17(2) 189-203, Summer 2025

Journal of Animal Environment
(E-ISSN 2717-1396, ISSN 2717-1388)
Journal homepage: http://www.aejournal.ir

Original Research Paper

Foodborne Diseases and the Impact of Zoonotic Transmission on the Gastrointestinal Health of Wildlife Species

Sevara Isamukhamedova[1*], Suxrob Narkulov[2], Ibrohim Sapaev[3], Narzikul Maxmudov[4], Giyosiddinov Abdurakhim Nasritdin Ugli[5], Nilufar Niyazova[6], Malokhat Komilova[7]

[1]Department of Neurology, Center for Development of Professional Qualification of Medical Workers, Tashkent, Uzbekistan. Email: yus.sevara@gmail.com, ORCID: https://orcid.org/0000-0002-0377-3637*
[2]Professor, Head, Department of Social Sciences, Tashkent State Medical University, Tashkent, Uzbekistan. Email: sukhrob.norqulov6623@gmail.com, ORCID: https://orcid.org/0000-0003-1815-2558
[3]Head, Department of Physics and Chemistry, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers National Research University, Tashkent, Uzbekistan; School of Engineering, Central Asian University, Tashkent, Uzbekistan. E-mail: sapaevibrokhim@gmail.com, https://orcid.org/0000-0003-2365-1554
[4]Department of Faculty of Medicine, Termez University of Economics and Service, Termez, Uzbekistan. Email: narzikul_makhmudov@mail.ru, ORCID: https://orcid.org/0000-0003-1098-1810
[5]Turan International University, Namangan, Uzbekistan. Email: abdurahimgi71@gmail.com, ORCID: https://orcid.org/0009-0000-1312-4596
[6]Department of Psychology, Mamun University, Khiva, Uzbekistan. Email: niyazova_nilufar@mamunedu.uz, ORCID: https://orcid.org/0009-0007-7731-0890
[7]Department of Pedagogy, Tashkent University of Applied Sciences, Tashkent, Uzbekistan. E-mail: malokhat.komilova@mail.ru, ORCID: https://orcid.org/0000-0002-3160-8495

Key Words

Foodborne zoonoses, Gastrointestinal infection, Wildlife health, Zoonotic transmission, One health, Pathogenesis, Public health burden, Surveillance and control.

Abstract

Zoonotic diseases that are transmitted through food are a significant global risk to gastrointestinal (GI) health, with high morbidity, mortality, and long-term morbidity. Salmonella, Campylobacter, ST137 E. coli, Listeria monocytogenes, and Yersinia enterocolitica are all known causes of foodborne illness in the world. There are still significant gaps in the knowledge of the actual disease burden, long-term GI sequelae, and environmental and host factors related to the pathogen transmission, as the WHO, the CDC, and EFSA have extensive surveillance. The goal of this review is to summarize the existing data on epidemiology, pathogenesis, and population health burden of significant foodborne zoonotic pathogens and identify the areas of prevention strategies in accordance with a One Health approach. This paper also explores the impact of zoonotic transmission on the gastrointestinal health of wildlife species, highlighting the ecological and public health implications. A narrative review approach was utilized using peer-reviewed articles, datasets of global burden, and international surveillance reports. The results show that bacterial zoonoses remain at the top of the world disease indicators and bring millions of diseases annually, and highly cost the economy. The pathogenesis includes epithelial invasion, toxin-dependent damage, inflammation, interference of the microbiota, and immune-mediated sequelae. The interventions need to be integrated, farm-to-fork, with increased surveillance and multisectoral collaboration to aid in prevention. The remaining gaps are underreporting, insufficient genomic surveillance, incomplete comprehension of chronic outcomes, and the up-and-coming role of antimicrobial resistance and climate change. These challenges need to be tackled to minimize the burden of foodborne zoonotic diseases in the world.

* Corresponding Author's email: yus.sevara@gmail.com
Received: 30 April 2025; Reviewed: 3 June 2025; Revised: 3 August 2025; Accepted: 23 August 2025
(DOI): 10.70102/AEJ.2025.17.2.21

Introduction

Both ingestion of food contaminated with pathogenic microorganisms causes foodborne diseases, of which most are of animal origin and are transmitted to human beings in a zoonotic manner (Hassanain et al., 2013; Abebe et al., 2020). These infections are a prominent global public health problem because of their high distribution, high gastrointestinal (GI) morbidity, and possible development of severe long-term complications (Bancerz-Kisiel & Szweda, 2015; Chlebicz & Śliżewska, 2018). Among the most commonly reported causes of GI illness globally, foodborne zoonotic pathogens such as Salmonella, Campylobacter, ETEC-producing Shiga toxin-producing E. coli (STEC), Listeria monocytogenes, and Yersinia enterocolitica are still present (Ali & Alsayeqh, 2022).

