***SALMONELLA***

**Key Facts**

* *Salmonella* is 1 of 4 key global causes of diarrheal diseases.
* In the European Union over 90,000 salmonellosis cases are reported every year. EFSA has estimated that the overall economic burden of human salmonellosis could be as high as EUR 3 billion a year.
* *Salmonella* is commonly found in the intestines of healthy birds and mammals.
* Most cases of salmonellosis are mild; however, sometimes it can be life-threatening. The severity of the disease depends on host factors and the serotype of *Salmonella*.
* Antimicrobial resistance is a global public health concern and *Salmonella* is one of the microorganisms in which some resistant serotypes have emerged, affecting the food chain.
* Cross-contamination is one of the most important factors for the spread of salmonellosis.

**Introduction**

*Salmonella* is a bacterium that can cause an illness called salmonellosis in humans. *Salmonella* is a gram negative rods genus belonging to the *Enterobacteriaceae* family. Within 2 species, *Salmonella bongori* and *Samonella enterica*, over 2500 different serotypes or serovars have been identified to date. *Salmonella* is a ubiquitous and hardy bacterium that can survive several weeks in a dry environment and several months in water.

*S. enterica* species is further divided into six subgroups based on host range specificity, which also involves immunoreactivity of three surface antigens, O, H and Vi. Many different diseases are caused by more than 1,400 serotypes of this bacteria genus.

*Salmonella* derived from Dr. Salmon, a U.S. veterinary surgeon, who discovered and isolated the strain enterica or choleraesuis from the intestine of a pig in 1885. *Salmonella* are found in the intestinal tract of humans, and many animals, including domestic animals, such as chicken and cattle.

Salmonellae are motile, except S. pullorum and S. gallinarum and express peritrichous flagella. They are facultative anaerobes that can grow in a temperature range of 5-45 °C with optimum temperature 35-37 °C. They are able to grow at low pH and are generally sensitive to increased concentrations of salt.

A few of salmonellae are host-specific and can reside in only one or a few animal species: for example, *Salmonella enterica* serotype Dublin in cattle and *Salmonella enterica* serotype Choleraesuis in pigs. Most serotypes, however, are present in a wide range of hosts. Typically, such serotypes cause gastroenteritis. This group features *Salmonella enterica* serotype Enteritidis and *Salmonella enterica* serotype Typhimurium, the two most important serotypes of *Salmonella* transmitted from animals to humans in most parts of the world.

**Source and Transmission**

*Salmonella* bacteria are widely distributed in the intestinal tract of domestic and wild animals. They are prevalent in food animals such as poultry, pigs, and cattle; and in pets, including cats, dogs, birds, and reptiles such as turtles. *Salmonella* can pass through the entire food chain from animal feed, primary production, and all the way to households or food-service establishments and institutions.

Risk of infection in humans is associated with the consumption of contaminated food, mainly eggs and poultry meat. Dairy products including cheese and ice-cream were also implicated in the outbreaks. However, fruits and vegetables such as lettuce, tomatoes, cilantro, alfalfa sprouts and almonds have also been implicated in recent outbreaks.

Person-to-person transmission can also occur through the faecal-oral route. Human cases also occur where individuals have contact with infected animals, including pets. These infected animals often do not show signs of disease.

In addition to primary contamination of animals used in food production, contamination with *Salmonella* can sometimes reach up to 50-100%, especially due to the cross-contaminaiton during the slaughtering in stages such as defeathering, evisceration and cooling. Eggs are also reservoirs for particularly serovar Enteritidis, as this organism can colonize the ovary of the laying hen. Such transovarian transmission allows bacteria to be present in the egg before the eggshell is formed in the oviduct.

One of the most important reasons for *Salmonella* to be in the first place in food infections is due to its high resistance to environmental conditions and its long-term viability in food.

**The disease**

*Salmonella* causes two main forms of disease in human: typhoid (enteric) fever and gastroenteritis (non-typhoid salmonellosis). Enteric fever is a systemic disease characterized by fever and abdominal pain caused by dissemination of *Salmonella* Typhi or *Salmonella* Paratyphi type A, B, or C. Fever (38.8-40.5°C) is documented at presentation in more than 75% of cases and is typically prolonged, continuing up to 4 weeks if untreated. In contrast to other *Salmonella*serotypes, the etiologic agents of enteric fever have no known hosts other than humans. Most commonly, food- or water-borne transmission results from fecal contamination by ill or asymptomatic chronic carriers. Typhoid fever is most common in parts of the world that have poor sanitation and limited access to clean water. If diagnosed at an early stage, the infection is likely to be mild and can usually be treated with a 7- to 14-day course of antibiotic.

Gastroenteritis is the most common clinical presentation of nontyphoidal *Salmonella* infection. The incubation period is typically 6–72 hours (usually 12–36 hours); while atypical, illness has been documented even 14 days after exposure. Illness is commonly manifested as acute diarrhea, abdominal pain, fever, and sometimes vomiting. The illness usually lasts 4–7 days, and most people recover without treatment. The infectivity of *Salmonella* varies depending on the serovar, the food, the age and health condition of the affected people.

