Campylobacteriosis: A One Health Perspective on Abortion and Zoonosis

30

Hafiza Dur E Najaf[1]†, Sana Asif[1]†, Talha Umer[2], Umair Ashraf[1], Muhammad Haseeb Qamar[1], Muhammad Talha Adil[1], Talha Mushtaq[1], Hassan Nawaz[1], Huma Jamil[1] and Saqib Umer[1]*

ABSTRACT

All infectious diseases that can transfer from vertebrate animals to humans are referred to as zoonotic diseases, or zoonosis. Contact with animals or their bodily fluids, ingestion of contaminated animal products, and exposure to contaminated environments are the ways in which these diseases can be acquired. Human infections with Campylobacter fetus can cause a variety of clinical symptoms, such as acute diarrhea, septicemia, and severe neurological problems. These infections can cause a variety of problems during pregnancy, including placentitis, abortion, and neonatal sepsis, highlighting the broad and catastrophic effects of C. fetal infection in both adults and infants. Efficient management and treatment of the disease depend on the timely and accurate detection of Campylobacter infection. Every diagnostic strategy discussed in this chapter, including molecular, immunological, serological, culture-based, and next-generation sequencing approaches, has advantages and disadvantages. The availability of laboratory resources, test duration, and other factors all play a role in the diagnostic approach that is selected. Antibiotics and supportive care are often used throughout treatment after a diagnosis has been made by laboratory analysis of stool samples. Good food hygiene practices, risk factor education, a single health approach, hand hygiene, and reporting to better understand and enhance preventative actions are all important components in preventing and controlling the illness. New campylobacteriosis diagnostic tests and treatment alternatives are being studied in ongoing research. The One Health concept, which recognizes the connection of human, animal, and environmental health, has proven critical in addressing the importance of campylobacteriosis for public health. Experts in environmental health, animal health, and human well-being must work together and coordinate in order to prevent, detect, and treat zoonotic illnesses. Overall, the chapter provides useful information for understanding, preventive and managing this infectious disease.

Keywords: Campylobacter, Zoonotic nature, Abortion, Reproduction, Public health

CITATION

Dur-e-Najaf H, Asif S, Umer T, Ashraf U, Qamar MH, Adil MT, Mushtaq T, Nawaz H, Jamil H and Umer H, 2023. Campylobacteriosis: A One Health Perspective on Abortion and Zoonosis. In: Altaf S, Khan A and Abbas RZ (eds), Zoonosis, Unique Scientific Publishers, Faisalabad, Pakistan, Vol 4: 392-406. https://doi.org/10.47278/book.zoon/2023.164

CHAPTER HISTORY Received: 27-March-2023 Revised: 05-May-2023 Accepted: 20-June-2023

[1]Department of Theriogenology, University of Agriculture, Faisalabad, 38000 Punjab, Pakistan

[2]Department of Clinical Veterinary Medicine, College of Veterinary Medicine, Huazhong Agricultural University, Wuhan, 430070, PR China
† Authors contributed equally
***Corresponding author:** saqib.umer@uaf.edu.pk

1. INTRODUCTION

Zoonosis or zoonotic disease, is the term used to describe any infectious disease that can spread from vertebrate animals to human. These diseases can be contracted through direct contact with animals or their body fluid, eating contaminated animal products, or being exposed to polluted environment. Various pathogens, including bacteria, viruses, parasites, and fungi can bring them on. Zoonotic diseases are a serious public health problem because they can cause outbreaks and epidemics. These diseases affect both humans and animals, causing a variety of signs and symptoms such as fever, gastrointestinal problems, respiratory issues, and abortion in mammals. One zoonotic disease caused by bacteria is Campylobacteriosis. Gram-negative bacteria with a distinctive curved or spiral-shaped rod appearance are called *Campylobacter*. Despite being fastidious, certain organisms can flourish in anaerobic circumstances, while others favor micro-aerobic ones (Kaakoush et al. 2015). In unfavorable growing conditions, *Campylobacter* species can produce viable but nonculturable cells (VBNC). Due to the organism's ability to establish colonization in hosts while remaining hidden by standard culture methods, this trait makes it difficult to undertake etiological research on the organism (Portner et al. 2007). Animals, such as cattle, birds, sheep, and pigs, have alimentary canals frequently colonised by commensal microbes called *Campylobacter* species. Because of avian relatively high body temperature, which creates an excellent development environment for this temperature-tolerant genus, avian species are recognized as a major reservoir of *Campylobacter* (Skirrow 1977). Therefore, it has been determined that poultry products, such as chicken meat, which is widely consumed by humans are the primary cause of gastroenteritis in people who are exposed to *Campylobacter* (Humphrey et al. 2007).

According to (Horrocks et al. 2009), specific bird species can spread the infection to broiler flocks horizontally and ultimately to people, particularly those who deal with or consume poultry (Humphrey et al. 2007). The three types of *Campylobacter—Campylobacter fetus ssp*. *fetus, Campylobacter coli*, and *Campylobacter jejuni*, are mainly present in the intestines and can be spread through fecal-oral contact, oral fluids, contaminated placenta, and fluids through the skin. The microorganisms can continue to spread across the flock from an aborting sheep to an uninfected one during outbreaks, which can result in pregnancy failure. A uterine infection in pregnant ewes can cause an abortion in the third trimester or the birth of a live infected lamb. Ewes often gain immunity to these bacteria after the initial infection. They can cause placentitis, which results in chorioallantois, yellow, friable cotyledons, and swelling tissue between the cotyledons. *C. jejuni* infections may cause serious consequences, such as Miller Fisher syndrome, arthritis, and Guillain-Barre syndrome (GBS) (Man 2011).

Certain nonzoonotic *Campylobacter* species, such as *C. concisus*, prevalent in the human oral cavity's microflora community, are of growing concern for non-zoonotic species. *C. concisus* is primarily found in healthy dental cavities, even though it was initially isolated from persons with periodontitis and gingivitis. Additional *Campylobacter* species have also been discovered in oral cavities, including *C. ureolyticus* and *C. curvus*. It has been proposed that a few species, namely *C. gracilis*, *C. rectus*, and *C. showae*, are the primary agents of periodontal diseases. Although some studies concentrated on their possible role in periodontal disease, more recent studies have mostly examined these species' ability to cause intestinal disorders such as inflammatory bowel disease (IBD) and gastroenteritis.

This chapter focuses mainly on the zoonotic species of *Campylobacter*, including their pathogenesis, symptoms, one health perspective, impact on reproduction, diagnostics, and preventative with therapeutic options (Man 2011).

