In developed countries, including Australia, France, Japan, Netherlands, New Zealand, Sweden U.K. and US, *Campylobacter* is one of the most frequently reported causes of acute infectious diarrhea. An estimated 2.5 million cases of campylobacteriosis are recorded every year in USA [8]. *Campylobacters* are responsible for approximately 17% of hospitalizations resulting from food-borne infections [14]. Annual economic cost due to *Camyplobacter* associated illnesses is estimated up to US $8 billion in the United States [15]. In 2004, 183,961 cases of *Campylobacter* infections were reported from 25 European Union countries [7].

In developing countries, direct animal-to-man transmission may be common as people live in close association with food animals; and waterborne transmission can occur due to poor sanitation [16]. The failure of routine water treatment in developed nations can cause sporadic and large outbreaks [16]. The present communication delineates the growing role of *Campylobacter jejuni* as an emerging foodborne pathogen of global public health importance.

Etiology

The name *Campylobacter* derived from the Greek word "Kampylos," which means curved. Presently, the genus *Campylobacter* consists of 17 species and 6 subspecies of which *C. jejuni* is most commonly reported as a cause of gastroenteritis in humans [17]. The organism is Gram-negative, non-spore-forming, microaerophilic, motile, catalase positive, oxidase positive, nitrate positive, hippurate positive, indole production negative and glucose utilization negative [7]. The bacterium can be curved, spiral, or occasionally straight rods, with size ranging from 0.2 to 0.9 μm wide and 0.5 to 5 μm long, and optimum growth temperature range from 35 to 45°C [18]. *Campylobacter jejuni* is quite sensitive to heat, drying, irradiation, freezing and salt concentration above 1% sodium chloride and is readily killed during pasteurization, and cooking [7].

Host

Natural infection in humans due to *C. jejuni* is reported from many countries of the world including India [6,17]. The organism has been isolated from baboon, cat, cattle, chicken, dog, duck, ferret, goat, horse, monkey, ostrich, pig, sheep, shellfish, turkey, and water fowl [11,17].

Transmission

Faecal-oral route is the principal mode of transmission of *C. jejuni*. Humans get the infection by consumption of unpasteurized milk, untreated water, fresh chicken, and uncooked meat of cattle, pig and sheep, which are contaminated with organisms. Close contact with diseased animals and their discharges can also transmit the infection. Clinically healthy animals may also be a source of infection [11]. It is pertinent to mention that the carcass of food animal may be contaminated during slaughtering with feces containing *C. jejuni* [17]. Swimming in natural resources of water may pose a risk to *Campylobacter* infection [19]. Humans may act as vectors by transferring the organism into poultry production area with contaminated clothing and foot wear [20]. Poultry is implicated in 50%-70% of human *Campylobacter* infections [21].

Clinical Spectrum in Humans

The incubation period of *C. jejuni* infection is 1-10 days with most people exhibiting clinical symptoms by 4 days [21]. The affected persons exhibit the signs of diarrhoea with mucus and blood, acute abdominal pain, fever, malaise, nausea and vomiting, headache, myalgia, arthritis, and occasionally endocarditis, meningitis, septicaemia and abortion [11,17]. The abdominal pain may persist for a week. The pain is so severe that it may be confused with appendicitis. The ileum, jejunum, colon and in few cases rectum are inflamed. The illness is most often self-limiting, as symptoms diminish after a few days up to two weeks. However, the excretion of organisms in faeces may continue for 14 to 21 days [21]. Some patients may develop Guillain-Barre syndrome, which is manifested with acute flaccid paralysis [7].