The global institutions are at the heart of characterizing and responding to the foodborne zoonoses. The authoritative estimates of global burden on foodborne disease are given by the World Health Organization (WHO), and it shows just how huge the health- and economic-impact of foodborne diseases is, and what the priority pathogens of most concern are (Al-Musawi et al., 2025; World Health Organization, 2015). In the United States, incidence trends, outbreak patterns, and hospitalization rates related to foodborne pathogens are specifically followed by the Centers for Disease Control and Prevention (CDC), specifically through its FoodNet surveillance system (Centers for Disease Control and Prevention, 2023). In Europe, annual reports of One Health zoonoses are organized by the European Food Safety Authority (EFSA) and the European Centre of Disease Prevention and Control (ECDC) to follow the trends of contamination in humans, animals, and food systems (European Food Safety Authority & European Centre for Disease Prevention and Control, 2022). Further economic estimates provided by the U.S. Department of Agriculture (USDA) also measure the high economic cost in terms of healthcare expenses and productivity of foodborne diseases (Hoffmann et al., 2014; EFSA Panel on Biological Hazards et al., 2018; Odeyemi, 2016).

The developing regions are among the most affected as they have to contend with poor sanitation, informal food markets, and a lack of cold-chain infrastructure and surveillance capacity (Olifiers et al., 2015; Senthil, 2025). There is repeated exposure and increased rates of disease transmission as a result of the pathogens that are spread by livestock, water sources that are contaminated, and food environments that are not well managed (Chlebicz & Śliżewska, 2018; Rasetti-Escargueil et al., 2019). Furthermore, foodborne Zoonotic pathogens are not only related to acute diarrheal disease but also severe complications, including reactive arthritis, GuillainBarré syndrome, hemolytic uremic syndrome, and long-lasting post-infectious gastrointestinal disorders (Warwick, 2004; Dhama et al., 2015). In addition to the human health risks, zoonotic foodborne pathogens also pose a significant threat to wildlife populations (Erickson, 2015). These pathogens can spread through direct contact with contaminated food or environments, leading to gastrointestinal illness in various wildlife species (Olifiers et al., 2015).

As wildlife often play key roles in maintaining ecosystem balance, the health of these animals is crucial not only for biodiversity but also for the transmission dynamics of zoonotic diseases. Pathogens like Salmonella, Campylobacter, and E. coli can infect wildlife, with some species acting as reservoirs, potentially bridging the gap between environmental contamination and human exposure. This wildlife aspect of zoonotic transmission complicates efforts to control these diseases, underscoring the need for a broader, One Health approach that includes wildlife in disease surveillance and management strategies.

Due to the interrelated nature of foodborne zoonotic transmission across the animal, human, food, and environmental pathways, to be effectively controlled, a coordinated multisectoral approach is required (Senthil, 2025). This is due to the contribution of international bodies, governmental public health agencies, veterinary networks, and food safety authorities to surveillance, prevention, regulatory management, and risk management using a One Health framework (Erickson, 2015; Pal, 2020). The remaining part of this review is in the following setup. Section 2 and Section 3 are the narrative review and approach of the paper, respectively; Section 3 explains the global burden and epidemiology of major foodborne zoonotic diseases. Section 4 provides the most important pathogens and their gastrointestinal effects. The pathogenesis of these pathogens to cause GI injury is described in Section 5. The sixth section deals with the economic and health consequences of foodborne zoonoses to the population. Section 7 includes prevention measures and One Health control strategies. The conclusion identifies the key findings, limitations, and I will conduct the research in the future**.**

Methods and Evidence Synthesis Approach

The synthesis of evidence on foodborne zoonotic diseases and their gastrointestinal effect was done using a narrative review approach (Fairfax & Sørensen, 2024). PubMed, Scopus, and Google Scholar searched literature on publications published in 20102024, and official surveillance and burden reports of the WHO, CDC FoodNet, EFSA/ECDC, and USDA were used to complement this search. The search terms were based on foodborne zoonoses, Salmonella, Campylobacter, STEC, Listeria, and Yersinia, gastrointestinal infection, food safety, and One Health. Articles that were used had to talk of epidemiology, burden, pathogenesis, clinical manifestations, prevention measures, or public health implications of zoonotic foodborne pathogens. Systematic reviews, authoritative surveillance datasets, and new high-quality primary studies received priority, and those articles that had no relevance to human GI outcomes were eliminated.

Figure 1 presents the description of the review procedure of the paper, including literature database searches, surveillance information sources (WHO, CDC FoodNet, EFSA/ECDC, U D-DA, relevant-thematic synthesis screening of final evidence).

