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## **Salmonella – still a threat? Epidemiological analysis of infection**

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### **Abstract:**

Salmonella infection causes morbidity and mortality throughout the world with the host immune response varying depending on whether the infection is acute and limited, or systemic and chronic. Global Salmonella infection, especially in developing countries, is a health and economic burden. These pathogen are responsible for millions of cases of food-borne illness each year, with substantial costs measured in hospitalizations and lost productivity. The growing number of bacteria resistant to the antibiotics commonly used to treat infections with this bacterium increases the use of alternative treatments. The species Lactobacillus and Bifidobacterium are the most commonly used probiotics to treat infectious diseases, including antibiotic diarrhea and traveler's diarrhea.

It is a Gram-negative, non-spore-forming, rod-shaped and facultative anaerobic bacterium. However, they have the ability to survive inside infected cells. These bacteria cause various clinical forms of disease. The most dangerous sticks of typhoid fever (*Salmonella typhi*) and paratyphoid (*Salmonella paratyphi*) multiply only in the human body and cause a very serious infectious disease - typhoid fever. In turn, non-malignant salmonella, *Salmonella bongori* and countless serological varieties of *Salmonella enterica* colonize the digestive tract of many animal species and are pathogenic to humans, causing gastroenteritis, i.e. acute salmonellosis, sometimes classified as food poisoning. All Salmonella infections begin with ingestion with contaminated food or water.

**Keywords:** salmonella infections, salmonella typhi, salmonella paratyphi,

**Aim:**

The aim of the review is to summarize data on Salmonella infections, its morbidity and hospitalization at the turn of 2010-2019 in Poland. It is worth adding that the review of statistical data is from before the pandemic caused by the Sars-Cov2. Perhaps the introduced recommendations on hand hygiene and disinfection will also contribute to reducing the incidence of diseases caused by bacteria from the salmonella group.

**Materials and methods:**

PubMed databases and statistics from the National Institute of Public Health (PZH) were searched in June and July 2021. In the PubMed database we used any medical text and terms „salmonella”, „salmonella infections”, „salmonella typhi”. No language restrictions were added. 19 scientific articles published in the years 2003-2020 were scanned.

**Conclusions:**

Salmonella is one of the most harmful pathogens responsible for foodborne outbreaks, illnesses and deaths.

In Poland, in the last ten years, the number of cases of salmonellosis has remained at a constant level, amounting to an average of 9,000 cases per year. The epidemiological situation of salmonellosis is unsatisfactory - the number of cases in 2019 was 9234, therefore it requires further monitoring.

The gut microbiota plays an important role in the colonisation resistance and invasion of pathogens. Clinical studies, animal studies and in vitro studies on the prophylactic and therapeutic efficacy of probiotics have shown antagonistic properties against Salmonella and other enteropathogenic bacteria. Nevertheless, there is a need for further research into the potential mechanisms, efficacy, and delivery of yeast probiotics in Salmonella infections.

**Introduction:**

Salmonella are gram-negative bacilli within the family Enterobacteriaceae. Salmonella is originally characterized by the ability to metabolize citrate as a sole carbon source and lysine as a nitrogen source as well as the ability to produce hydrogen sulfide. More than a century ago, infections by Salmonella were already associated with foodborne enteric diseases with high morbidity in humans and cattle. Intestinal inflammation and diarrhea are hallmarks of infections caused by nontyphoidal Salmonella serovars, and these pathologies facilitate pathogen transmission to the environment. In those early times, physicians and microbiologists also realized that typhoid and paratyphoid fever caused by some Salmonella serovars could be transmitted by "carriers," individuals outwardly healthy or at most suffering from some minor chronic complaint. (1)

Salmonellosis are a zoonotic disease caused by Salmonella, with the exception of Salmonella typhi and Salmonella paratyphi ABC. Reservoir of Salmonella are wild and domestic animals, fertilizer, soil, people who are sick or carriers. Infection occurs by ingestion after eating food containing the bacteria. (2)

Salmonella enterica is a leading cause of community-acquired bloodstream infections in many low- and middle-income countries.