Epidemiology

The epidemiology of campylobacteriosis is still not well studied. The disease has been described from developed as well as developing nations of the world [4-7,17]. *Campylobacter jejuni* is the leading bacterial zoonotic pathogen, which may serious infection in children, elderly and immunocompromised patients [7,22]. The prevalence of *C. jejuni* infection in AIDS patients is about forty fold as compared to unaffected patients. Low levels of immunoglobulins in AIDS patients, make them sensitive to severe, persistent and recurrent *C. jejuni* infections [23]. *Campylobacter jejuni* and *C. coli* are the two main human gastroenteric pathogens, and are responsible for more than 95% of food-borne diseases [4]. An estimated 2.5 million cases of *C. jejuni* are diagnosed each year in the United States alone [8]. In the United Kingdom, 82% of people admitted to hospital with a diagnosis of food poisoning, were found to be suffering from *Campylobacter* infections [3]. The organism has been isolated from poultry, beef, pork, fish, fish products, milk, vegetables, surface water, lakes and rivers [7]. The cross contamination of *Campylobacter* from raw chicken to prepared food is recognized as an important risk factor. It is reported that approximately 50 % of sporadic cases of Campylobacter infections in European countries are related due to handling or ingestion of chicken meat [24]. *Campylobacter jejuni* is also an important causative agent of traveler's diarrhea [9].

Unpasteurized milk, cheeses, butter, and yoghurt can act as vehicle of pathogen. Epps and co-investigators [21] reported that 12% of raw bovine milk samples in a dairy farm were contaminated with *C. jejuni* possibly as a result of contact with bovine faeces, contaminated water or direct contamination due to mastitis. McNaughton and co-workers [25] investigated an outbreak of *Campylobacter* enteritis due to ingestion of raw milk. Several studies have demonstrated the contamination of surface water such as streams, lakes and rivers with *Campylobacter* [26,27]. It was mentioned that *C. jejuni* was the major *Campylobacter* species present in water as revealed by *Campylobacter* species-specific PCR assays [28].

A recent study conducted on 3186 faecal samples from diarrheic patients in Kolkata, India revealed 7% isolation rate of *Campylobacter* species. In this investigation, *C. jejuni* was identified as the predominant species (78%). There was no seasonal prevalence as infection was prevalent throughout the year. Further, the recovery of *C. jejuni* was significantly was higher in children who had diarrhoea [*6*]. It is emphasized that growing role of *C. jejuni* should be further investigated in all cases of diarrhoea, and dysentery. It is also imperative to study the real magnitude of *C. jejuni* infections.

Diagnosis

As campylobacteriosis simulate to other diarrheal diseases such as salmonellosis, shigellosis, colibacillosis, it is, therefore, imperative to confirm the diagnosis by employing standard laboratory tests. Direct demonstration of 'S' or comma shaped organism in freshly voided stool by dark field microscopy is a simple and cheap method to make diagnosis. The pathogen can be isolated from stool, rectal swab, bile, blood and other clinical specimens on several media such as Butzler's agar, Preston medium, Skirrow medium, *Campylobacter* thioglycollate medium, *Campylobacter* cefoperazone desoxycholate agar, semi-solid Campylobacter medium, *Campylobacter* Blaser agar and Campy-Brucella agar plate [7,11,29]. Immunological tests such as passive haemagglutination, complement fixation and ELISA are also useful to demonstrate antibody titer in sera samples. Currently, real time PCR is employed to screen *C. jejuni* in fecal samples [6]. Multiplex-PCR can be applied for confirmatory identification of *C. jejuni* and *C. coli* isolates, both at genus and species level [30,31]. Pulsed field gel electrophoresis (PFGE) is considered as the reference typing method for *Campylobacter* species [32].

Treatment

In many patients, therapy with antimicrobial drugs is usually not attempted due to mild and self-limited nature of *Campylobacter* infections. Nevertheless, treatment is recommended in patients who are immunocompromised or show high fever, bloody stools, and prolonged illness. Erythromycin and azithromycin are considered as the drugs of choice [7]. Some isolates of *Campylobacter jejuni* are susceptible to azithromycin, clarithromycin, erythromycin, chloramphanicol and gentamicin and some showed resistance to ciprofloxacin, norfloxacin, oflooxacin and nalidixic acid. Multiple resistances to two or more antibacterial antibiotics are also observed [6]. It is advised that electrolyte balance should be restored to prevent dehydration in *Campylobacter* enteritis.

