

Understanding foodborne pathogens: Causes, effects, and prevention.

Boyce Didier*

Department of Environmental Health, University of Birmingham, United Kingdom

Introduction

Foodborne illnesses, also known as food poisoning, remain a significant public health concern worldwide. The primary cause of these illnesses is foodborne pathogens microorganisms such as bacteria, viruses, and parasites that contaminate food and beverages, leading to health issues ranging from mild gastrointestinal discomfort to severe, life-threatening conditions. The rise in global food trade, changing food production methods, and the increasing complexity of food supply chains have made foodborne pathogens a critical area of study for food safety experts, public health officials, and the food industry. Foodborne pathogens can be present at any stage of the food supply chain, from production and harvesting to processing, storage, and distribution. This wide range of potential contamination points complicates efforts to reduce the incidence of foodborne illnesses. Pathogens can enter food through direct contact with contaminated water, soil, animals, or human handlers, making control measures vital at multiple levels. The most common foodborne pathogens include *Salmonella*, *Escherichia coli* (*E. coli*), *Listeria monocytogenes*, *Campylobacter*, and Norovirus, each of which is associated with distinct clinical symptoms, transmission routes, and sources of contamination. *Salmonella* infections are among the most prevalent causes of foodborne illness, leading to symptoms such as diarrhea, abdominal cramps, fever, and vomiting. This bacterium is often found in raw poultry, eggs, and meat, and can survive in various environments, which makes it difficult to eradicate [1, 2].

Escherichia coli (*E. coli*), particularly the O157:H7 strain, is notorious for causing severe outbreaks, especially in undercooked ground beef, leafy greens, and contaminated water. *E. coli* infections can lead to hemolytic uremic syndrome, a condition that can result in kidney failure, especially in vulnerable populations like children and the elderly. *Listeria monocytogenes* is another concerning foodborne pathogen due to its ability to grow at refrigeration temperatures, which makes it a unique challenge in food safety. It is commonly found in ready-to-eat deli meats, soft cheeses, and unpasteurized milk. Listeriosis, the illness caused by *Listeria*, can be particularly dangerous for pregnant women, newborns, the elderly, and immunocompromised individuals, leading to miscarriage, stillbirth, and severe infections. In addition to bacteria, viruses like Norovirus are significant contributors to foodborne illnesses. Often referred to as the "winter vomiting

bug," Norovirus is highly contagious and can spread rapidly in environments such as cruise ships, restaurants, and nursing homes. Its symptoms include vomiting, diarrhea, and stomach cramps, and it is commonly transmitted through contaminated food, water, or surfaces [3, 4].

Parasites also play a role in foodborne illnesses, although they are less frequently discussed than bacteria and viruses. *Toxoplasma gondii*, *Cryptosporidium*, and *Giardia* are common foodborne parasites that can cause gastrointestinal distress and other more serious health complications. These parasites can be found in undercooked meats, contaminated water, and unwashed produce, making food safety practices such as proper cooking and washing essential. One of the challenges in controlling foodborne pathogens is the phenomenon of antimicrobial resistance (AMR). Many foodborne pathogens have developed resistance to common antibiotics, making infections harder to treat. The overuse and misuse of antibiotics in livestock production contribute significantly to this issue. AMR poses a growing threat to public health and underscores the importance of careful antibiotic stewardship in both human and veterinary medicine. Foodborne illnesses are not just a matter of individual health—they can have substantial economic consequences. Infections caused by foodborne pathogens lead to billions of dollars in healthcare costs, lost productivity, and legal liabilities for food producers. According to the Centers for Disease Control and Prevention (CDC), foodborne diseases result in nearly 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths annually in the United States alone [5, 6].

In response to the global food safety challenge posed by foodborne pathogens, various preventive measures have been introduced. The implementation of Hazard Analysis Critical Control Point (HACCP) systems in food production, rigorous sanitation protocols, and the use of food safety management systems have all contributed to reducing the risk of contamination. In addition, public health agencies worldwide work together to track outbreaks, identify sources, and provide guidance on food safety practices. Education plays a crucial role in preventing foodborne illnesses. Consumers must be educated on safe food handling practices, such as washing hands, cooking meats to the correct temperature, and avoiding cross-contamination between raw and cooked foods. Food service workers and manufacturers also need ongoing training in proper food safety procedures to minimize the

*Correspondence to: Boyce Didier, Department of Environmental Health, University of Birmingham, United Kingdom. E-mail: Didier@Boyce.uk

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risk of pathogen spread during food preparation, processing, and distribution. While considerable progress has been made in reducing foodborne illnesses, the battle is far from over. Emerging pathogens, changes in food production, and evolving consumer behaviors present ongoing challenges to food safety [7, 8].

The increasing frequency of foodborne outbreaks linked to novel pathogens and the persistence of older ones highlight the need for continued research and investment in food safety measures. In addition to traditional pathogen detection methods, advances in biotechnology and molecular diagnostics are enhancing the ability to identify pathogens in food rapidly. Techniques such as polymerase chain reaction (PCR), next-generation sequencing, and metagenomics are enabling more precise tracking of contamination sources and faster identification of outbreaks. These innovations are helping to improve the speed and accuracy of foodborne illness investigations, ultimately contributing to better protection for consumers. As the global food supply chain becomes more complex and interconnected, the need for international collaboration on food safety grows. Global trade and travel have increased the spread of foodborne pathogens, making it essential for countries to share data and best practices in managing food safety risks. Organizations such as the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) play key roles in coordinating international efforts to combat foodborne illnesses [9, 10].

Conclusion

Foodborne pathogens remain a major challenge to public health worldwide. With a wide variety of bacteria, viruses, and parasites responsible for foodborne illnesses, it is essential to maintain vigilance across all stages of food production and consumption. Preventing foodborne illnesses requires a multifaceted approach, including education, improved food safety practices, and the development of better pathogen detection technologies. As food safety practices continue to evolve and new challenges emerge, collaboration at the local, national, and international levels will be crucial in reducing the burden of foodborne diseases and ensuring a safe food supply for all.

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