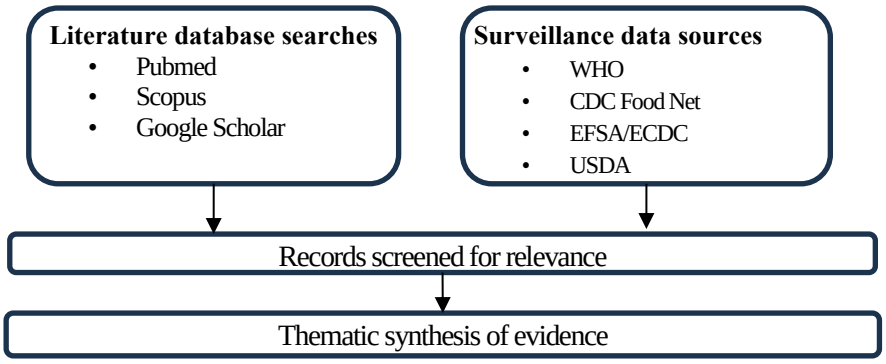

Figure 1: Overview of the Narrative Review Process

Burden and Epidemiology of Foodborne Zoonotic Diseases

The problem of foodborne zoonotic diseases is a significant health problem at the global level, as it affects millions of people each year and is one of the causes of acute and chronic gastrointestinal (GI) diseases. The most comprehensive global estimates are those of the World Health Organization (WHO), which indicate that there are huge morbidity, mortality, and disability-adjusted life years (DALYs) of foodborne pathogens across the globe (World Health Organization, 2015). These approximations underscore the unequal effect on the poor and middle-income nations whose lack of sanitation, lax regulatory controls, and informal food systems are among the triggers of increased risks of exposure (Olifiers et al., 2015; Senthil, 2025). Nationally and supranationally, national and supranational organizations are necessary in the monitoring of foodborne diseases caused by zoonotic pathogens. Active surveillance in the United States is done by the Centers for Disease Control and Prevention (CDC) with the FoodNet program that tracks the incidence of Salmonella, Campylobacter, STEC, and Listeria infections and demographic groups most vulnerable (Centers for Disease Control and Prevention, 2023). The European Union has a dual publication of annual One Health zoonoses reports by the European Food Safety Authority (EFSA) and European Centre for Disease Prevention and Control (ECDC), as these reports monitor pathogen prevalence in humans, animals, and food sources and allow cross-sector risk analysis and relative comparison of regions (European Food Safety Authority & European Centre for Disease Prevention and Control, 2022).

The zoonotic foodborne burdens are globally supported by studies carried out in different regions. Studies in Mexico, e.g., have shown complicated transmission systems of contaminated foods, animal husbandry, and domestic ways of exposure (Pal, 2020; Zaidi et al., 2012). Similar studies conducted in Greece show that there are great health effects of foodborne pathogens on the people, and risk-based food safety measures are necessary (Gkogka et al., 2011). In developing countries, recurrent contact with contaminated food and poor hygiene infrastructure causes constantly high disease rates and dire results (Olifiers et al., 2015). The most frequent zoonotic pathogens, like Campylobacter, Salmonella, STEC, Yersinia

enterocolitica, and Listeria monocytogenes, still prevail in the number of reported cases in the world. The risk groups (children, pregnant women, older adults, and immunocompromised people) are associated with a high intensity of the disease and the increased probability of complications (Hassanain et al., 2013; Geetha & Gowsikraja, 2025). Additional factors affecting patterns in epidemiology are the environmental and host factors, and the epidemiological trends in a region are influenced by climate variability, agriculture, and socioeconomic determinants (Erickson, 2015; Pal, 2020).

In general, foodborne zoonotic diseases pose a heavy burden, which justifies the need to enhance the detection, reporting, and surveillance systems. It is necessary to make the integration of the global datasets provided by WHO, CDC, EFSA/ECDC, and the national agencies stronger to characterize trends correctly, target intervention, and support evidence-based policymaking.

Major Foodborne Zoonotic Pathogens Affecting Gastrointestinal Health

Foodborne zoonotic pathogens are a range of bacteria, parasites, and viruses that may result in acute and, in some cases, chronic gastrointestinal disease. Of these, there is a higher global burden of bacterial pathogens. Salmonella spp., Campylobacter spp., Shiga toxin-positive Escherichia coli (STEC), Listeria monocytogenes, and Yersinia enterocolitica are always discovered as the most common causes of foodborne GI disease in the globe (World Health Organization, 2015; European Food Safety Authority & European Centre for Disease Prevention and Control, 2022).

The most prevalent infections reported are Salmonella and Campylobacter, both usually due to contaminated poultry, meat, eggs, and unpasteurized milk. These infections result in diarrhea, stomachache, and fever, and can result in such complications as reactive arthritis or GuillainBarré syndrome in some patients. STEC, which is commonly caused by undercooked beef and contaminated fruits, may cause serious hemorrhagic colitis and hemolytic uremic syndrome because of Shiga toxin production (Abebe et al., 2020; Hassanain et al., 2013). Listeria monocytogenes is a relatively rare cause of severe invasive disease, which is especially common in pregnant women, neonates, and immunocompromised persons, with one of the highest mortality rates of foodborne pathogens (Dhama et al., 2015). Yersinia enterocolitica, a pathogen most often associated with pork products, is the cause of fever, diarrhea, and abdominal pain, which can be mistaken for appendicitis, and may result in a post-infectious reactive arthritis.