2. CAUSES OF CAMPYLOBACTERIOSIS

Campylobacteriosis is caused by the genus *Campylobacter*. There are 24 species in the Campylobacter genus, and the *Campylobacter fetus* is significant due to its zoonotic significance. The *Campylobacter* bacteria frequently bring on a bacterial infection known as campylobacteriosis. The infection is typically contracted by consuming contaminated food and water or touching contaminated animals or their feces (Rukambile et al. 2019). The bacteria can infect meat during slaughtering and processing and are frequently detected in the intestines of animals, particularly poultry. Infections can also come via unpasteurized milk, uncleaned water, and contaminated vegetables while *C. fetus subspecies venerealis* mostly affects the reproductive systems of cattle and can cause infertility and abortion, *C. fetus subspecies fetus* is frequently found in the intestinal tracts of numerous animals, including cattle and sheep (Mahlangu et al. 2022).

Overall, understanding the cause, unique characteristics and habitats of *Campylobacter* bacteria is important for diagnosing, treating, and preventing infections caused by this bacterium.

3. PATHOGENESIS

According to studies on the pathogenesis of *Campylobacter* bacteria, the disease is mostly caused by the virulence of the infecting strain as well as the sensitivity of the host. It takes at least 800 organisms to cause the infection by consuming contaminated food or water (Lopes et al. 2021). The main events involved in the pathogenesis of campylobacteriosis are motility, chemotaxis, translocation, adhesion, invasion, and toxin generation. High motility and a spiral form allow the *Campylobacter* bacteria to get through the gastrointestinal mucus and attach to enterocytes, which are gut cells that release toxins to cause diarrhea. Depending on the strain, bacteria secrete different toxins, such as cytotoxins and enterotoxins, that vary in form and potency. The sort of discharged toxin, which might be minor to severe, determines how serious will be the enteritis. Immunoglobulin levels rise during the infection, with IgA being the most crucial because it may pass the gut barrier. IgA renders organisms immobile by causing aggregation and complement activation, granting temporary immunity against the pathogenic strain. Other types of immunoglobulins operate to stop bacteremia by concentrating on bacteria that enter the bloodstream. Bacteria can activate the cellular immune system. To infect healthy animals, the sick animal releases bacteria through body secretions, aborted fetus, and placenta (Fritz and Byers 2023). Pathogenesis of bacteria is shown in Fig. 1:

3.1. Pathogenesis of abortion

Bacteria enter into the body of animal by oral route from where they go to blood circulation. After entering the bloodstream, the organism induces a brief period of bacteremia lasting for approximately 1 to 2 weeks before it localizes in the chorionic epithelial cells and ultimately enters the fetus, where it causes abortion. Histopathological examination of placenta from an aborted ewe showed severe neutrophilic and fibrinonecrotizing placentitis (Dorsch et al. 2022). The placenta has a strong infiltration of inflammatory cells, as shown in the first image of Fig. 2. The second one has been highly magnified to demonstrate placentitis. The third one displays the arteriolitis of arterioles of chorion (Dorsch et al. 2022).

4. SYMPTOMS AND CLINICAL MANIFESTATIONS OF CAMPYLOBACTERIOSIS

Human Campylobacteriosis infection can cause a variety of clinical signs, including acute diarrheal illness and systemic illness (Man 2011). The location of the scattered pathogen affects the later appearances.