Prevention and Control

Currently, no prophylactic vaccine is available to protect the susceptible population against *C. jejuni* infection. However, avoiding the use of untreated water, unpasteurized milk, undercooked red meat, raw poultry, hygienic handling of foods, sanitary disposal of faeces and other faeces soiled articles, biosecurity at poultry farm, good hygienic practices at meat processing plants, application of hazard analysis critical control point, training of abattoir workers, keeping children away from sick pets, active surveillance, personal hygiene and health education on basic principles of food hygiene will certainly reduce the incidence of campylobacteriosis, which has emerged as an important foodborne zoonosis of global importance [11,17].

Conclusion

Microbial food pathogens still remain a major public health concern all over the world, which endangers the health of people and leads to socioeconomic costs. *Campylobacter jejuni* is one of the most important the causes of bacterial diarrheal disease in the world. The reservoirs of this organism include poultry, cattle, sheep, pig, and wild birds. The epidemics of *Campyobacter* infections are related to ingestion of raw milk, untreated water, and contact with infected animals. Multidrug resistance is frequently detected in many isolates of *C. jejuni*. It is imperative to pay attention to food safety from farm to table to prevent *C. jejuni* infection. Attempts should be made to develop a potent, safe and low cost vaccine to immunize the animals against a number of zoonotic foodborne pathogens including *C. jejuni*. It is emphasized to undertake further studies on the risk factors, host agent interaction and faecal carriage of bacterium in various food animals.

Acknowledgements

The author is highly indebted to Prof. Dr. R. K. Narayan for his critical comments during the preparation of the manuscript. Thanks are also due to Anubha for helping in computer work.

References

1. Pal M (2013) Public health concern due to emerging and re-emerging zoonoses. Inter J Livestock Research 3: 56-62.
2. Pal M, Mahendra R (2015) Sanitation in Food Establishments. 1st ed. LAMBERT Academic Publishing, Saarbrchen, Germany.
3. Adak G, Cowden J, Nicholas S, Evans H (1995) The public health laboratory service national case-control study of primary indigenous sporadic cases of Campylobacter infection. Epidemiol Infect 115: 15-397.
4. Allos BM (2001) Campylobacter jejuni infections: update on emerging issues and trends. Clin Infect Dis 32: 1201-1206.
5. Coker AO, Isokpehi RD, Thomas BN, Amisu KO, Obi CL (2002) Human campylobacteriosis in developing countries. Emerg Infect Dis 8: 237-243.
6. Mukherjee S, Babitzke P, Kearns DB (2013) FliW and FliS function independently to control cytoplasmic flagellin levels in Bacillus subtilis. J Bacteriol 195: 297-306.
7. Pal M (2014) Impact of emerging bacterial foodborne pathogens on human health. Ph.D. Lecture Notes. Addis Ababa University, College of Veterinary Medicine, Debre Zeit, Ethiopia. pp.1-15.
8. Bhaduri S, Cottrell B (2004) Survival of cold stressed Campylobacter jejuni on ground chicken and chicken skin during frozen state. App Environ Microbiol 70:7103-7109.
9. Hadush A, Pal M (2013) Detection of Camylobacter from foods and its epidemiology. J Pub Health Epidemiol 5: 357-361.
10. Wagenaar JA, French NP, Havelaar AH (2013) Preventing Campylobacter at the source: Why is it so difficult? Clin Infect Dis 57: 1600-1606.
11. Pal M (2007) Zoonoses. 2nd ed. Satyam Publishers, Jaipur, India.
12. WHO (2012) The global view of campylobacteriosis: report of an expert consultation, Utrecht, Netherlands, 9-11 July 2012.
13. Mishu B, Blaser MJ (1993) Role of infection due to Campylobacter jejuni in the initiation of Guillain-Barré Syndrome. Clin Infect Dis 17: 104-108.
14. Mead PS, Slutsker L, Dietz V, McCaig LF, Bresee JS, et al. (1999) Food-related illness and death in the United States. Emerg Infect Dis. 5: 607-625.
15. Buzby JC, Allos BM, Roberts T (1997) The economic burden of Campylobacter associated Guillain-Barré syndrome. J Infect Dis 176: 192-197.
16. Suzuki H, Yamamoto S (2009) Campylobacter contamination in retail poultry meats and by-products in Japan: A literature Survey of Food Control. J Food Cont 20: 531-537.
17. WHO (2016) Campylobacter Fact Sheet. World Health Organization, Geneva, Switzerland.
18. Cox NA, Richardson LJ, Musgrove MT (2010) Campylobacter jejuni and other Campylobacters. Juneja VK and Sofos JN (Edit). Pathogens and Toxins in Foods Challenges and Interventions. ASM Press, Washington, DC.
19. Schonberg-Norio D, Takkinen J, Hanninen ML, Katila ML, Kaukoranta SS, et al. (2004) Swimming and Campylobacter infections. Emerging Infect Dis 10: 1474-1477.
20. Doyle P, Beuchat R (2007) Food Microbiology. Fundamentals and Frontiers 3rd Edition. Washington DC. ASM Press pp. 817-836.

