

Foodborne Pathogens: A Comprehensive Mini-Review

Elena Petrova*

Department of Microbial Ecology, Moscow State University, Moscow, Russia

Mini Review

Received: 02-Jun-2025, Manuscript No. JMB-25-187554; **Editor assigned:** 04-Jun-2025, Pre-QC No. JMB-25-187554 (PQ); **Reviewed:** 18-Jun-2025, QC No. JMB-25-187554; **Revised:** 23-Jun-2025, Manuscript No. JMB-25-187554 (R); **Published:** 30-Jun-2025, DOI: 10.4172/2320-3528.14.009

*For Correspondence

Elena Petrova, Department of Microbial Ecology, Moscow State University, Moscow, Russia

E-mail: petrova@msu.ru

Citation: Elena Petrova, Foodborne Pathogens: A Comprehensive Mini-Review. Rep Cancer Treat. 2025.14.009.

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ABSTRACT

Foodborne pathogens are a major global public health concern, causing significant morbidity, mortality, and economic burden worldwide. These pathogens include bacteria (*Salmonella* spp., *Escherichia coli*, *Listeria monocytogenes*, *Campylobacter*), viruses (norovirus, hepatitis A), and parasites (*Toxoplasma gondii*, *Giardia lamblia*), as well as toxins and chemical contaminants. Transmission occurs primarily through contaminated food or water, with clinical manifestations ranging from mild gastroenteritis to severe systemic illness. This review provides a comprehensive overview of the epidemiology, pathogenesis, clinical features, diagnostic approaches, and public health impact of foodborne pathogens. Key prevention and control strategies, including proper food handling, hygiene, regulatory measures, and antimicrobial stewardship, are discussed. Emerging challenges such as antimicrobial resistance, globalization of the food supply, and climate change underscore the need for continued research, surveillance, and integrated One Health approaches. Understanding the biology, transmission, and control of foodborne pathogens is critical to reducing disease burden and protecting public health.

Keywords

Foodborne pathogens, food safety, *Salmonella*, *Listeria*, norovirus, antimicrobial resistance, public health

INTRODUCTION

Foodborne diseases remain a leading cause of morbidity and mortality globally, affecting both developed and developing nations. Contaminated food can carry pathogenic bacteria, viruses, parasites, or chemical toxins, resulting in illnesses ranging from mild gastroenteritis to life-threatening systemic infections.

Modern challenges including globalization of the food supply, intensive animal farming, and climate change have increased the risk of contamination and outbreaks.

Globally, the World Health Organization (WHO) estimates that 1 in 10 people fall ill annually due to contaminated food, leading to more than 420,000 deaths, with children under five disproportionately affected. Understanding the epidemiology, transmission pathways, and control measures for foodborne pathogens is essential to safeguarding public health.

Epidemiology and Disease Burden

Foodborne illnesses affect millions annually, imposing a heavy economic and health burden. In the United States, the Centers for Disease Control and Prevention (CDC) estimates 48 million cases, 128,000 hospitalizations, and 3,000 deaths each year. High-risk populations include infants, the elderly, pregnant women, and immunocompromised individuals.

Globally, outbreaks are often linked to specific food items such as raw or undercooked meat, eggs, seafood, dairy, and fresh produce. Epidemiological surveillance, outbreak reporting, and risk assessment play key roles in controlling disease spread.

Major Foodborne Pathogens

Bacterial Pathogens

Bacteria are the most common cause of foodborne disease and may contaminate foods at multiple points along the production and supply chain.

Salmonella spp:

Gram-negative Salmonella species are responsible for salmonellosis, typically presenting with fever, diarrhea, abdominal cramps, and vomiting. Contamination often occurs in poultry, eggs, and dairy products. Severe infections can lead to septicemia, particularly in vulnerable populations.

Escherichia coli (E. coli):

Pathogenic strains such as E. coli O157:H7 produce Shiga toxins causing hemorrhagic colitis and hemolytic uremic syndrome (HUS). Transmission is primarily via undercooked beef, contaminated produce, and unpasteurized milk.