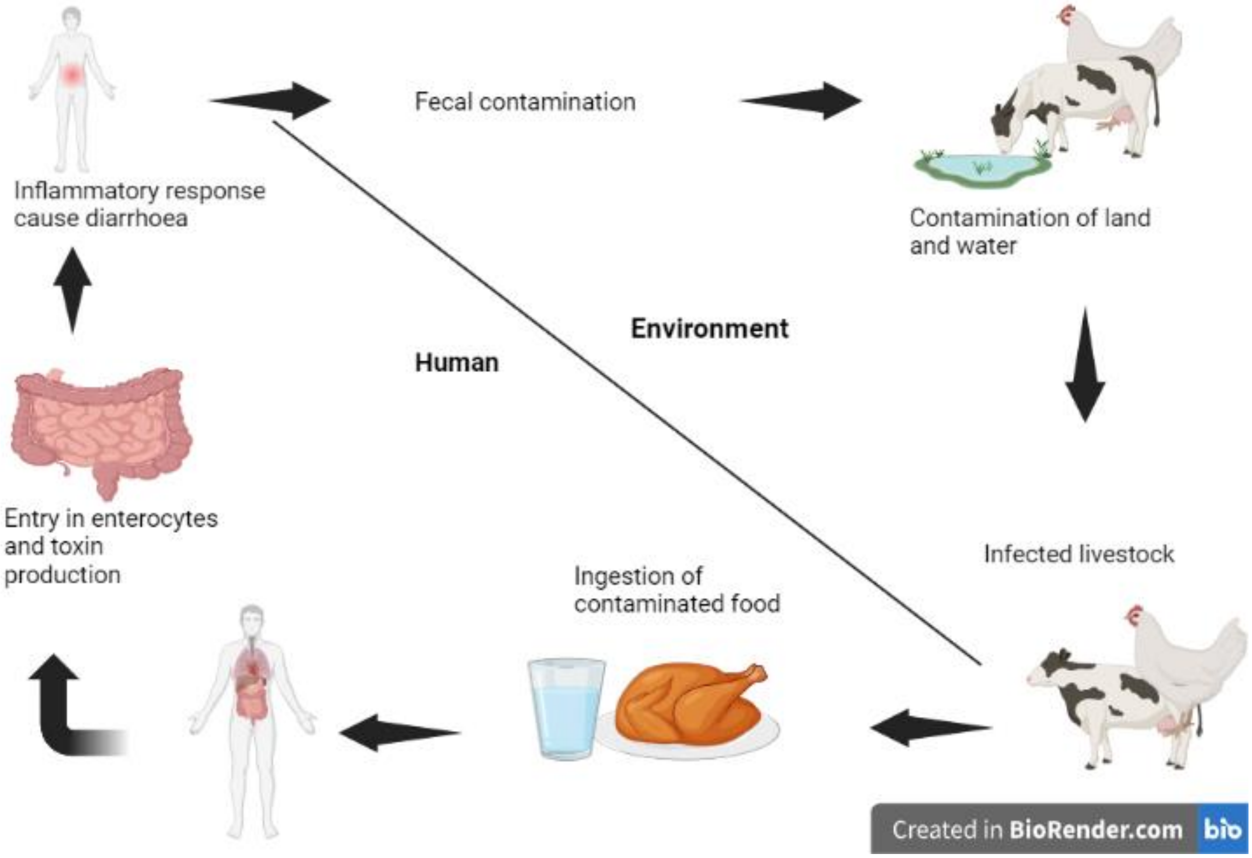

Fig. 1: Lifecycle and pathogenesis of *Campylobacter.*

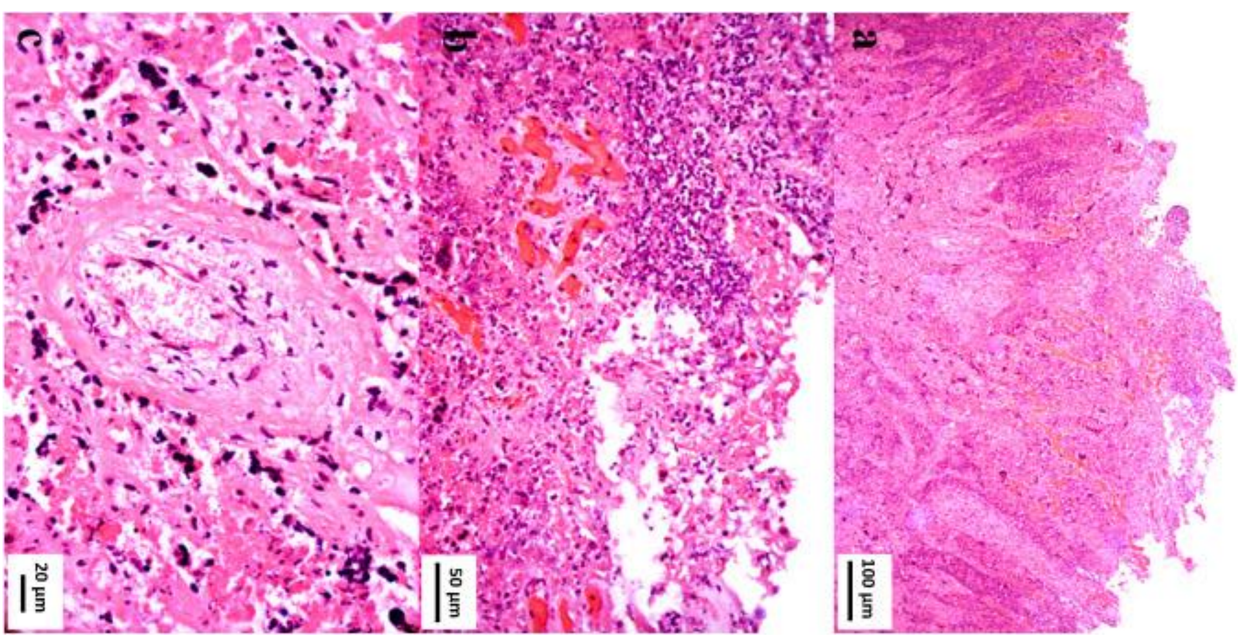

Fig. 2: The pathological changes in placenta (Dorsch et al. 2022).

Patients may occasionally display septicemia, a condition marked by fever without any obvious localized infection (Gazaigne et al. 2008). Neurological disorders such as meningitis, meningoencephalitis, brain abscesses, or subdural empyema may manifest as a consequence of *C.fetal* infection. Additionally, manifestations of this infection can include osteomyelitis, arthritis, lung abscesses, and prenatal illnesses such as endometritis, placentitis, and abortion (Man 2011). Additionally, vascular consequences from this kind of infection can include endocarditis, mycotic aneurysms, vasculitis, pericarditis, or thrombophlebitis. Any stage of pregnancy might experience *Campylobacter fetus* infections, which can cause a variety of clinical symptoms including fever, loss of appetite, placentitis, abortion, irregular estrus, prolonged breeding seasons and diarrhea. Infected pregnant women occasionally go through spontaneous miscarriages without exhibiting any other clinical symptoms (Fujihara et al. 2006). Additionally, babies with *C. fetus* infections are more likely to experience *C. fetus* sepsis, which can result in meningitis and have potentially fatal consequences. Nine of the 14 infants in the study who had *C. fetus* sepsis died, underscoring the seriousness of neonatal diseases (Fujihara et al. 2006). A *C. fetus* infection in the mother is typically linked to perinatal infections. Numerous research investigations on the subject have validated these conclusions. According to the data, the majority of *C. fetus* infections in people are brought on by *C. fetus subsp. fetus*, while *C. fetus subsp. venerealis* is identified from vaginal secretions (Holst et al. 1987). The pattern of subspecies distribution in bovine infections, where the reproductive system is colonized by *C. fetus subsp. venerealis*, which is also replicated in human infections. The ratio of *C. fetus subsp. fetus* to *C. fetus* sub spp. *venerealis*. Despite this, *venerealis* in human isolates is not well known, and subspecies identification is not frequently done in human diagnostic laboratories. In order to better understand the epidemiology of these diseases, it is advised that subspecies identification to be used in the investigation of these infections (Kalka-Moll et al. 2005).

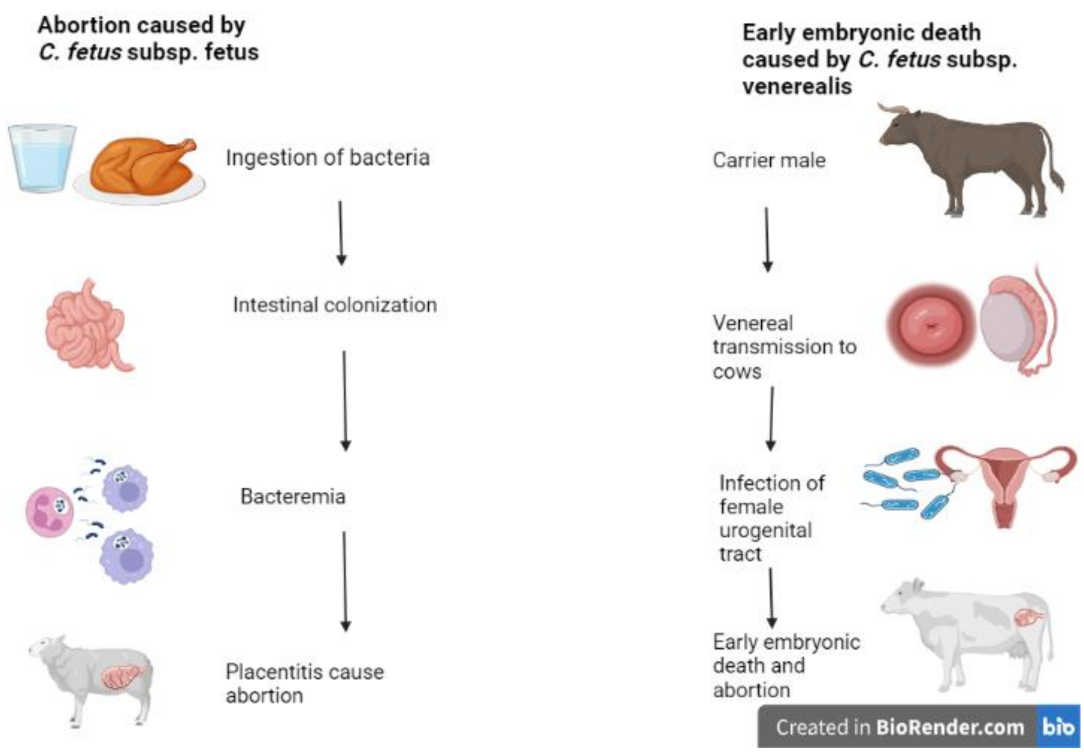

Fig. 3: Reproductive clinical manifestation of Campylobacteriosis.