21. Epps SV, Harve RB, Hum ME, Phillip TD, Anderso RC, et al. (2013) Foodborne Campylobacter: Infections, metabolism, pathogenesis and reservoirs. Int J Environ Res Public Health 10: 6292-6304.
22. Humphrey TJ, O'Brien S, Madsen M (2007) Campylobacters as zoonotic pathogens: A food production perspective. Int J Food Microbiol 117: 237-257.
23. Barros-Velázquez J, Jiménez A, Villa TG (1999) Isolation and typing methods for the epidemiologic investigation of thermotolerant campylobacters. Internat Microbiol 2: 217-226.
24. Jacobs-Reitsma WF (1997) Aspects of epidemiology of Campylobacter in poultry. Vet Quarterly 19: 113-117.
25. McNaughton RD, Leyland R, Mueller L (1982) Outbreak of Campylobacter enteritis due to consumption of raw milk. Can Med Assoc J 126: 657-658.
26. Eyles R, Niyogi D, Townsend C, Benwell G, Weinstein P (2003) Spatial and temporal patterns of Campylobacter contamination underlying public health risk in the Taieri River, New Zealand. J Environ Qual 32: 1820-1828.
27. Denis M, Tanguy M, Chidaine B, Laisney MJ, Me´graud F, et al. (2011) Description and sources of contamination by Campylobacter spp. of river water destined for human consumption in Brittany, France. Pathologie Biologie 59: 256-263.
28. Lu J, Ryu H, Vogel J, Domingo JS, Ashbolta NJ (2013) Molecular detection of Campylobacter spp. and fecal indicator bacteria during the northern migration of sandhill cranes (Grus canadensis) at the Central Platte River. Appl Environ Microbiol 79: 3762-3769.
29. Jeffrey JS, Hunter A, Atwill ER (2000) A field–suitable, semisolid aerobic enrichment medium for isolation of Campylobacter jejuni in small numbers. J Clin Microbiol 38: 1668-1669.
30. Linton D, Lawson AJ, Owen RJ, Stanley J (1997) PCR detection, identification to species level, and fingerprinting of Campylobacter jejuni and Campylobacter coli direct from diarrheic samples. J Clin Microb 35: 2568-2572.
31. Denis M, Soumet C, Rivoal K, Ermel G, Blivet D, et al. (1999) Development of a m-PCR for simultaneous identification of Campylobacter jejuni and Campylobacter coli. Lett Appl Microbiol 29: 406-410.
32. Behringer M, Miller WG, Oyarzabal OA (2011) Typing of Campylobacter jejuni and Campylobacter coli isolated from live broilers and retail broiler meat by flaA-RFLP, MLST, PFGE and REP-PCR. J Microbiol Methods 84: 194-201.