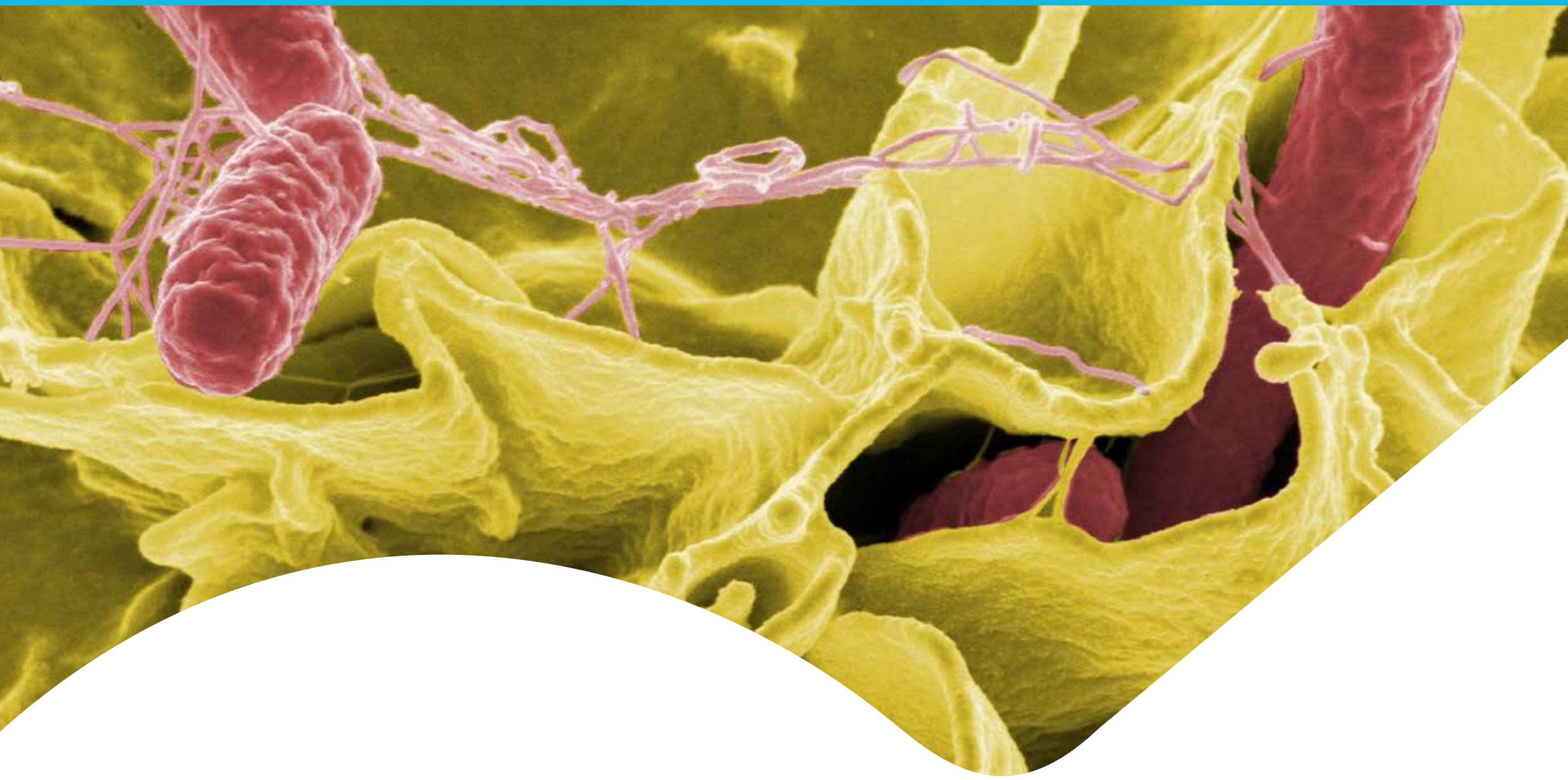

SEASONAL VARIATION OF FOOD INTOXICATIONS

MAIN PATHOGENIC BACTERIA DEVELOPING IN THE SUMMER

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Foodborne diseases appear to thrive in the summer when high temperatures are reached. The risk of pathogenic bacteria growth increases if storage temperatures are not observed. This means that producers and consumers alike should be vigilant to ensure that the products reaching their homes are safe and pathogen free. It is imperative for the food industry to implement strategies to monitor and control any hazards that could pose a risk to consumer health. Consumers are equally responsible for observing some guidelines to handle food, in addition to keeping best practices in personal hygiene.

