Food for Public Health Series

# Basic Overview of Foodborne *Salmonella* and Salmonellosis

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## *Salmonella* and the Food industry

*Salmonella* is a common pathogen in the food industry with important public health and food industry significance. Bacterial genus *Salmonella* was first discovered in the late 19th century by Theobald Smith and was named in honor of his supervisor, a prominent USDA scientist, Dr. Daniel Elmer Salmon (1,2). *Salmonella* is a Gram-negative, rod-shaped bacterium that belongs to the Enterobacteriaceae family. *Salmonella* can be categorized into two different species, *Salmonella bongori* and *Salmonella enterica*. *Salmonella bongori* has been only very rarely linked to human health complications (3). In contrast, *Salmonella enterica* is a very prevalent and researched pathogen. *Salmonella enterica* can be further subcategorized into six different subspecies of enterica, salamae, arizonae, diarizonae, houtenae, and indica (4).

## Public Health Impact of *Salmonella*

*Salmonella enterica* is one of the most prevalent foodborne illnesses within the food industry. According to the CDC, there are 47.8 million foodborne illness cases annually in the United States and *Salmonella* contributes to roughly 1.35 million of those illnesses in a typical year (5). *Salmonella* is also additionally responsible for 26,500 hospitalizations and annual 420 deaths in the United States (6). A recent outbreak in September 2024 is associated with *Salmonella* contamination of eggs that impacted 12 states, causing 93 illnesses and 34 hospitalizations. Another recent outbreak is *Salmonella* contamination of cucumbers in June 2024 that impacted 34 states, caused 551 illnesses and 155 hospitalizations. Other notable recent outbreaks are a *Salmonella* contamination of fresh basil in April of 2024 that caused 36 cases, and 4 hospitalizations in 14 states, and in January 2024 outbreak, where a *Salmonella* contamination of charcuterie meats caused 104 illnesses and 27 hospitalizations in 33 states (7). These recent examples show how the contamination of one product can cause a nationwide outbreak of *Salmonella* and thousands of infections leading to hospitalizations and deaths. *Salmonella* does not only cause infections and even death but also can lead to lifelong disabilities. The calculation of disabilities caused can be measured by DALY, which is an acronym meaning disability adjusted life years (8).

## Symptoms and Severity of Infections

Ingestion of this pathogen can cause two different *Salmonella*-induced diseases: (1) Nontyphoidal *Salmonella* sickness, or salmonellosis, as the most common bacterial foodborne infection in the United States, and (2) typhoidal *Salmonella* most common in third-world countries and known as typhoid disease. According to CDC statistics, nontyphoidal *Salmonella* infections in >95% of cases are foodborne in nature in the United States. On the other hand, typhoidal *Salmonella* is transmitted typically through unclean water supply, unsanitary hygiene practices and fecal-oral contaminations and in many cases are acquired by Americans when travelling abroad (9). Unlike nontyphoidal *Salmonella,* which is not specific to a host, typhoid

*Salmonella* is adopted exclusively to humans. *Salmonella* infection in both diseases produces symptoms of diarrhea, abdominal cramping, headache, nausea, vomiting, and possible loss of appetite. These symptoms can start anywhere from 6 hours to 6 days after a possible infection and can last anywhere from 4 to 7 days based on severity. The more severe symptoms of a *Salmonella* infection include, bloody stool, fever higher than 102 degrees Fahrenheit, dehydration, and diarrhea and/or vomiting lasting longer than 2 days. If severe symptoms occur, it is important to see a doctor to prevent long-term damage and even death (7).

## Transmission and Survival Mechanisms

*Salmonella* has a highly complex nature due to its ability to form biofilm and subsequently cross-contaminate various products, its ability to withstand stressors in low-moisture environments, and its fast multiplication rate when the environment is favorable for the pathogen (10). *Salmonella* is commonly transmitted through eating contaminated food such as poultry, beef, eggs, fresh produce and processed commodities such as fruit juices (7). In many cases of *Salmonella* infection, a person may have purchased and consumed contaminated food or may have prepared the food incorrectly such as not using the instructions for cooking on the package of the food product. The food industry has many different tools to inactivate and eliminate foodborne pathogens, some of these techniques being thermal pasteurization, use of chemical preservatives, as well as use of non-thermal processing such as high-pressure processing (11). Label instructions on various products are designated to assist consumers eliminate the risk of sickness with this prevalent pathogen if the risk is not eliminated by the above-mentioned methods in the food industry. *Salmonella* can survive in an environment that has the pH of 4.0 – 9.5 and also in presence and absence of oxygen. In other words, *Salmonella* can grow both anaerobically (without oxygen) and aerobically (with oxygen) in a wide array of products (11). *Salmonella* replicates in as short as 20 minutes if the intrinsic and extrinsic factors of the food are favorable for the pathogen. In other words, in less than 24 hours, one *Salmonella* cell could multiply and turn to billions of *Salmonella* in a food product. It is noteworthy that as low as 10 single cells of *Salmonella* could cause health complications in humans if ingested (12).

## Prevention Strategies by Consumers

Preventive measures start with simple hygienic factors such as washing hands especially when dealing with raw meats, and meat products. Washing your hands is the first line of defense when it comes to preventing *Salmonella* from spreading. Any food items that are considered “perishables” such as meats, eggs, dairy products, fruits, vegetables, etc. and leftovers need to be refrigerated as quickly as possible to avoid potential *Salmonella* multiplication (13,14). When cooking, keep food separated and keep the area you are cooking clean to avoid cross-contamination between cooked and uncooked products. An important step for preventing a *Salmonella* infection is to read the instructions on the back of the food packaging. Many foods products, especially many meat-containing foods, come with a label that details how to properly and safely handle the product.

## Preventive Measures by the Food Industry

The food industry has implemented various practices to combat and prevent the spread of Salmonellosis. Some of those techniques are the use of antimicrobials and preservatives, use of non-thermal processing such as high-pressure processing, and use of heat in context of thermal processing and pasteurization. As an example, a commonly used and highly effective antimicrobial is carvacrol, found in oregano and thyme. High-pressure processing is also a novel practice in the food industry, most commonly used for juices and liquid foods. The most common and longest used technique is pasteurization and use of heat. Heating is very effective in the decontamination of foods, however, excessive heat can change the food’s quality, nutrient content, and physiochemical

properties. These techniques can be used both separately and together to increase the efficacy of the decontamination of foodborne pathogens. As an example, in our 2025 nontyphoidal *Salmonella* study, the use of an antimicrobial (carvacrol), mild heat and high-pressure processing resulted in >5 log reduction (>99.999%) of the *Salmonella* population when the factors were used synergistically. This study highlights that a >5 log reduction can be achieved with mild high-pressure processing and heat which protects the food from altering its quality during the treatment (15). This study confirms the idea that foodborne pathogens such as *Salmonella,* both nontyphoidal and typhoidal, can be inactivated to prevent Salmonellosis.

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