The minimal infection dose (MID) is reported to be 108-109 cfu/g (colony-forming unit) or 105-106 cfu/g in many other sources, although there are major differences in MID, serotypic virulence, individual defense mechanism and food composition. For example, the high fat content in the foods such as cheese, chocolate and salami provides the protection of the agent against the stomach acid and causes the infective dose to be low. A significant salmonellosis outbreak has been reported due to the consumption of minced meat containing high virulent *S.* Newport at 60-2300 cfu/g. It has also been reported that 50 cfu/g. of a strain of *S.* Napoli caused an infection.

Treatment in severe cases is electrolyte replacement and rehydration. Routine antimicrobial therapy is not recommended for mild or moderate cases in healthy individuals. This is because antimicrobials may not completely eliminate the bacteria and may select for resistant strains, which subsequently can lead to the drug becoming ineffective. However, health risk groups such as infants, the elderly, and immunocompromised patients may need to receive antimicrobial therapy. Antimicrobials are also administered if the infection spreads from the intestine to other body parts.

*Salmonella* infection usually isn't life-threatening. However, in certain people — especially infants and young children, older adults, transplant recipients, pregnant women, and people with weakened immune systems — the development of complications can be dangerous. Dehydration, septicemia and reactive arthritis are the main complications.

**Prevention**

Prevention requires control measures at all stages of the food chain, from agricultural production, to processing, manufacturing and preparation of foods in both commercial establishments and at home.

In this framework, animals raised for food production should be healthy and contamination of animal shelters, feed, feed additives and water with *Salmonella* should be prevented. Effective cleaning, disinfection processes and personnel hygiene should be emphasized to prevent secondary and cross contaminations that are formed at different stages of the production chain. In addition, taking care of the continuity of the cold chain and general hygienic measures in distribution and sales stages, taking care of personnel and kitchen hygiene on consumer basis is important.

The following recommendations will help ensure safety;

* Ensure food is properly cooked and still hot when served.
* Avoid raw milk and products made from raw milk. Drink only pasteurized or boiled milk.
* Wash hands thoroughly and frequently using soap, in particular after contact with pets or farm animals, or after having been to the toilet.
* Wash fruits and vegetables carefully, particularly if they are eaten raw. If possible, vegetables and fruits should be peeled.
* To prevent cross-contamination; store raw meat, poultry and seafood away from other foods in your refrigerator, if possible, have two cutting boards in your kitchen — one for raw meat and the other for fruits and vegetables, never place cooked food on an unwashed plate that previously held raw meat.
* Avoid eating raw eggs. If you must consume raw eggs, make sure they've been pasteurized.
* Five keys to safer food; keep clean, separate raw and cooked, cook thoroughly, keep food at safe temperatures, use safe water and raw materials.

***CAMPYLOBACTER***

**Key Facts**

* *Campylobacter* is considered to be the most common bacterial cause of human gastroenteritis in the world.
* *Campylobacter* infections are generally mild, but can be fatal among very young children, elderly, and immunosuppressed individuals.
* The bacteria normally inhabit the intestinal tract of warm-blooded animals such as poultry and cattle, and are frequently detected in foods derived from these animals.
* *Campylobacter* species can be killed by heat and thoroughly cooking food.

**Introduction**

Despite their widespread occurrence, *Campylobacter* species were not understood as a cause of diarrhea in humans until 1957, and their impact in terms of sheer numbers of human infections emerged only in the past 20 years. The first recognized *Campylobacter* infections were reported in the early part of the 20th century and occurred in farm animals. In 1973, the new genus *Campylobacter* was proposed. Finally, the development and increasingly widespread use of selective media for isolation of *Campylobacter* from stool samples in the 1970s led to the recognition in the early 1980s of the importance of these infections as a cause of human gastrointestinal illness. By the mid-to-late 1980s, it had been determined that *Campylobacter* species are one of the most common bacterial causes of diarrhea worldwide.

The family *Campylobacteraceae* consists of two genera, *Campylobacter* and *Arcobacter* and occur primarily as commensals in humans and domestic animals. The genus *Campylobacter* contains small (0.2–0.8 μm × 0.5–5 μm) Gram-negative, slender spirally curved rods. The majority of the species have a corkscrew-like motion by means of a single polar unsheathed flagellum at one or both ends of the cell. The only exceptions are *Campylobacter gracilis* which is non-motile and *Campylobacter showae* which has multiple flagella.

Thermophilic *Campylobacter* species are able to grow between 37 and 42°C, but incapable of growth below 30°C. *Campylobacter* grows best in a low oxygen or microaerophilic environment, such as an atmosphere of 5% O2, 10% CO2, and 85% N2. The organism is sensitive to freezing, drying, acidic conditions (pH ≤ 5.0), and salinity. Most *Campylobacter* species are resistant to cephalothin. Survival of *Campylobacter* outside the gut is poor, and replication does not occur readily. Under unfavorable growth conditions, these microorganisms have the ability to form viable but non-culturable cells (VBNC).