Among the dangers arising from food consumption, the presence of pathogenic microorganisms responsible for food intoxications is one of the most serious. The bacteria most commonly associated to foodborne diseases are, as described in Figure 1, *Campylobacter, Salmonella, Yersinia* and *veterotoxigenic Escherichia coli* (STEC/VTEC) (EFSA and ECDC, 2019). In addition, due to its high toxicity and high mortality rates, *Listeria monocytogenes* has become very remarkable and an important cause for concern in premises where food is handled.

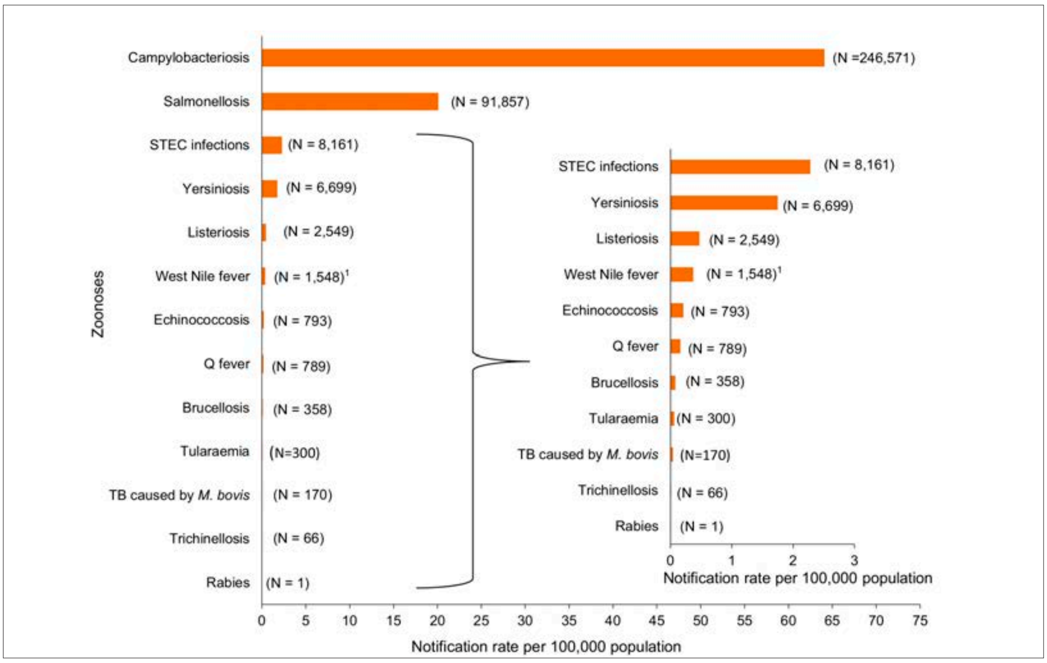


Figure 1. Main microorganisms causing zoonoses and foodborne diseases in the European Union in 2018 (EFSA and ECDC, 2019).

The disease causes can be diverse and, sometimes, they may create a chain reaction leading to a high presence of microorganisms or their metabolites in the final product. They are typically associated to unsatisfactory hygiene conditions during food production and/or preparation, like ineffective thermal treatments or consuming untreated products, and with storage conditions at excessively high temperatures or where the cold chain is broken.

SEASONAL VARIATION OF FOODBORNE DISEASES

Literature and statistical data prove that foodborne outbreaks display a high level of seasonal variation, with a significant increase in the number of cases during the summer months, when temperatures are high, whereas colder months show a clear remission (Figure 2) (Semenza et al, 2012). Despite the cooling systems available to the food industry and food preparation premises, the cold chain breaks with a relatively common frequency. For example, when sending and receiving goods, refrigerated vehicles and cold work rooms may be left open, which makes it harder to maintain the appropriate cooling temperature. Also, the cold chain may be broken in kitchens and collective catering facilities when the raw products are being taken from cold rooms to other areas, as these or the semi-prepared products are exposed to temperatures higher than those in the refrigerated areas for long periods of time, promoting the microbial growth as the conditions become ideal for toxin production.