Here we discuss briefly about the other complications caused by *Campylobacter* bacteria.

4.1. TERMINATION OF PREGNANCY (ABORTION)

According to researchers, *Campylobacter* can cause sporadic abortions in humans (Sahin et al. 2012) and termination of pregnancy in both large and small ruminants worldwide. Although *C. jejuni* outbreaks are becoming more frequent, *C. fetus* still accounts for most abortions in animals (Sahin et al. 2017). Septic abortion caused by *C. fetus* infection in the placenta was documented in early-pregnant women (Simor et al. 1986), and the first clinical instance of C. fetus-induced abortion in humans was testified in 1947 (Hannah et al. 2016).

Campylobacter-related abortion is more frequently seen in animals, although in America, the rate of *Campylobacter*-related abortion in bovine ranges from 1.78 to 15.99%. Additionally, a highly pathogenic *C. jejuni* clone known as clone SA that causes sheep abortions in the United States has been discovered by researchers (Sahin et al. 2012). The ability of clone SA to cause abortions was studied in a guinea pig model (Plummer et al. 2012), though there is currently no proof that it causes abortions in humans. However, it is impossible to completely rule out the possibility that clone SA will impact human abortions, thus more research is necessary.

4.2. GASTROENTERITIS

Globally, *Campylobacter* can induce gastrointestinal tract inflammation. This disease, which affects domestic animals, was first discovered in the 20th century. According to (Acheson and Allos 2001), the bacteria *Campylobacter* can lead to septic abortions in animals, especially sheep, cattle, and pigs. Since it is a zoonotic bacterium, it is also a frequent cause of gastroenteritis in humans, primarily through ingesting contaminated food, particularly poultry. Diarrhea, fever, and abdominal pain are some of the symptoms and signs of gastroenteritis brought on by *Campylobacter*, and they are comparable to those brought on by other pathogens including *Shigella* and *Salmonella* (Acheson and Allos 2001). To avoid misinterpretation based simply on clinical symptoms, diagnosis requires the isolation of *Campylobacter* from stool samples (Galanis 2007).

C. jejuni, which invades the gastrointestinal system and colonizes the colon and reduces the capacity of intestinal cell to absorb nutrients, is the primary cause of gastroenteritis brought on by *Campylobacter* (Konkel et al. 2001). Although *Campylobacter* gastroenteritis usually cures on its own within a few days, serious cases may necessitate the administration of antibiotics like azithromycin, erythromycin, or amoxicillin (Galanis 2007). Early detection is crucial because Guillain-Barre syndrome (GBS), a severe neurological condition that can develop after a *C. jejuni* infection, is frequently seen after the onset of *Campylobacter* gastroenteritis (Kuroki et al. 1993).

Campylobacter gastroenteritis can affect people of all ages, it is more frequently observed in infants and young adults. In order to stop the infection from spreading, it is crucial to take the essential precautions, such as proper handling and boiling food properly.

4.3. SEPSIS

Septicemia, also known as sepsis, is a health condition characterized by a bacterial pathogen that infects the bloodstream (Singer et al. 2016). Peritonitis, pancreatitis, sepsis, meningitis, and septic arthritis are some serious problems that can result from *Campylobacter* sepsis (Acheson and Allos 2001). A major cause of septicemia is *C. fetus*, especially in individuals who are extremely elderly or young, drink alcohol, have weakened immune systems, have had gastrointestinal surgery in the past, or have HIV infection (Nagy and Hla 2013). Even when infected with *Campylobacter* spp., healthy persons with a strong immune system can also get recurrent septicemia (Krause et al. 2002). The most frequent causes of gastrointestinal illnesses in humans are *C. jejuni* and *C. coli*, however, infrequently (less than 1% of cases) lead to septicemia (Krause et al. 2002). To treat septicemia brought on by *Campylobacter* spp., various antibiotics including erythromycin, imipenem, carbapenem, and gentamicin can be administered (Krause et al. 2002). According to a study by the researcher, carbapenem effectively treated newborn sepsis caused by *C. fetus* (Fujihara et al. 2006).

4.4. INFLAMMATORY BOWEL DISEASE (IBD)

The two main types of inflammatory bowel disease (IBD), ulcerative colitis and Crohn's disease (CD), both cause chronic inflammation of the gastrointestinal tract and exhibit symptoms like extreme abdominal pain, diarrhea, weight loss, and fatigue (Lee and Chang 2003).IBD has become more prevalent all over the world (Molodecky et al. 2012), and it is thought that the gut microbiota, which contains bacterial pathogens such as invasive *Escherichia coli, Fusobacteria, Campylobacter,* and *Mycobacteria*, are responsible. IBD is likely to be influenced by environmental and genetic predisposition factors, despite its primary etiology being unknown (Sartor 2006).

Campylobacter spp. has been linked to IBD in several studies, with IBD patients having a greater prevalence of the bacteria in their intestinal samples. Eight different *Campylobacter* species, including *C. concisus*, *C. showae*, *C. hominis*, *C. rectus*, *C. gracilis*, *C. jejuni*, and C. ureolyticus, were isolated from patients. *C. concisus* was the most often seen species. (Zhang et al. 2009).

Numerous studies have been conducted on the connection between specific *Campylobacter* species strains and inflammatory bowel disease (IBD) emergence. According to studies, the prevalence of human oral *Campylobacter* species, including as *C. concisus* and *C. showae*, is higher in IBD patients' biopsy samples of the gut than in healthy people. Despite being mostly present in the mouth cavity, *C. concisus* has been found in the intestine of IBD patients and may be spread via saliva and food. Additionally discovered in the oral cavity, *C. showae* is strongly linked to an increased risk of IBD (Zhang 2015). Other *Campylobacter* species, including *C. gracilis, C. hominis, C. rectus, C. curvus, C. jejuni,* and *C. ureolyticus*, have also been noticed more frequently in IBD patients. However, the specific main specie of bacteria that cause IBD is not yet clear. *Campylobacter* species may be linked to the development of IBD, however additional research is required to prove this.