Currently, there are 17 species and 6 subspecies assigned to the genus *Campylobacter*, of which the most frequently reported in human diseases are *C. jejuni* (subspecies *jejuni*) and *C. coli*. Other species such as *C. lari* and *C. upsaliensis* have also been isolated from patients with diarrhoeal disease, but are reported less frequently.

**The Disease**

Campylobacteriosis is the disease caused by the infection with *Campylobacter*. Most typically, infection with *C. jejuni* results in an acute, self-limited gastrointestinal illness. The onset of disease symptoms usually occurs 2 to 5 days after infection with the bacteria, but can range from 1 to 10 days. People with *Campylobacter* infection usually have diarrhea (often bloody), fever, and abdominal cramps. The diarrhea may be accompanied by nausea and vomiting.

Local complications of *Campylobacter* infections occur as a result of direct spread from the gastrointestinal tract and can include cholecystitis, pancreatitis, peritonitis, and massive gastrointestinal hemorrhage. Extraintestinal manifestations of *Campylobacter* infection are quite rare and may include meningitis, endocarditis, septic arthritis, osteomyelitis, and neonatal sepsis. Bacteremia is detected in <1% of patients with *Campylobacter*enteritis and is most likely to occur in patients who are immunocompromised or among the very young or very old.

The most important postinfectious complication of *C. jejuni* infection is the Guillain-Barré syndrome (GBS). GBS a demyelating disorder resulting in acute neuromuscular paralysis that affects 1–2 persons per 100,000 population in the United States each year. GBS that occurs after *C. jejuni* infection is usually a more severe disease, associated with extensive axonal injury, a greater likelihood of the need for mechanical ventilation, and increased risk of irreversible neurological damage. GBS is thought to be autoimmune responses stimulated by infection.

Maintenance of hydration and electrolyte balance, not antibiotic treatment, is the cornerstone of treatment for *Campylobacter* enteritis. Indeed, most patients with *Campylobacter* infection have a self-limited illness and do not require antibiotics at all. Nevertheless, there are specific clinical circumstances in which antibiotics should be used. These include high fevers, bloody stools, prolonged illness (symptoms that last >1 week), pregnancy, infection with HIV, and other immunocompromised states.

**Source and Transmission**

*Campylobacter* species are widely distributed in most warm-blooded animals. They are prevalent in food animals such as poultry, cattle, pigs, sheep and ostriches; and in pets, including cats and dogs. The bacteria have also been found in shellfish. The avian species are the most common hosts for *Campylobacter* spp. probably because of their higher body temperature. Although all commercial poultry species can carry *Campylobacter* spp. the risk is greater from chicken because of the large quantities consumed.

The intestinal tract of chicken, especially the cecum and colon, can harbor a large number of *Campylobacter* spp.; during processing, the intestinal tract may leak or rupture and the contents are transferred to the skin of the carcass. *Campylobacter* spp. remain in a liquid film on the skin and become entrapped in its cervices and channels which provides a favorable environment for cross-contamination. Persistence and survival of *Campylobacter* spp. are fostered by a suitable microenvironment of the skin.

Most cases of human campylobacteriosis are sporadic. The main route of transmission is generally believed to be foodborne, via undercooked meat and meat products, as well as raw or contaminated milk. Most *Campylobacter*infections are associated with eating raw or undercooked poultry or from contamination of other foods by these items. Contaminated water or ice is also a source of infection. A proportion of cases occur following contact with contaminated water during recreational activities.

Levels of *Campylobacter* in excess of 103 cfu/processed broiler carcasses have been implicated in transmission of the organism to humans, resulting in human gastroenteritis.

**Prevention**

Although *Campylobacter* spp. have been generally regarded as sensitive to the environment exterior to animals, they are in fact more resilient than previously thought. Also, it is now recognized that campylobacters can attain the state of VBNC, that can lead to under-estimation or non-detection of the organism by culture-based techniques, yet cells in this state can still infect susceptible hosts. However, campylobacters are sensitive to drying or even low humidity, freezing and freeze–thaw stress, oxygen, etc., so control, in general, should concentrate on these aspects where relevant.

Because most *Campylobacter* infections are acquired by consuming or handling poultry, the ideal way to control the number of human infections would be to limit contamination of poultry flocks. Epidemiologic studies indicate that strict hygiene reduces intestinal carriage in food producing animals. Measures to reduce the prevalence of *Campylobacter* in poultry include enhanced biosecurity to avoid transmission of *Campylobacter* from the environment to the flock of birds on the farm. Slaughter and processing provide opportunities for reducing *C. jejuni* counts on food-animal carcasses. Bacterial counts on carcasses can increase during slaughter and processing steps. Good hygienic slaughtering practices reduce the contamination of carcasses by feces, but will not guarantee the absence of *Campylobacter* from meat and meat products. Training in hygienic food handling for abattoir workers and raw meat producers is essential to keep contamination to a minimum.

Since *Campylobacter* spp. are heat sensitive, in domestic and catering settings cooking temperatures and times are sufficient to eliminate the organisms. Also, campylobacters can readily transfer and appear to attach to surfaces, cross-contamination needs to be avoided.