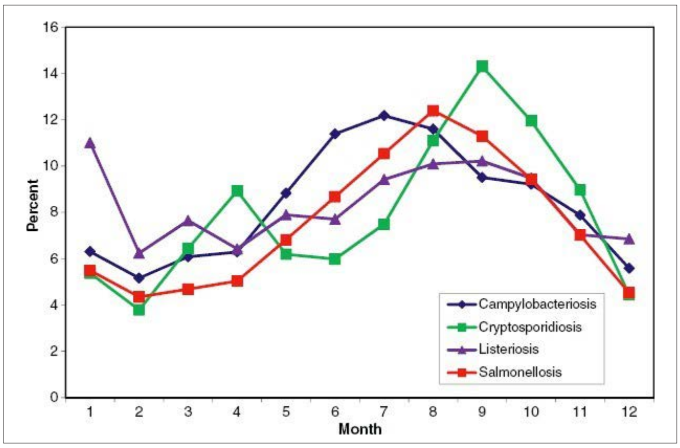


Figure 2. Seasonal distribution of campylobacteriosis, cryptosporidiosis, listeriosis and salmonellosis in the UE and EEA/EFTA in 2007. Source: Semenza et al 2012.

We may then conclude that the reasons for this seasonal variation are linked to the higher temperatures during the summer months and the higher rate of microbial development under these conditions. A large proportion of pathogenic bacteria, such as *Salmonella, Listeria and E. coli*, are mesophilic bacteria and their optimum growth temperature is approximately 37°C (Table 1). The reproduction of these bacteria occurs through a process called binary fission, meaning that, under the ideal conditions of high temperature, they may split in two every 20 minutes, so a single bacterium will generate 2,097,152 bacteria in seven hours. On the other hand, Campylobacter is thermotolerant, with an optimum growing temperature of 42°C.

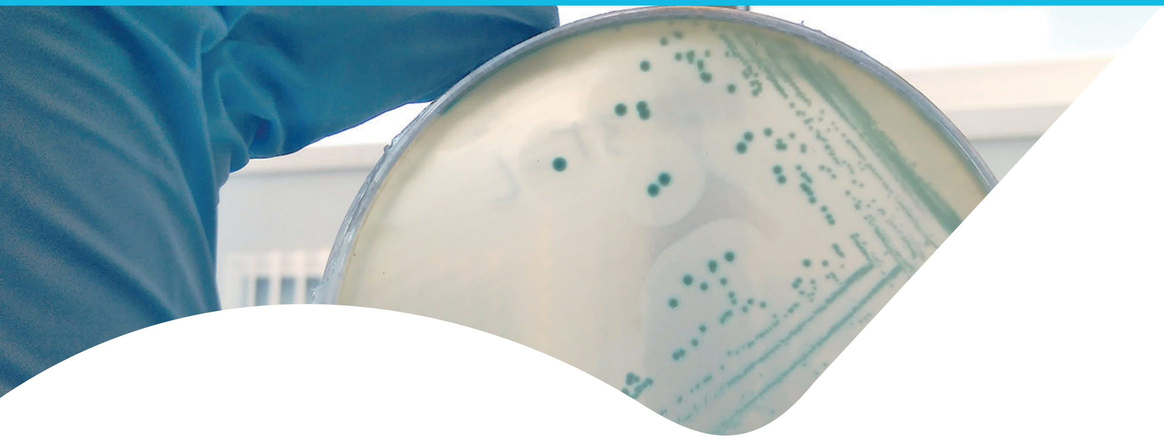
Conversely, low temperatures act as a deterrent of microbial development mainly due to the reduction of the biochemical reaction rate and to the status change of the cell membrane lipids, which become crystalline rather than fluid, thus preventing the correct functioning of the cell membrane (Keenleyside, 2019).. Having said that, psychrophilic and psychrotrophic bacteria undergo specific adaptations that increase their low temperatures tolerance, such as the existence of specific enzymes that remain active despite the low temperatures and the modification of the plasmatic membrane to keep it semi-fluid. In addition, the presence of larger amounts of short chain unsaturated fatty acids generates cryoprotecting compounds, such as proteins or sugars, that prevent the formation of ice crystals (Keenleyside, 2019).

The adaptation to high temperatures is also based on variations that help maintain the semi-fluid consistency of the cell membrane with the presence of a high content of saturated fatty acids that allow creating a more compact structure, increasing the fusion temperature.