In conclusion, although evidence points to a potential connection between the development of IBD and certain *Campylobacter* bacteria, further research is required to validate this association. However, the discovery of human oral *Campylobacter* species in IBD patients' guts emphasizes the need for additional research into how these bacteria contribute to the progression of this disease.

4.5. PERIODONTITIS

Periodontitis is a common chronic inflammatory disorder brought on by the oral pathogenic bacterial species found in dental plaque. It weakens the connective tissue and other tissues that support the teeth and eventually results in tooth loss (Pihlstrom et al. 2005). *Campylobacter* species are one of the major bacteria in human periodontal spaces and have a significant influence on periodontitis development at various stages. Different *Campylobacter* species found in the oral cavity are intimately associated to various phases of periodontitis development in individuals with active damaging periodontal disease, *C. rectus*, for example, is a common *Campylobacter* species discovered in deeper subgingival pockets and plaque (Gmur and Guggenheim 1994). However, in patients with refractory periodontitis, *C. gracilis* and *C. concisus* are more common than health-associated bacteria. However, there is still a dearth of information regarding *C. concisus* involvement in oral infections.

While *C. rectus* was once believed to have a connection to periodontitis, the validity of many other *Campylobacter* species, including *C. gracilis*, C. curvus, and *C. concisus*, is still debatable (Henne et al. 2014). Therefore, further study is required to determine how these *Campylobacter* species affect tooth infections.

5. DIAGNOSTIC TECHNIQUES FOR CAMPYLOBACTERIOSIS

Due to the high prevalence of Campylobacteriosis, accurate and timely diagnosis is crucial for effective treatment and management of the disease. So here we will discuss the various diagnostic techniques that are used to identify and diagnose *Campylobacter* infection.

5.1. CULTURE-BASED METHODS

Culture-based methods are the gold standard for diagnosing *Campylobacter* infection. These methods involve isolating the bacteria from clinical samples such as stool, blood, or tissue, and then growing them in a laboratory setting (Özcan et al. 2022). The most commonly used culture media for *Campylobacter* isolation are selective media, such as *Campylobacter* blood-free selective agar (CCDA), and non-selective media, such as blood agar. The culture-based methods require specific laboratory conditions, such as microaerophilic conditions, and can take 3-4 days to obtain a positive result.

Table 1: Diseases caused by *Campylobacter* species and symptoms.

Diseases	Symptoms and risk factors	Zoonotic spp.	Reference
Abortion	One highly virulent clone of *C. jejuni*, known as SA, is primarily associated with sheep rather than humans.	C. fetus, *C. jejuni*,	(Sahin et al. 2012)
Gastroenteritis	*Campylobacter* spp. colonizes the intestinal epithelium. This colonization leads to a reduction in intestinal absorption capacity. *Campylobacter* spp. destroys cell structures and relocates across cells. The bacteria use several proteins to aid in their relocation. Biofilm formation is another mechanism used by *Campylobacter* spp. for relocation.	*C. coli* *C. jejuni*,	(Konkel et al. 2001)
Sepsis	Bacteria in blood. Low immunity level, Age, consumption of alcohol, History of gastric and intestinal surgery, and HIV infection .	*C. jejuni* C. fetus, *C. coli* C. lari,	(Nagy and Hla 2013)
IBD	Inflammation of GIT, pain, diarrhea. Presence of *Campylobacter* in the oral cavity may impact inflammatory bowel disease (IBD), although a direct correlation has not been established.	*C. jejuni* *C. hominis*,	(Mukhopadhya et al. 2011)
Periodontitis	The severity and stages of periodontitis are influenced by various *Campylobacter* species present in the oral cavity.	Spp. that cause periodontitis are not zoonotic	(Henne et al. 2014)

5.2. MOLECULAR METHODS

Molecular methods have gained popularity recently due to their high sensitivity and specificity. These methods involve detecting the genetic material of the bacteria, such as DNA or RNA, in clinical samples. The most commonly used molecular methods for *Campylobacter* detection are polymerase chain reaction

(PCR) and real-time PCR (RT-PCR) (Bodie 2022). These methods are faster and more sensitive than culture-based methods, with results available within hours. However, molecular methods require specialized laboratory equipment and expertise, which may not be available in all settings.

5.3. SEROLOGICAL METHODS

Serological methods involve detecting the presence of antibodies against *Campylobacter* in the blood of infected individuals (Borovikov et al. 2023). These methods are not used for diagnosing acute infections but can be useful for identifying past infections or for epidemiological studies. The most commonly used serological method is the enzyme-linked immunosorbent assay (ELISA), which detects antibodies against *Campylobacter* in blood samples (Borovikov et al. 2023). However, serological methods have limitations, such as low sensitivity and specificity, and cross-reactivity with other bacteria.

5.4. IMMUNOLOGICAL METHODS

Immunological methods involve detecting the presence of antigens, or proteins, produced by *Campylobacter* in clinical samples. These methods are less commonly used for *Campylobacter* detection, but have the advantage of being rapid and easy to perform. The lateral flow assay is the most commonly used immunological method, which detects *Campylobacter* antigens in stool samples. However, immunological methods also have limitations, such as low sensitivity and specificity, and may require culture-based or molecular methods confirmation.

5.5. NEXT-GENERATION SEQUENCING

According to researchers, next-generation sequencing (NGS) is a high-through technology that enables the quick sequencing of substantial volumes of DNA or RNA (Tong et al. 2021). Because NGS offers a thorough examination of the bacterial genome, it has the potential to completely change how *Campylobacter* infections are diagnosed. This can assist in identifying certain genes linked to virulence or antibiotic resistance, which can inform management and treatment plans. However, NGS needs specialized laboratory tools and training, which can restrict its applicability in environments with little resources.

In conclusion, prompt and precise identification of *Campylobacter* infection is essential for efficient management and treatment of the disease. There are benefits and drawbacks to each diagnostic approach covered in this chapter, including culture-based techniques, molecular methods, serological methods, immunological methods, and next-generation sequencing. The choice of diagnostic technique is based on several variables, including the availability of laboratory resources and the length of the test, etc.

6. TREATMENT, PREVENTION AND CONTROL OF CAMPYLOBACTERIOSIS

Effective treatment, prevention, and control methods are crucial to decrease the prevalence and effects of campylobacteriosis.