Salmonella enterica serovars Typhi, Paratyphi A, Paratyphi B, and Paratyphi C may be referred to collectively as typhoidal Salmonella, whereas other serovars are grouped as nontyphoidal Salmonella (NTS). (3) Typhoidal Salmonella strains are human host-restricted organisms that cause typhoid fever and paratyphoid fever, together referred to as enteric fever. NTS strains may be host generalists, infecting or colonizing a broad range of vertebrate animals. (4)

In the developed world, food-borne acute gastroenteritis and enterocolitis are the most common forms of Salmonella infection. (5) The studies have estimated that Salmonella infection causes 2.8 billion cases of diarrhea annually worldwide. Salmonella enterica serovar Typhi (S. Typhi) is the cause of 16-33 million infectious cases, with an estimated 500,000 to 600,000 deaths, while NTS is responsible for 90 million cases and 155 000 deaths annually worldwide. (6) However, actual cases of salmonellosis may be underestimated as it was assumed that for every reported Salmonella infection, there were seven unreported cases of salmonellosis in the community.(7) The prevalence of each subtype differs from region to region of the world.(8,9)

### **Salmonella Disease Manifestations:**

Infection with Salmonella typically follows 2 very different disease courses, depending on whether the infecting Salmonella strain is a typhoidal or nontyphoidal serovar. Infection with nontyphoidal serovars presents as diarrhea associated with fever and abdominal cramping 12 to 72 hours after infection.

In most cases this infection runs a self-limited course over 4 to 7 days. However nontyphoidal strains of Salmonella may spread systemically to other sites in the body. Although this is more common in those with compromised immune systems or underlying medical conditions. We need to remember that systemic spread of nontyphoidal Salmonella strains may also be seen in otherwise healthy individuals. (5)

Nevertheless infection with typhoidal strains (primarily serovars Typhi and Paratyphi) presents as a systemic, often serious, disease. Typhoidal strains disseminate through a transient primary bacteremia that may occur without diarrhea. Some individuals will develop typhoid fever, which involves high temperature ( $>39^{\circ}\text{C}$ ), vomiting, and headache, sometimes with complications that include neurologic involvement, intestinal perforation, and death. (10)

### **EPIDEMIOLOGY AND CLINICAL ASPECTS:**

In 2000, typhoid fever was estimated to cause approximately 21.7 million illnesses and 216,000 deaths and paratyphoid fever 5.4 million illnesses. Children in south-central and southeast Asia are at particular risk (11)

In 2010 there were 11.9 million typhoid fever illnesses and 129,000 deaths in low- and middle-income countries. (3,12)

In Poland, the number of cases in 2010 was 9,732, of which 70% were hospitalized. The majority of cases were food poisoning, while there were only 183 cases of extraintestinal infections.

The largest percentage (42%) of patients were children aged 0-4 years. Children 0-9 years of age account for more than half of all infections each year. (Fig. 1)

The highest incidence of diseases from the salmonellosis group is in the summer months (June-September). (13) Over the period 2010-2019, the overall number of salmonellosis remained stable, with a slight decrease in the number of cases in 2013. (Fig. 2)

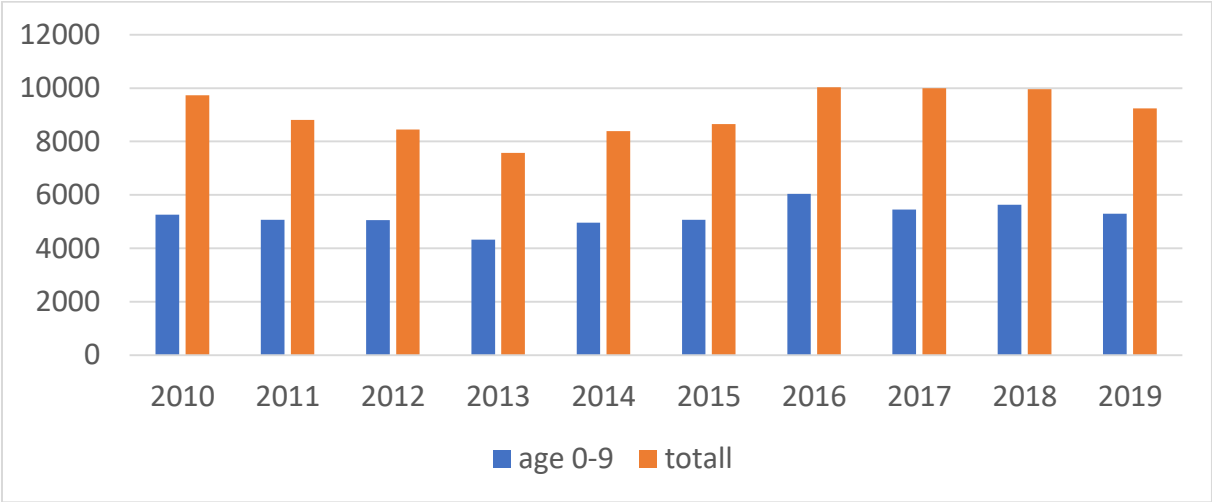


Figure 1. Number of cases of children aged 0-9 and the total number of cases in 2010-2019.