Table 1. Classification of microorganisms based on temperature ranges.

Type of microorganism	Minimum temperature	Optimum temperature	Maximum temperature
Psychrophilic	-5 +5	12-15	15-20
Psychrotrophic	-5 +5	25-30	30-35
Mesophilic	5 - 15	30-45	35-47
Thermophilic	40 - 45	55-75	60-90

In addition to the microorganisms' own characteristics, there are other factors that impact on the increase of pathogenic bacteria in raw materials and their persistence throughout the food chain. Thus, the most significant prevalence of pathogens in living animals may be due to different causes, such as alterations of the food and fodder consumption pattern during the hot months, higher activity of microorganisms transmission vectors and transmitters in farms (parasites, insects, rodents), higher levels of animal stress due to high temperatures leading to an increase of their susceptibility to infections by enteric bacteria, e.g. *E. coli* or *Salmonella,* and a more intense growth of microorganisms in organic waste (Smith et al, 2019).



MAIN PATHOGENIC BACTERIA

Campylobacter

The bacteria of the *Campylobacter* genus are gram-negative bacilli with a curved spiral shape and a unipolar or bipolar flagellum. Their size ranges from 0.2 to 0.8µm in width and 0.5 to 5µm in length. Campylobacter spp are microaerophilic and thermophilic microorganisms with an optimum growth temperature between 42 and 43°C (Keener et al., 2004). *Campylobacter* spp is the foodborne pathogen responsible for the most part of foodborne diseases, with 246,571 cases in 2018, which is a ratio of 64.1 cases per 100,000 population in the EU (EFSA and ECDC, 2019). Out of all the different *Campylobacter* species, *Campylobacter* jejuni is responsible for the higher number of infections (80%), followed by *Campylobacter* coli (10%). Most cases of campilobacteriosis are associated to food consumption, particularly poultry; according to the reports by the European Food Safety Authority (EFSA and ECDC, 2019).

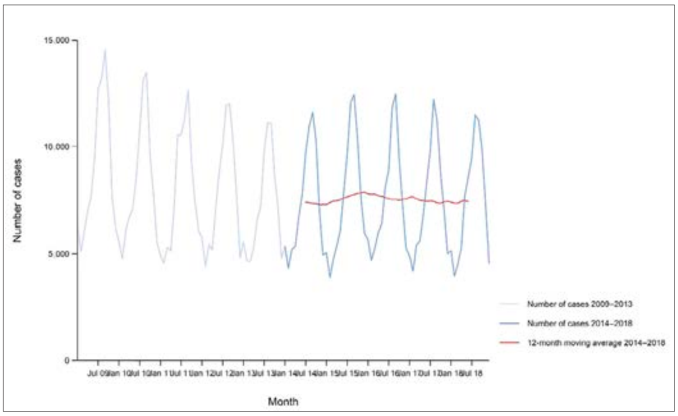


Figure 3. Confirmed campilobacteriosis cases in the EU/EEA per month for the period 2009-2018 (EFSA and ECDC, 2019).

In the EU, the campilobacteriosis cases follow a defined seasonal trend, with significant peaks during the months of June, July and August, while in January, February and March the incidence is at its lowest (fewer than half the cases reported during the summer months), as shown in Figure 3.

The graph shows a constant and stable number of cases throughout the years, without any significant reduction. In tropical countries, campilobacteriosis does no show these seasonal trends, probably due to the lower temperature variations between the different seasons (Coker et al. 2002).

Listeria monocytogenes

L. monocytogenes is a gram-positive, psychrotrophic and halotolerant bacterium. Its ability to reproduce at refrigeration temperatures (4-10°C) and its tolerance to high salt concentrations (up to 10% of sodium chloride) make it a common source of food diseases (Orihuel et al, 2013). It is one of the most virulent pathogen among those responsible for foodborne infections, with a mortality rate between 20 and 30%. In 2018, 2.548 confirmed cases of listeriosis were reported in the EU, which is a rate of 0.47 cases per 100,000 population. The mortality rate of *Listeria monocytogenes* is 15.8% (EFSA, 2019).