6.1. TREATMENT OF CAMPYLOBACTERIOSIS

The majority of campylobacteriosis cases are self-limiting and disappear in a few days. Antibiotics, however, may occasionally be recommended in order to shorten the illness length and lessen the intensity of its symptoms. Antibiotics like erythromycin and azithromycin are frequently used to treat Campylobacteriosis (Dai et al. 2020). Hospitalization might be necessary in serious situations to deliver intravenous fluids and electrolytes to prevent dehydration. Inflammation can be decreased with the use of steroids. NSAIDs are administered in case of fever. In hospitals, patients receive symptomatic treatment.

6.2. PREVENTION AND CONTROL OF CAMPYLOBACTERIOSIS

By practicing appropriate cleanliness habits, campylobacteriosis can be avoided most successfully. This entails using separate cutting boards for raw and cooked meat, washing hands with soap and warm water before and after handling food, and cooking chicken to an internal temperature of 165°F (74°C). Additionally, it's crucial to avoid unpasteurized milk, untreated water, and raw or undercooked meat. Additionally, until they are completely well, those ill with diarrhea should refrain from cooking for others. Reduced animal-to-human transmission of the germs is the main goal of treatment for Campylobacteriosis. This can be accomplished by taking steps like enhancing biosecurity and hygiene on farms and in processing facilities and administering vaccines and antibiotics to animals. Additionally, a thorough food safety programme that monitors food production and processing, tests food products, and conducts public education campaigns can assist to lower the frequency of Campylobacteriosis. Probiotics can also help children's intestines build a healthy microbiota so that harmful microbes cannot thrive there (Dai et al. 2020).

6.3. VACCINATION

An efficient strategy to stop the spread of the disease is to utilize vaccines to prevent campylobacteriosis in animals (Jeon et al. 2022). The risk of contaminating the environment and food products can be decreased by vaccination since it reduces the amount of bacteria that animals shed in their faeces. The genetic variety of the bacterium has made it difficult to produce vaccinations that are effective against *Campylobacter*.
In healthy cows and heifers, VIBRIN is a vaccine that can be used to avoid campylobacteriosis (vibriosis) brought on by *Campylobacter fetus* (Rush and Edmondson 2021).

6.4. ANTIBIOTICS

Another strategy for preventing the spread of Campylobacteriosis in animals is the administration of antibiotics. Infected animals can be treated with antibiotics, which also stop the bacteria from spreading to other animals. However, the rise of antibiotic-resistant *Campylobacter* strains in animals has been linked to the use of antibiotics, which poses a serious concern to public health (Yang et al. 2019).

6.5. BIOSECURITY

Enhancing biosecurity protocols in hospitals, farms, and processing facilities is crucial for lowering the prevalence of Campylobacteriosis (Abd El-Hack et al. 2021). This entails actions including maintaining stringent worker hygiene practices, routinely cleaning and disinfecting tools and facilities, and minimizing the movement of animals between farms and patients.

7. ONE HEALTH APPROACH TO CAMPYLOBACTERIOSIS AND PUBLIC HEALTH SIGNIFICANCE

Due to *Campylobacter*'s widespread, high prevalence and the possibility that it could result in serious illnesses like gastroenteritis, sepsis, and abortion, it is a significant public health problem. In addition to direct contact with infected animals and contaminated food or water, the disease can also spread from person to person. Millions of individuals are thought to be affected each year by Campylobacteriosis, which is thought to be the most frequent bacterial cause of foodborne sickness worldwide (Holland et al. 2023).

The One Health concept, which acknowledges the interdependence of human, animal, and environmental health, has been crucial in addressing the importance of Campylobacteriosis for public health. To prevent, identify, and respond to zoonotic infections, the technique entails collaboration and coordination among professionals in environmental health, animal health, and human health Campylobacteriosis has a considerable impact on morbidity and mortality in public health. 400–500 million incidents of bacterial gastroenteritis are thought to be caused by the illness each year, making it the primary cause worldwide. Even while most Campylobacteriosis episodes are self-limiting and go away on their own, more serious cases can result in hospitalization, sepsis, and even fatality. Long-term consequences of the illness can also include reactive arthritis, Guillain-Barré syndrome, and irritable bowel syndrome (Endtz 2020).

Campylobacteriosis has a large financial impact. Global estimates place the annual cost of the disease's medical care, lost productivity, and diminished quality of life in the billions of dollars' range. Additionally, the economic damage spreads to the agriculture industry because diseased animals produce less and it costs money to put preventive measures in place.

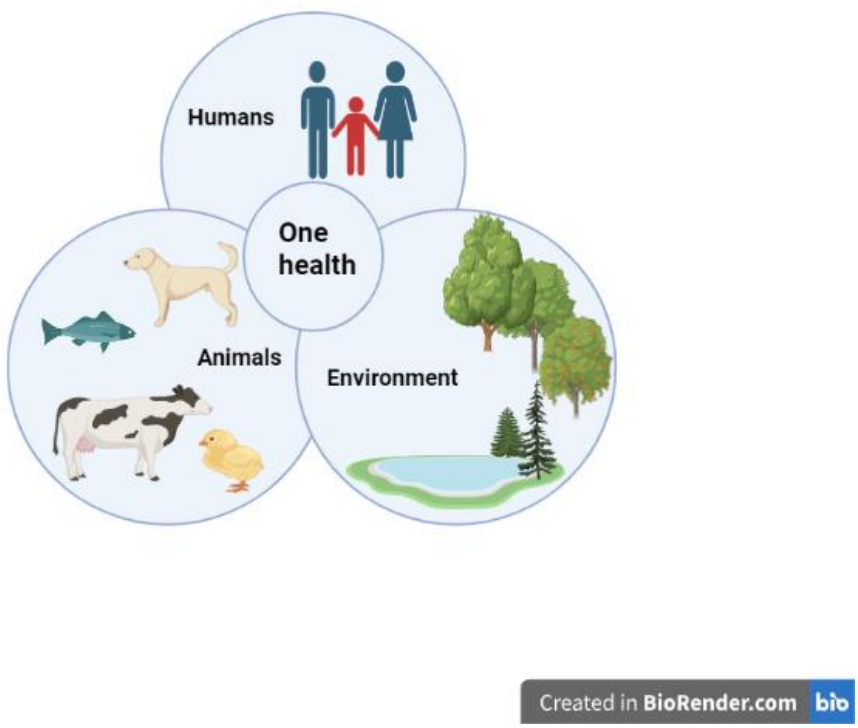

Fig. 4: One Health concept.

A One Health approach is required to address the importance of Campylobacteriosis for public health (Igwaran and Okoh 2019). This strategy acknowledges that Campylobacteriosis is a zoonotic illness that calls for a collaborative effort from environmental, animal, and human health experts. Effective preventative and control measures must be implemented throughout the whole food production chain, including on the farm, during transit, and at the processing level.