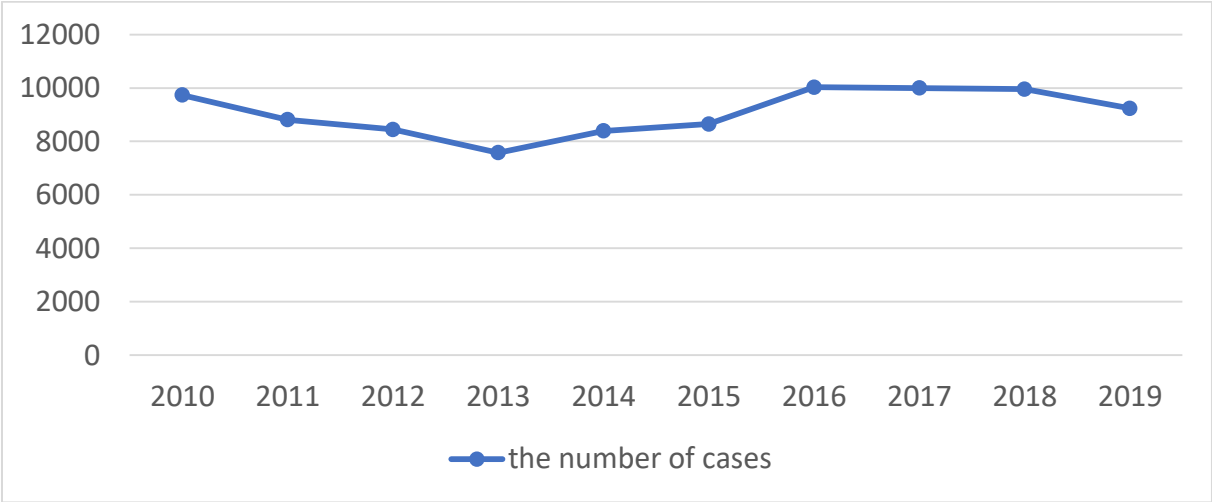


Figure 2. The number of cases infections by Salmonella in years 2010-2019

**Prevention of infection:**

Antibiotics are now widely used to combat infectious diseases, which has created favorable conditions for the selection, spread and persistence of antibiotic-resistant bacterial strains capable of causing infection. However, in recent years there has also been increased awareness of the public health implications of the selection of antibiotic-resistant bacteria in the slaughter animal population and of worldwide trade in both animals and food of animal origin. (14,15) According to the provisions of Regulation (EC) No 2160/2003, the Community countries are obliged to develop and implement national programs for the eradication of Salmonella in reproductive flocks of chickens, broilers, laying hens, pigs and turkeys. However, it is most beneficial to focus on monitoring those animal populations that the consumer is most exposed to.

National programs for monitoring resistance among pathogenic bacteria such as Salmonella have been implemented by a number of countries around the world. (16) According to Article 7 of Directive 2003/99/EC on the monitoring of zoonoses and zoonotic agents, Member States must establish a monitoring system that provides comparable data on the occurrence of antimicrobial resistance in zoonotic agents originating from animals, food and feed and, insofar as they present a threat to public health, other agents. (17) In February 2017, the European Food Safety Authority (EFSA) and the European Center for Disease Prevention and Control (ECDC) published another report concerning resistance to antibacterial substances of zoonotic bacteria, including Salmonella, isolated in the European Union from animals, food and humans in 2015. The data from the study shows that the highest percentage of resistant strains was found, as in previous years, in relation to sulfamethoxazole, tetracycline and ampicillin. On the other hand, only a small percentage of Salmonella isolates were resistant to cefotaxime, gentamicin, chloramphenicol, trimethoprim, and ciprofloxacin. There was a slight decrease in the percentage of resistant strains, especially for colistin (15.9% and 11.4%, respectively), nalidixic acid (20.1% and 15.4%) and tetracycline. (18)

### **Treatment:**

An important achievement was the introduction of antimicrobials for use in human clinical medicine and animal breeding. The course of treatment of salmonellosis includes various activities: intravenous fluid replacement, properly diet and pharmacological treatment. Although there is a broad spectrum of disease associated with these pathogens, infections are self-limiting in most cases. Antimicrobial therapy is ordinarily indicated only for severe gastrointestinal and systemic disease. (5)

The gut microbiota plays an important role in the colonisation resistance and invasion of pathogens. Probiotic supplementation improved the gut microbiota by balancing the abundance of most of the genera displaced by the Salmonella challenge with clearer effects observed with continuous supplementation of the probiotic. Strategic feeding of a Bacillus based probiotic helps in restoring many of the microbial genera displaced by Salmonella Typhimurium challenge. (19)

### **Conclusion:**

In Poland, in the last ten years, the number of cases of salmonellosis has remained at a constant level, amounting to an average of 9,000 cases per year. The epidemiological situation of salmonellosis is unsatisfactory - the number of cases in 2019 was 9234, therefore it requires further monitoring.

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