L. monocytogenes is widely spread in the environment and in food. Its presence in meat industries and facilities is relatively common, as it can enter the production plants in several ways, with raw materials or from the surrounding environment. Once in the facilities of a meat factory, various factors determine its ability to survive, thus becoming a potential danger to the food being processed. Such survival is enabled by factors such as: environmental parameters, ability to form biofilms, tolerance, or resistance to disinfecting products and hygiene deficiencies (Orihuel et al, 2013).

Listeriosis outbreaks and occasional cases are mainly related to ready-to-eat products (RTE), a wide category of food including milk and dairy products, meat products, vegetables, fish, drinks, etc.

Some of the most relevant outbreaks in the past few years were:

• In June 2018, the EFSA and ECDC (EFSA, ECDC, 2018) reported that, allegedly, frozen corn had been the origin of a listeriosis outbreak that affected 5 countries: Austria, Denmark, Finland, Sweden and United Kingdom. It was established that the strain of *L. monocytogenes IVb ST6 was related to this outbreak and to tho*se caused by other frozen vegetables produced during the 2016, 2017 and 2018 seasons. The source was a production plant in Hungary. A total of 47 cases and 9 deaths were reported (19% mortality).

• Listeriosis outbreak caused by salmon consumption in 2018. Using the whole genome sequencing (WGS) it was possible to identify the *Listeria monocytogenes* ST8 serotype.

• Outbreak of *Listeria monocytogenes* in South Africa, 2017-2018. From January 2017 to 14 March 2018: 978 cases, with 189 deaths. 42% of the cases were new-born children infected during pregnancy or labour. Considered by the World Health Organization as the most serious outbreak recorded worldwide. Its source was a bologna sausage factory in Polokwane. The whole genome sequencing determined that 91% of the strains were of the *Listeria monocytogenes* (ST6) type.

• Outbreak of *Listeria monocytogenes* in Spain in 2019. There were 226 people affected, three deaths and seven abortions, most of them in Andalusia. The source was Magrudis, a factory of sliced meat products. At the same time, two more alerts were raised in two other Andalusian meat factories.

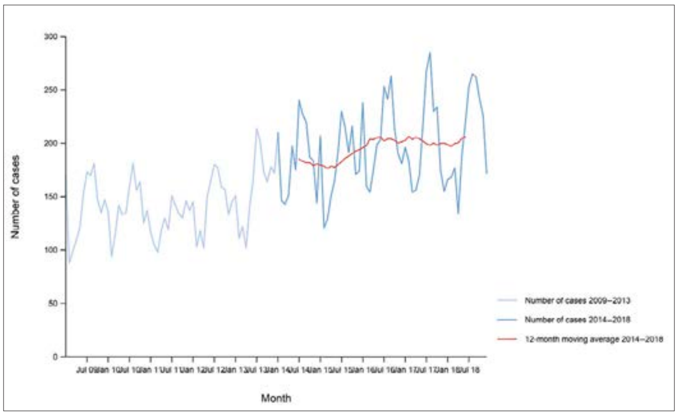


Figure 4. Confirmed listeriosis cases in the EU/EEA per month for the period 2009-2018 (EFSA and ECDC, 2019).

Despite the ability of *Listeria monocytogenes* to reproduce at refrigeration temperatures, Figure 4 shows a seasonal component, as cases increase in the summer months and reach a minimum in the colder ones. This seasonality could be explained by the factors mentioned above: optimum growth at 37°C, interruption of cold chain (which, although does not stop it, slows down the reproduction of the microorganisms), presence of vectors and dirt, etc. The graph shows a slight upward trend in the number of cases recorded in recent years.

Salmonella

Salmonella is a gram-negative bacterium grouped in the family of the Enterobacteriaceae. The species S. enteritidis and S. Typhimurium are responsible for most of the salmonellosis outbreaks being the second most important cause of foodborne diseases. In 2018, 91,857 cases were confirmed in the EU, representing a ratio of 20.1 cases per 100,000 population (EFSA, 2019). The food primarily involved in these outbreaks was eggs and egg products, as well as bakery products. However, the highest prevalence levels were observed in meat, specially poultry, intended to be cooked before consumption. The presence of *Salmonella* in poultry slaughterhouses has been constant over the years, however, through the implementation of biosafety strategies in farms, it should be possible to reduce it in poultry and, consequently, in the final product.