Listeria monocytogenes

A Gram-positive intracellular bacterium capable of surviving at refrigeration temperatures. Listeriosis can lead to meningitis, septicemia, or miscarriage. Ready-to-eat foods and unpasteurized dairy are common sources.

Campylobacter jejuni:

Causes gastroenteritis, often linked to undercooked poultry or contaminated water. Rare complications include Guillain-Barré syndrome.

Clostridium perfringens and Bacillus cereus

These spore-forming bacteria produce toxins causing diarrheal or emetic syndromes. Improperly cooked or stored meat, rice, and sauces are typical vehicles.

Viral Pathogens

Viruses cannot multiply in food but can be transmitted through contaminated food or water.

Norovirus

Leading cause of viral gastroenteritis globally. Highly contagious and often linked to shellfish, fresh produce, and person-to-person transmission in food-handling settings.

Hepatitis A Virus

Causes hepatitis with jaundice, fatigue, and abdominal discomfort. Transmission occurs via contaminated food or water, particularly in areas with poor sanitation.

Parasitic Pathogens

Parasitic infections arise from ingestion of contaminated food or water.

Toxoplasma gondii

Transmitted via undercooked meat or contaminated produce. Severe disease occurs in immunocompromised individuals and during pregnancy.

Giardia lamblia and Other Protozoa

Cause prolonged diarrheal illness; commonly transmitted through contaminated water used to irrigate food crops.

Chemical and Natural Toxins

Some foodborne illnesses result from mycotoxins, heavy metals, or marine toxins. Chronic exposure can cause cancer, neurological deficits, and organ damage.

Mechanisms of Pathogenesis

Foodborne pathogens employ various mechanisms:

Adhesion and invasion: e.g., Salmonella attaches to intestinal cells and invades mucosa.

Toxin production: e.g., Clostridium botulinum neurotoxin inhibits neuromuscular transmission.

Immune modulation: evasion or suppression prolongs infection and systemic spread.

Disease severity depends on pathogen virulence, infectious dose, host immunity, and comorbidities.

Clinical Features and Diagnosis

Clinical Manifestations

Symptoms include nausea, vomiting, abdominal pain, diarrhea, and fever. Severe complications include dehydration, hemolytic uremic syndrome, sepsis, and neurological disorders.

Diagnostic Approaches

Culture and isolation: traditional method for bacteria.

Molecular techniques (PCR, sequencing): rapid and sensitive.

Serology and toxin assays: useful for viral and intoxication cases.

Early and accurate diagnosis is crucial for clinical management and outbreak containment.

Public Health Impact

Foodborne diseases cause significant morbidity, mortality, and economic losses. Global surveillance systems and outbreak reporting are critical for early detection and response. Children, elderly, and immunocompromised individuals bear the highest risk.

Prevention and Control Strategies**Individual Level**

Proper handwashing and hygiene

Thorough cooking and food handling

Safe storage at appropriate temperatures

Industry and Regulatory Measures

HACCP: identifying and mitigating risks in food production

GMPs: sanitation and monitoring practices

Surveillance systems: outbreak detection and rapid response

Antimicrobial Resistance (AMR)

AMR is increasing in foodborne bacteria, complicating treatment. Prudent antibiotic use in agriculture and human medicine, along with surveillance and novel therapeutics, are critical.

Emerging Challenges

Globalization and complex food chains

Climate change affecting pathogen ecology

Urbanization increasing demand for diverse foods

Emergence of new pathogenic strains

One Health approaches, integrating human, animal, and environmental health, are essential for effective control.

CONCLUSION

Foodborne pathogens remain a pervasive public health challenge. Multi-level interventions, from individual hygiene to global surveillance, are vital to reduce disease burden. Continued research, innovation, and collaboration will help prevent outbreaks, mitigate antimicrobial resistance, and protect public health.

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