Vaccines, biosecurity precautions, and good hygiene practices are examples of prevention and control measures. The prevalence of the disease is decreased by immunizing animals against Campylobacteriosis. In healthy cows and heifers, vaccinations have been shown to be successful in avoiding the disease (Igwaran and Okoh 2019). Additionally, biosecurity measures, such as limiting access to farms and implementing sanitation protocols, can aid in preventing the disease's spread among animals.
To eradicate *Campylobacter* bacteria, the World Health Organization advises boiling poultry to an internal temperature of at least 165°F (Thames and Theradiyil Sukumaran 2020).
Campylobacteriosis must be prevented and controlled through early detection and surveillance. Modernized diagnostic procedures, such molecular techniques, can help quickly and accurately diagnose the illness, resulting in fast treatment and control measures. In addition, monitoring programs for both humans and animals can be used to spot illness outbreaks and keep track of their prevalence.
The One Health approach has successfully addressed the public health significance of Campylobacteriosis (Igwaran and Okoh 2019).Professionals in human health, animal health, and environmental health have been collaborating more recently, which has enhanced prevention and control methods. The disease still needs to be controlled and prevented, though, and much effort needs to be done. In conclusion, Campylobacteriosis is a serious public health concern because of its widespread occurrence and propensity to result in life-threatening illness. To combat Campylobacteriosis and secure the safety of both humans and animals, and lessen the strain on healthcare systems and the economy, it is crucial to use a One Health approach.

8. FUTURE DIRECTIONS IN RESEARCH AND CONTROL OF CAMPYLOBACTERIOSIS

The creation of efficient vaccinations is one of the future directions in the management of Campylobacteriosis. Although *Salmonella* and other bacterial diseases have been successfully treated with vaccines, creating one for *Campylobacter* has proven difficult (Frost et al. 2022). Outer membrane Surface proteins (OMPs), CmeC (a component of outer member), lipooligosaccharides, and flagellin are a few possible vaccine targets that researchers have found (Zeng et al. 2010). However, extensive preclinical and clinical investigations are required to fully evaluate the efficacy of these targets. Successful vaccine development would be a major step towards controlling Campylobacteriosis (Quintel et al. 2020).
The use of bacteriophages is a potential future strategy for combating Campylobacteriosis. Bacteriophages are viruses that target and destroy bacteria only. Both humans and animals have been used to successfully treat bacterial infections (D'Accolti et al. 2021). According to studies, bacteriophages can lower the amount of *Campylobacter* in chickens and other animals. Bacteriophage use in the food business may offer an antibiotic substitute and lessen the threat of antibiotic resistance.
In addition, a One Health strategy is required to lessen the impact of Campylobacteriosis. A concept called "One Health" acknowledges the connections between the health of people, animals, and the environment. As a result, managing the condition in animals can aid in lowering its prevalence in humans. Collaboration between the medical and veterinary professions and other fields like environmental health and food safety is necessary for the One Health concept.
Better monitoring mechanisms are also required to track the spread of Campylobacteriosis. The epidemiology and prevalence of the disease can be learned by surveillance systems, which can assist guide management measures. Advanced molecular typing techniques like whole genome sequencing can deliver more precise and in-depth data on the disease's transmission and spread.
Finally, there is a need for improved education and awareness programs to reduce the risk of infection (Bowler and Evans). Programmes for education can teach the general public and the food sector about

the dangers of Campylobacteriosis and how to stop the disease from spreading. These programmes can also offer guidance on handling, preparing, and storing food correctly to lower the risk of infection.
Finally, to lessen the disease’s impact on public health and the food business, it is essential to create Campylobacteriosis control strategies and therapies. The creation of efficient vaccinations, the use of bacteriophages, a One Health strategy, better surveillance systems, and enhanced education and awareness campaigns are some potential directions in the control of Campylobacteriosis. If these tactics are successfully applied, Campylobacteriosis incidence might be greatly decreased, and both human and animal health and welfare could be enhanced.

9. CONCLUSION

As a result of *Campylobacter* species, Campylobacteriosis is a typical bacterial infection that can spread by contaminated water, food, or contact with sick animals. Fever, stomach- ache and diarrhea are just a few symptoms; this condition can produce. In some situations, it can also result in more serious problems. Antibiotics and supportive care are typically used during treatment after a diagnosis has been made through laboratory analysis of stool samples. Good food hygiene practices, risk factor education, one health approach, hand hygiene, and reporting to better understand and improve preventive measures are all part of preventing and controlling the illness. New Campylobacteriosis diagnostic methods and treatment options are being investigated in ongoing research. Overall, most cases of Campylobacteriosis can be effectively controlled with suitable preventative measures and quick treatment.

REFERENCES

Abd El-Hack ME et al., 2021. Approaches to prevent and control Campylobacter spp. colonization in broiler chickens: A review. Environmental Science and Pollution Research 28: 4989-5004.

Acheson D and Allos BM, 2001. Campylobacter jejuni infections: update on emerging issues and trends. Clinical Infectious Diseases 32: 1201-1206.

Bodie AR et al., 2022. The Development and Optimization of a RT-PCR Assay for Rapid Campylobacter Spp. Detection and Quantification in Poultry Rinsates, The University of Wisconsin-Madison.

Borovikov S et al., 2023. Expression of recombinant Omp18 and MOMP of Campylobacter jejuni and the determination of their suitability as antigens for serological diagnosis of campylobacteriosis in animals. Veterinary World 16: 222-226.

Bowler R and Evans EW, 2018. UK consumer awareness of food safety practices associated with Campylobacter.

D’Accolti M et al., 2021. Bacteriophages as a potential 360-degree pathogen control strategy. Microorganisms 9: 261-266.

Dai L et al., 2020. New and alternative strategies for the prevention, control, and treatment of antibiotic-resistant Campylobacter. Translational Research 223: 76-88.

Dorsch MA et al., 2022. Placentitis and abortion caused by a multidrug resistant strain of Campylobacter fetus subspecies fetus in a sheep in Uruguay. Revista Argentina de Microbiologia 54: 25-30.

Endtz HP, 2020. Campylobacter infections. Hunter's Tropical Medicine and Emerging Infectious Diseases 50: 507-511.

Fritz S and Byers CG, 2023. Personnel Precautions for Patients with Zoonotic Disease. Advanced Monitoring and Procedures for Small Animal Emergency and Critical Care 65: 845-857.

Frost I et al. 2022. The role of bacterial vaccines in the fight against antimicrobial resistance: an analysis of the preclinical and clinical development pipeline. The Lancet Microbe 4: 111-125.