The public in general is aware of the seasonality of salmonellosis and it is commonly associated to cross-contamination from carrier food to other ready-to-eat ones, such as sauces, mayonnaise, etc. Being a mesophilic bacterium with optimum growth at 30-37°C, temperature has a relevant influence in the proliferation of the pathogen up to infection causing levels. Figure 5 reflects this seasonal trend, as the peak of cases appears in the summer months, with values three times higher than those for colder months. It also shows that the number of cases has remained stable over the past few years.

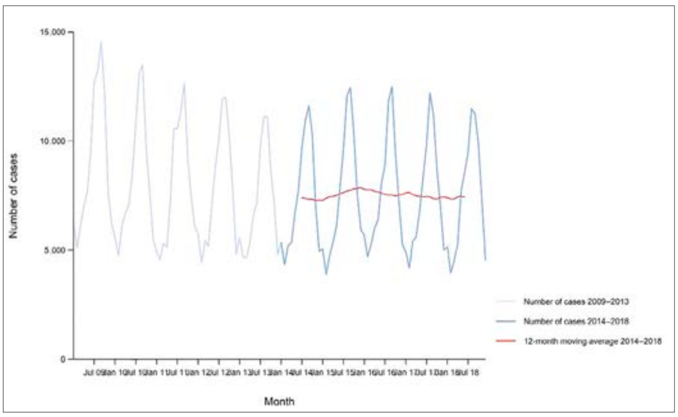


Figure 5. Confirmed salmonellosis cases in the EU/EEA per month, for the period 2009-2018 (EFSA and ECDC, 2019).

Escherichia coli

E. coli is a mesophilic bacterium and its optimum growth temperature is 35-43°C. The threshold growth temperature is approximately 7°C, so an efficient control of the cold chain in food industries is essential to prevent the growth of this bacterium in food. *E. coli* is sensitive to temperatures above 70°C and this simplifies its removal; therefore, the appropriate thermal treatment of the food is particularly important. The main intestinal pathogens are enterotoxigenic *E. coli* (ETEC), enteropathogenic *E. coli* (EPEC), enteroaggregative *E. coli* (EAggEC), enterohaemorrhagic *E. coli* (EHEC) and enteroinvasive *E. coli* (EIEC). EHEC are a group of pathogenic bacteria responsible for a constantly increasing number of infections. The 0:157 serotype produces a verotoxin responsible for haemorrhagic diarrhoea (Rodriguez-Angeles, 2002). E. coli is a common guest in the intestinal microflora of humans and different animal species, and from there, it spreads to industries and irrigation water. Some outbreaks of EHEC were also reported as caused by the consumption of fruit, vegetables and cheese.

In 2018, 8,161 confirmed cases of infections caused by Shiga toxin producing *E. coli* were reported in humans in the EU. The EU reporting ratio was 2.28 cases per 100,000 population, which means a 39.0% increase from 2017 (EFSA and ECDC, 2019).

Figure 6 shows that, as the rest of mesophilic bacteria, these too have a seasonal component with an increment of infections in the summer months between June and October over the period 2009-2018.

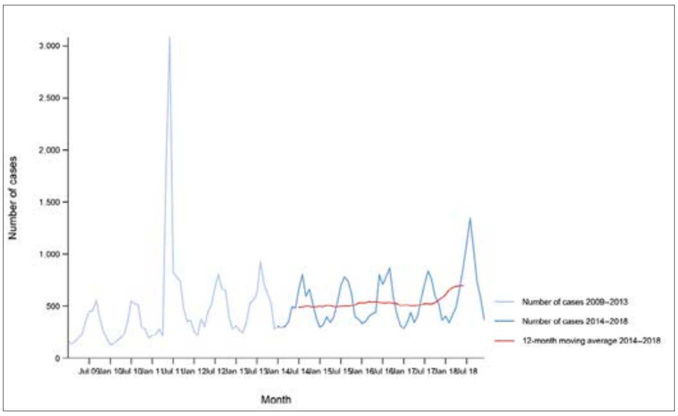
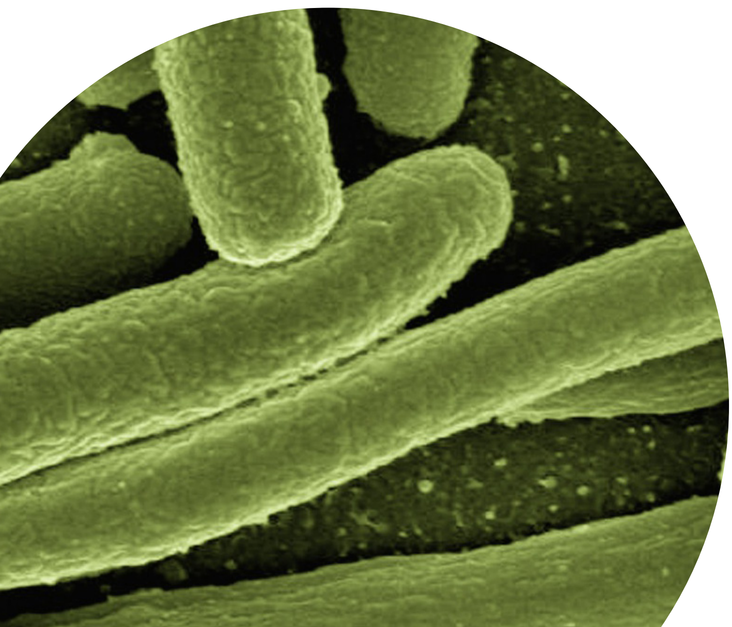


