milk. J Am Med Assoc., 248: 1728-1732.

Sciutto, E. (2013). Development of the S3PVAC vaccine against porcine *Taenia solium* cysticercosis: A historical review. J. Parasitol, 99: 686–692.

Slifko, T.R., Smith, H.V. and Rose, J.B. (2000). Emerging parasite zoonoses associated with water and food. Internat. J. Parasitol., 30: 1379-1393

Smith, H.V., Caccio, S.M., Cook, N., Nichols, R.A.B. and Tait, A. (2007). *Cryptosporidium* and *Giardia* as food-borne zoonoses. Vet. Parasitol, 149: 29-40.

Stark, D. (2008). Invasive amebiasis in men who have sex with men, Australia. Emerg. Infect. Dis., 14: 141-1143.

Tanyuksel, M. and Petri, W.A. (2003). Laboratory diagnosis of Amebiasis. Clin. Microbiol. Rev., 16: 713–729.

WHO. (2011). Initiative to estimate the global burden of foodborne diseases: Information and publications. World Health Organization. Available at .

Xiao, L., Sulaiman, I., Fayer, R. and Lal, A.A. (1998). Species and strain-specific typing of Cryptosporidium parasites in clinical and environmental samples. Mem Inst Oswaldo Cruz. 93: 687-691.

Xiao, L.H. and Fayer, R. (2008). Molecular characterisation of species and genotypes of *Cryptosporidium* and *Giardia* and assessment of zoonotic transmission. Internat. J. Parasitol, 38: 1239-1255.

Yoshida, H., Matsuo, M., Miyoshi, T., Uchino, K., Nakaguchi, H., Fukumoto, T., Teranaka, Y. and Tanaka, T. (2007). An outbreak of cryptosporidiosis suspected to be related to contaminated food, October 2006, Sakai City, Japan. Jpn. J. Infect. Dis., 60: 405-407.