Zoonotic agents that cause diseases in the world are also parasitic and viral. The significant parasitic hazards are Toxoplasma gondii and Cryptosporidium spp., whereas some noroviruses lead to outbreaks associated with shellfish and fresh vegetables contamination. These foodborne pathogens point out the various and long-lasting characterizations of foodborne zoonotic risks.

Gastrointestinal Symptoms and Clinical Manifestations

The manifestations of the disease are gastrointestinal in nature and clinical. There is a vast array of manifestations of foodborne zoonotic infections, such as acute watery or bloody diarrhea, abdominal cramps, vomiting, fever, dehydration, and, in severe cases, systemic manifestations. Post-infectious irritable bowel syndrome, reactive arthritis, GuillainBarré syndrome, and chronic dysfunction of the gastrointestinal system are long-term sequelae that contribute to gross disease burden.

Table 1 lists a concise list of the key zoonotic foodborne pathogens, their approximate prevalence, clinical courses, and complications related to them. They are based on the WHO data on global burden (World Health Organization, 2015), CDC FoodNet surveillance (Centers for Disease Control and Prevention, 2023), EFSA/ECDC One Health monitoring (European Food Safety Authority & European Centre for Disease Prevention and Control, 2022), and pathogen-specific literature (Dhama et al., 2015).

Table 1: Major Foodborne Zoonotic Pathogens and Gastrointestinal Manifestations

Pathogen	Estimated Global Annual Cases	Case-Fatality Rate (CFR)	Primary GI Manifestations	Severe Complications
Salmonella spp. (non-typhoidal)	~94 million cases	0.1–1%	Diarrhea, fever, abdominal cramps	Bacteremia, reactive arthritis
Campylobacter spp.	~96 million cases	<0.1%	Watery/bloody diarrhea, severe abdominal pain	Guillain–Barré syndrome, post-infectious IBS
Shiga toxin–producing *E. coli* (STEC)	~2.5 million cases	0.5–5% (higher in children)	Bloody diarrhea, abdominal cramps	Hemolytic uremic syndrome (HUS)
Listeria monocytogenes	~1,600 confirmed cases in high-income countries; thousands undetected globally	20–30%	Mild GI symptoms or asymptomatic	Meningitis, septicemia, fetal loss
Yersinia enterocolitica	~117,000 cases	<0.5%	Fever, abdominal pain, diarrhea	Reactive arthritis, mesenteric adenitis
Cryptosporidium spp.	~8 million food/waterborne cases	0.2–0.5%	Profuse watery diarrhea	Chronic infection (immunocompromised)
Toxoplasma gondii (foodborne)	Millions exposed yearly; ~10–20% symptomatic	<1%	Mild GI symptoms	Congenital toxoplasmosis, encephalitis

These pathogens, as Table 1 illustrates, vary significantly in clinical severity, route of transmission, and long-term outcomes, and it is thus important to consider risk-based surveillance and specific intervention strategies.

Pathogenesis and Mechanisms of Gastrointestinal Injury

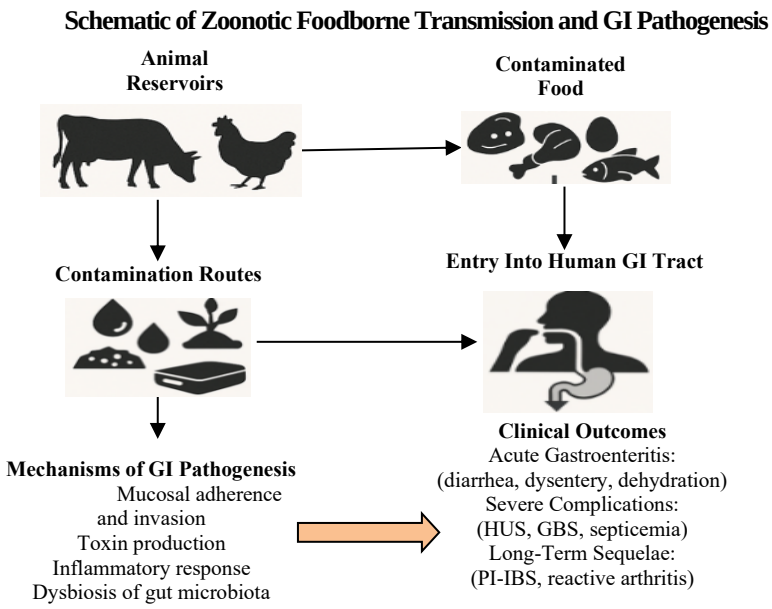

Figure 2: Schematic of Zoonotic Foodborne Transmission and Gastrointestinal (GI) Pathogenesis

Figure 2. Demonstrates farm-to-fork pathways of contamination, human GI access, key processes (mucosal invasion, toxin production, inflammation, dysbiosis), and outcomes of disease (acute gastroenteritis, invasive disease, post-infectious sequelae).