Figure 6. Confirmed STEC infection cases in the EU/EEA per month, for the period 2009-2018 (EFSA and ECDC, 2019)

CONCLUSION AND MEASURES TO PREVENT FOODBORNE DISEASES

As described in this article, foodborne diseases show a strong seasonal component, due to the temperature increase that allows microbial proliferation and the stronger habit of eating out Therefore, it is important to establish strategies to minimize the foodborne diseases increase during the summer months. These strategies must be based on the implementation of a self-control system, a Hazard Analysis and Critical Control Points Plan (HACCP) and Preliminary Conditions Plan, which must tackle many of the factors directly related to the foodborne diseases causes. Water Control Plan, Traceability Plan, Cleaning and Disinfection Plan, Pest Control Plan, Waste Plan, Staff Hygiene Training Plan and Premises Hygienic Maintenance Plan. These plans must be implemented in the food industries and they must also be included in hotel businesses and catering services addressed to the final consumer.



REFERENCES

Coker A.O., Isokpehi R.D., Thomas B.N., Amisu K.O., Obi C.L. (2002). *Human Campylobacteriosis in Developing Countries.* Emerging Infectious Diseases, Vol. 8, No. 3, Pages 237-243.

EFSA and ECDC (2019). *The European Union One Health 2018 Zoonoses.* EFSA Journal, 17(12):5598. efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2019.5598

Keener, K., Bashor, M., Curtis, P., Sheldon, B. and Kathariou, S. (2004). *Comprehensive Review of Campylobacter and Poultry Processing.* Comprehensive Reviews in Food Science and Food Safety, 3: 105-116. doi:10.1111/j.1541-4337.2004.tb00060.x

Keenleyside, W. (2019). *Microbiology: Canadian Edition.* C. 9.6 Temperature and Microbial Growth. Pressbooks.

https://ecampusontario.pressbooks.pub/microbio/chapter/temperature-and-microbial-growth/

Orihuel, E., Bertó, R. Canet, J.J., Lorenzo, F., Milvaques, A. (2013). *Listeria monocytogenes en industrias cárnicas.* Cap. 2. Descripción microbiológica.Características y ecología. Ed. Betelgeux (Gandia).

Rodríguez-Ángeles, Guadalupe. (2002). *Principales características y diagnóstico de los grupos patógenos de Escherichia coli.* Salud Pública de México, 44(5), 464-475. Recuperado en 07 de julio de 2020, de http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0036-36342002000500011&lng=es&tlng=es.

Semenza, J. C., Herbst, S., Rechenburg, A., Suk, J. E., Höser, C., Schreiber, C., & Kistemann, T. (2012). Climate Change Impact Assessment of Food- and Waterborne Diseases. *Critical reviews in environmental science and technology,* 42(8), 857–890. https://doi.org/10.1080/10643389.2010.534706

Smith, B. A., Meadows, S., Meyers, R., Parmley, E. J., & Fazil, A. (2019). Seasonality and zoonotic foodborne pathogens in Canada: relationships between climate and Campylobacter, E. coli and Salmonella in meat products. *Epidemiology and infection*, 147, e190. https://doi.org/10.1017/S0950268819000797

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