Fujihara N et al., 2006. A case of perinatal sepsis by Campylobacter fetus subsp. fetus infection successfully treated with carbapenem–case report and literature review. Journal of Infection 53: 199-202.

Galanis E, 2007. Campylobacter and bacterial gastroenteritis.Canadian Medical Association Journal 177: 570-571.

Gazaigne L et al., 2008. Campylobacter fetus bloodstream infection: risk factors and clinical features. European Journal of Clinical Microbiology & Infectious Diseases 27: 185-189.

Gmur R and Guggenheim B, 1994. Interdental supragingival plaque—a natural habitat of Actinobacillus actinomycetemcomitans, Bacteroides forsythus, Campylobacter rectus, and Prevotella nigrescens. Journal of Dental Research 73: 1421-1428.

Hannah WB et al., 2016. Carotid Artery Mycotic Pseudoaneurys Carotid Artery Mycotic Pseudoaneurysm Associated with Campylobacter fetus Bacteremia in an Immunocompromised Host. Infectious Diseases in Clinical Practice 24: 83-85.

Henne K et al., 2014. Shifts in Campylobacter species abundance may reflect general microbial community shifts in periodontitis progression. Journal of Oral Microbiology 6: 25874.

Holland D et al., 2023. Can foodborne illness estimates from different countries be legitimately compared: case study of rates in the UK compared with Australia, Canada and USA. BMJ Open Gastroenterology 10: 001009.

Holst E et al., 1987. Bacterial vaginosis: microbiological and clinical findings. European journal of Clinical Microbiology 6: 536-41.

Horrocks S et al., 2009. Incidence and ecology of Campylobacter jejuni and coli in animals. Anaerobe 15: 18-25.

Humphrey T et al., 2007, O'Brien S, Madsen M. Campylobacters as zoonotic pathogens: a food production perspective. International Journal of Food Microbiology 117: 237-57.

Igwaran A and Okoh AI, 2019. Human campylobacteriosis: A public health concern of global importance. Heliyon 5: 02814.

Jeon B et al., 2022. Live-Attenuated Oral Vaccines to Reduce Campylobacter Colonization in Poultry. Vaccines 10: 685.

Kaakoush NO et al., 2015. Global epidemiology of Campylobacter infection. Clinical Microbiology Reviews 28: 687-720.

Kalka-Moll W et al., 2005. The need to differentiate Campylobacter fetus subspecies isolated from humans. Clinical Microbiology and Infection 11: 341-2.

Konkel ME et al., 2001. The pathogenesis of Campylobacter jejuni-mediated enteritis. Current issues in intestinal microbiology 2: 55-71.

Krause R et al., 2002. Recurrent septicemia due to Campylobacter fetus and Campylobacter lari in an immunocompetent patient. Infection 30: 171-174.

Kuroki S et al., 1993. Campylobacter jejuni strains from patients with guillain-barré syndrome belong mostly to penner serogrpup 19 and contain β-N-acetylglucosamine residues. Annals of Neurology 33: 243-247.

Lee DK and Chang C, 2003. Molecular communication between androgen receptor and general transcription machinery. The Journal of Steroid Biochemistry and Molecular Biology 84: 41-9.

Lopes GV et al., 2021. Virulence factors of foodborne pathogen Campylobacter jejuni. Microbial Pathogenesis 161: 105265.

Mahlangu P et al., 2022. Prevalence of Campylobacter Species on Cattle Breeding Farms in Zimbabwe. Veterinary Medicine International.

Man SM, 2011. The clinical importance of emerging Campylobacter species. Nature reviews Gastroenterology & Hepatology 8: 669-685.

Molodecky NA et al., 2012. Increasing incidence and prevalence of the inflammatory bowel diseases with time, based on systematic review. Gastroenterology 142: 46-54.

Mukhopadhya I et al., 2011. Detection of Campylobacter concisus and other Campylobacter species in colonic biopsies from adults with ulcerative colitis. Public Library of Science One 6: e21490.

Nagy MT and Hla SM, 2013. Campylobacter fetus sepsis in an immunocompetent patient with haematological complication. Case Reports 2013: bcr2013008610.

Özcan N et al., 2022. Culture and culture-independent diagnostic tests in Campylobacter enteritis. The Journal of Infection in Developing Countries 16: 616-21.

Pihlstrom BL et al., 2005. Periodontal diseases. The Lancet 366: 1809-1820.

Plummer P et al., 2012. Critical role of LuxS in the virulence of Campylobacter jejuni in a guinea pig model of abortion. Infection and Immunity 80: 585-593.

Portner DC et al., 2007. Optimising the viability during storage of freeze-dried cell preparations of Campylobacter jejuni. Cryobiology 54: 265-70.

Quintel BK et al., 2020. Vaccine-mediated protection against Campylobacter-associated enteric disease. Science Advances 6: 4511.

Rukambile E et al., 2019. Infection, colonization and shedding of Campylobacter and Salmonella in animals and their contribution to human disease: A review. Zoonoses and Public Health 66: 562-78.

Rush JB and Edmondson MA, 2021. Infectious agents: Campylobacter. Bovine Reproduction 57: 717-724.

Sahin O et al., 2012. Molecular evidence for zoonotic transmission of an emergent, highly pathogenic Campylobacter jejuni clone in the United States. Journal of Clinical Microbiology 50: 680-687.

Sahin O et al., 2017. Campylobacter-associated diseases in animals. Annual Review of Animal Biosciences 5: 21-42.

Sartor RB, 2006. Mechanisms of disease: pathogenesis of Crohn's disease and ulcerative colitis. Nature clinical practice Gastroenterology & Hepatology 3: 390-407.

Simor A et al., 1986. Abortion and perinatal sepsis associated with Campylobacter infection. Reviews of Infectious Diseases 8: 397-402.

Singer M et al., 2016. The third international consensus definitions for sepsis and septic shock (sepsis-3). Jama 315: 801-10.

Skirrow M, 1977. Campylobacter enteritis: a" new" disease. British Medical Journal 2: 9-11.

Thames HT and Theradiyil Sukumaran A, 2020. A review of Salmonella and Campylobacter in broiler meat: emerging challenges and food safety measures. Foods 9: 776.

Tong S et al., 2021. Whole genome sequencing of Campylobacter in agri-food surveillance. Current Opinion in Food Science 39: 130-139.

Yang Y et al., 2019. A historical review on antibiotic resistance of foodborne Campylobacter. Frontiers in Microbiology 10: 1509.

Zhang L et al., 2009. Detection and isolation of Campylobacter species other than C. jejuni from children with Crohn's disease. Journal of Clinical Microbiology 47: 453-5.

L, 2015. Oral Campylobacter species: initiators of a subgroup of inflammatory bowel disease? World journal of Gastroenterology