Zoonotic pathogens present in food trigger gastrointestinal disease in a number of interacting processes that determine the severity, duration, and long-term outcomes of infection. Once it has been transmitted via contaminated food, water, or animal-derived products, the pathogens enter the intestinal mucosa, where they initiate interactions that predetermine both local and systemic responses. These are epithelial adherence and invasion, toxic-related injury, inflammatory reactions, breakdown in microbiota, and immune-mediated post-infectious sequelae. Most disease-causing pathogens infect or destroy intestinal epithelium. Salmonella spp. Enters through M cells in the small intestine and induces inflammation and epithelial damage, resulting in diarrhea and abdominal pain. Yersinia enterocolitica also invades the ileum and mesenteric lymph nodes and occasionally resembles appendicitis. When the epithelial barrier is lost, certain pathogens can propagate beyond the gut, leading to invasive disease amongst susceptible people.

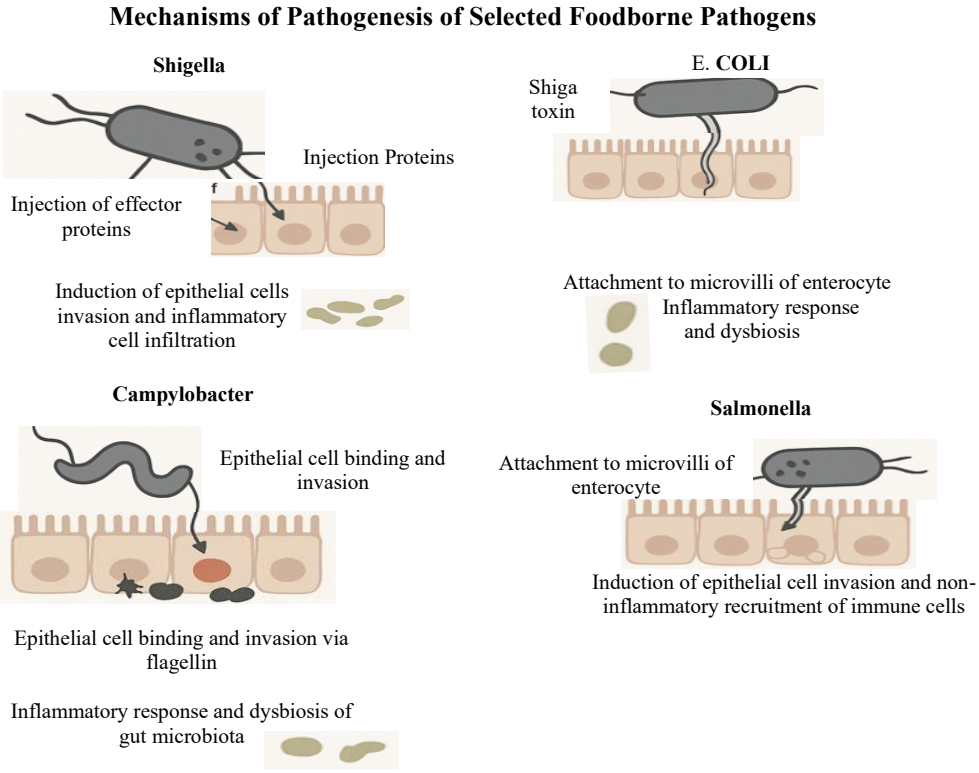

Figure 3. Mechanisms of GI Pathogenesis of Selected Foodborne Zoonotic Pathogens

Figure 3. provides an overview of the most important processes like epithelial invasion, toxin production, inflammation and dysbiosis and their role in acute and chronic gastrointestinal outcomes.

The production of toxins contributes significantly towards the hospitality of illness. STEC produces Shiga toxins that injure vascular endothelium causing hemorrhagic colitis and hemolytic uremic syndrome especially in young people.

Children Electrolyte and fluid secretions are interfered with by toxins that are produced by some Salmonella and Campylobacter strains leading to profuse watery diarrhea and dehydration. These effects of toxins are compounded with host inflammatory reactions that enhance intestinal permeability and augment tissue damage.

Although immune responses are necessary to clear pathogen, they can also be the cause of disease. Pro-inflammatory cytokine release triggers inflammatory diarrhea and in other cases, autoimmune complications may build up in response to autoimmune cross-reactivity to the Campylobacter infection, like reactive arthritis and Guillain-Bar syndrome. Gut microbiota is also commonly disrupted by foodborne infections decreasing colonization resistance and leading to long-time symptoms or chronic diseases like post-infectious irritable bowel syndrome.

The combination of these mechanisms; epithelial damage, toxin effects, inflammation, dysbiosis and immune responses is the cause of the wide clinical spectrum of foodborne zoonotic diseases, including mild self-limiting diarrhea to severe systemic complications. Knowledge on

these mechanisms aids in clinical decision-making as well as prevention. As an example, antibiotics are not implemented in STEC infections because of the danger of aggravated toxin release, but early fluid management is at the heart of the treatment. The interventions needed by reducing contamination along the farm-to-fork continuum such as biosecurity, hygienic food processing and cold-chain controls are necessary at the population level to prevent the transmission at the point of entry.

Public Health and Economic Impact

Foodborne The effect of foodborne zoonotic diseases is a massive burden to the whole world with millions of affected people each year in terms of acute gastrointestinal disease, chronic sequelae and major economic damages. According to the World Health Organization (WHO), the prevalence and death rates of significant foodborne pathogens are high in the world, and the role of the diarrheal agents is a significant cause of disability-adjusted life years (DALYs) lost worldwide. The estimates of the burdens confirm that the low- and middle-income nations suffer disproportionately because of poor sanitation systems, unofficial food sales, and low healthcare accessibility (Olifiers et al., 2015).

WHO assessments are supplemented by national and regional agencies. Salmonella, Campylobacter, STEC, and Listeria have continued to record high rates of incidence in the United States, recorded through its FoodNet surveillance initiative, with young children, elderly, and immunocompromised persons at the highest rate of hospitalization (Centers for Disease Control and Prevention, 2023). The European Food Safety Authority (EFSA) and the European Centre of Disease Prevention and Control (ECDC) One Health Zoonoses Report lists Campylobacter as the most commonly reported zoonotic pathogen, with Salmonella in second followed by Listeria despite a lower incidence (European Food Safety Authority & European Centre for Disease Prevention and Control, 2022).

In addition to morbidity and mortality, foodborne zoonotic infections are associated with significant costs to the society and economy. These involve costs on clinical care, productivity, recall of food, trade restrains, supply disruptions, and long term disability management (Gkogka et al., 2011; Hoffmann et al., 2014). Research in the third world.

highlight the economic burden on families and health infrastructures where the local areas are poor and lack infrastructures to support exposure and disease outcomes (Senthil, 2025; Olifiers et al., 2015). The history of outbreaks of STEC, Listeria, norovirus have all proven that they can create multimillion-dollar losses to economies, diminished consumer trust in food sectors, and high costs to borne by governments to respond to the outbreaks (Gkogka et al., 2011; Pal, 2020).

This combination of both the high disease burden, substantial economic consequences as well as the distribution of vulnerability among populations creates the necessity of better international surveillance, coordinated responses during outbreaks, and investment in food safety mechanisms.

Table 2: Public Health Burden Indicators of Major Foodborne Zoonotic Diseases

Metric	Representative Values / Global Estimates	Notes
Total foodborne illness cases globally	~600 million per year	WHO estimate
Total foodborne deaths	~420,000 deaths annually	WHO, 2015 FBD burden study
DALYs lost globally from foodborne diseases	~33 million DALYs	Diarrheal pathogens = major contributors
Salmonella DALYs	~3.6 million DALYs	High due to widespread prevalence
Campylobacter DALYs	~3.0 million DALYs	Significant post-infectious sequelae burden
STEC DALYs	~1.2 million DALYs	Severe outcomes (HUS) increase burden
Listeria DALYs	~0.6 million DALYs	High fatality despite low incidence
Economic cost – United States	USD 15.5 billion/yr (direct + indirect)	USDA estimates
Economic cost – EU	€7–10 billion annually	EFSA/ECDC
Productivity loss globally	Billions annually; varies by region	Mostly indirect losses
Outbreak response costs	Large outbreaks cost USD 50–100 million each	Example: STEC, listeriosis outbreaks

Table 2 provides a summary of the main indicators of public health burden obtained through global burden estimates by WHO (World Health Organization, 2015), surveillance data reported by CDC (Centers for Disease Control and Prevention, 2023), One Health analyses provided by EFSA/ECDC (European Food Safety Authority & European Centre for Disease Prevention and Control, 2022), and economic analyses of the USDA and epidemiological research (Gkogka et al., 2011; Hoffmann et al., 2014) to put the global and regional effects of foodborne zoonotic diseases into context.

Prevention, Control, and One Health Strategies

Preventing To prevent and manage foodborne zoonotic diseases, there is a need to implement concerted efforts on the entire farm to fork continuum. Due to the fact that pathogens begin their development in animals, infect food and the environment, and eventually lead to the occurrence of the disease in humans, no single sector can resolve the issue on its own. One Health framework, that is, a tie up between the public health, veterinary health, food safety authorities, and environmental management is consequently critical to effective and sustainable control (Erickson, 2015; Pal, 2020).

International organizations like the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), European Food Safety Authority (EFSA), and Food and Agriculture Organization (FAO) are the source of. surveillance, risk evaluation, outbreak imminent reaction counseling and capacity building to educate national food safety controls (World Health Organization, 2015; Centers for Disease Control and Prevention, 2023; European Food Safety Authority & European Centre for Disease Prevention and Control, 2022). These interconnected systems are beneficial in the detection of emerging threats, surveillance of antimicrobial resistance, enhancement of

traceability, and strengthening of laboratory and epidemiological preparedness across all areas of the globe (Geetha & Gowsikraja, 2025).

The significant predictor variables that affect the risk of foodborne zoonotic disease are summarized in Table 3. These are hazard related factors, exposure pathways, host vulnerability features and environmental drivers, which are critical to One Health risk evaluation and specific interventions. The table combines the WHO evidence, CDC evidence, EFSA/ECDC evidence, and literature evidence.

Table 3: Predictor Variables for Foodborne Zoonotic Disease Risk (Hazard, Exposure, Vulnerability, Environmental Drivers)

Variable Category	Variable	Response	Predictor
Overall Risk	Incidence and prevalence of foodborne GI diseases in humans	X	
	Confirmed zoonotic foodborne outbreaks	X	
	DALYs attributable to zoonotic pathogens	X	
Hazard (Pathogen Factors)	Presence of zoonotic pathogens in food animals (*Salmonella, Campylobacter, STEC, Listeria, Yersinia*)		X
	Prevalence in food products (meat, poultry, dairy, produce)		X
	Contamination load / pathogen density		X
	Antimicrobial resistance (AMR) profiles		X
	Virulence traits (e.g., toxin production, invasion factors)		X
Exposure (Food Chain & Behavioral Factors)	Consumption of high-risk foods (raw milk, undercooked meat)		X
	Cross-contamination in kitchens or processing facilities		X
	Cold-chain failures / improper temperature control		X
	Poor sanitation in food environments		X
	Occupational exposure (farm, slaughterhouse, food processing workers)		X
Vulnerability (Host Factors)	Children <5, elderly, pregnant individuals, immunocompromised	X	
	Pre-existing GI diseases	X	
	Low socioeconomic status affecting food safety access		X
	Limited healthcare access or diagnostics	X	
Environmental Drivers	Contaminated water used for irrigation or food processing		X
	Animal density near farms/food production sites		X
	Climate and seasonal patterns affecting pathogen survival		X
	Waste management and sanitation infrastructure quality		X

Conclusion

Zoonotic food-borne diseases are still causing a significant health and economic burden on the world, and this disease is disproportionately impacting vulnerable populations and areas with inadequate food safety infrastructures. The discussed major pathogens, such as Salmonella, Campylobacter, STEC, Listeria monocytogenes, and Yersinia enterocolitica, are still a significant threat to the farm-to-fork continuum and cause numerous gastrointestinal, death, and long-term sequelae. One Health needs to be implemented

effectively through coordinated prevention and control involving human, animal, and environmental system by enhancing surveillance networks, regulatory frameworks and strong multisectoral coordination. Moreover, the impact of zoonotic foodborne diseases on wildlife species cannot be overlooked. As wildlife plays a critical role in ecosystem health, infections in wildlife populations can have cascading effects on biodiversity and ecosystem services. The transmission of these pathogens through contaminated food sources or environments poses a threat to wildlife gastrointestinal health, further complicating zoonotic control efforts. Involving wildlife in the One Health framework is essential for improving surveillance and preventing the spread of zoonotic diseases, particularly in areas where wildlife-human interactions are frequent.

Regardless of the significant advances, there are a number of constraints that still pose a problem in the proper evaluation and control of foodborne zoonotic diseases. The lack of standardized surveillance systems, the lack of harmonized systems, and inconsistency in the documentation of the outbreaks across regions leads to substantial underreporting. Numerous nations with low- and middle-income level lack the routine testing of the pathogen, the laboratory facilities, and the systematic data collection, which creates the gaps of global burden estimation. Moreover, the long-term consequences (post-infectious irritable bowel syndrome, reactive arthritis, and neurological consequences) are not well quantified and underestimate the overall impact on the population.

In the future, there are few areas that need urgent attention. The outbreaks can be better detected, tracked, and monitored with the increased application of genomic tools including whole-genome sequencing and metagenomics. To overcome the gaps in humans, animal, and environment data, more resources should be invested in integrated One Health surveillance systems capable of providing better early warning systems. There is also the need of research to elucidate the long-term and quality-of-life outcomes of acute infections, along with the contribution of climate change, changing ecosystems, and informal food markets to future trends in zoonotic foodborne disease transmission. Lastly, it will be important to assess the effectiveness and cost-efficiency of One Health interventions in the real world to inform policy and resources allocation priorities. In general, the development of food safety and reduction of the burden of foodborne zoonotic diseases will require the continued international collaboration, the evidence-based interventions, and the enhanced public health systems, which will be able to respond to emerging and new threats.

References

[1] Abebe, Engidaw, Getachew Gugsa, and Meselu Ahmed. "Review on major food-borne zoonotic bacterial pathogens." *Journal of tropical medicine* 2020, no. 1 (2020): 4674235. https://doi.org/10.1155/2020/4674235

[2] Ali, Sultan, and Abdullah F. Alsayeqh. "Review of major meat-borne zoonotic bacterial pathogens." *Frontiers in Public Health* 10 (2022): 1045599. https://doi.org/10.3389/fpubh.2022.1045599

[3] Al-Musawi, Adil Turki, Sudad Jasim Mohammed, and Mohammad A. Alsoufi. "The Evaluation of the Antagonistic Effect of Certain Strains of Lactobacillus spp. on Various Virulence Factors of Foodborne Pathogenic Bacteria." *Natural and Engineering Sciences* 10, no. 2 (2025): 184-192. https://doi.org/10.28978/nesciences.1704071

[4] Bancerz-Kisiel, Agata, and Wojciech Szweda. "Yersiniosis–zoonotic foodborne disease of relevance to public health." *Annals of agricultural and environmental medicine* 22, no. 3 (2015): 397-402. https://doi.org/10.5604/12321966.1167700

[5] Centers for Disease Control and Prevention. *Foodborne Diseases Active Surveillance Network (FoodNet): 2023 Surveillance Report.* U.S. Department of Health and Human Services, 2023.

[6] Chlebicz, Agnieszka, and Katarzyna Śliżewska. "Campylobacteriosis, salmonellosis, yersiniosis, and listeriosis as zoonotic foodborne diseases: a review." *International journal of environmental research and public health* 15, no. 5 (2018): 863. https://doi.org/10.3390/ijerph15050863

[7] Dhama, Kuldeep, Kumaragurubaran Karthik, Ruchi Tiwari, Muhammad Zubair Shabbir, Sukhadeo Barbuddhe, Satya Veer Singh Malik, and Raj Kumar Singh. "Listeriosis in animals, its public health significance (food-borne zoonosis) and advances in diagnosis and control: a comprehensive review." *Veterinary Quarterly* 35, no. 4 (2015): 211-235. https://doi.org/10.1080/01652176.2015.1063023

[8] EFSA Panel on Biological Hazards (BIOHAZ), Kostas Koutsoumanis, Ana Allende, Avelino Alvarez-Ordóñez, Declan Bolton, Sara Bover-Cid, Marianne Chemaly et al. "Public health risks associated with food-borne parasites." *EFSA journal* 16, no. 12 (2018): e05495. https://doi.org/10.2903/j.efsa.2018.5495

[9] Erickson, Marilyn C. "Overview: foodborne pathogens in wildlife populations." *Food safety risks from wildlife: challenges in agriculture, conservation, and public health* (2015): 1-30.

[10] European Food Safety Authority, and European Centre for Disease Prevention and Control. "The European union one health 2021 zoonoses report." *EFSA Journal* 20, no. 12 (2022): e07666. https://doi.org/10.2903/j.efsa.2022.7666

[11] Fairfax, Julian, and Anika Sørensen. "Integrating Telemedicine and Pharmacists in Chronic Gastrointestinal Diseases: A Critical Role During the COVID-19 Pandemic." *Global Journal of*

Medical Terminology Research and Informatics 2, no. 4 (2024): 23-29.

[12] Geetha, K., and P. Gowsikraja. "Biosecurity Risk Assessment of Cross-Species Microbial Invasion: Lessons from Extraterrestrial Microbe Simulation Models." *National Journal of Animal Health and Sustainable Livestock* 3, no. 1 (2025): 10-17. https://doi.org/10.17051/NJAHSL/03.01.02

[13] Gkogka, Elissavet, Martine W. Reij, Arie H. Havelaar, Marcel H. Zwietering, and Leon GM Gorris. "Risk-based estimate of effect of foodborne diseases on public health, Greece." *Emerging infectious diseases* 17, no. 9 (2011): 1581. https://doi.org/10.3201/eid1709.101766

[14] Hassanain, Nawal A., Mohey A. Hassanain, Wahid M. Ahmed, Raafat M. Shaapan, Ashraf M. Barakat, and H. A. El-Fadaly. "Public health importance of foodborne pathogens." *World Journal of Medical Sciences* 9, no. 4 (2013): 208-222. https://doi.org/10.5829/idosi.wjms.2013.9.4.8177

[15] Hoffmann, Sandra, B. Maculloch, and M. Batz. "Cost estimates of foodborne illnesses." *USDA Economic Research Service* (2014).

[16] Odeyemi, Olumide A. "Public health implications of microbial food safety and foodborne diseases in developing countries." *Food & nutrition research* 60, no. 1 (2016): 29819. https://doi.org/10.3402/fnr.v60.29819

[17] Olifiers, Natalie, Ana Maria Jansen, Heitor Miraglia Herrera, Rita de Cassia Bianchi, Paulo Sergio D'Andrea, Guilherme de Miranda Mourao, and Matthew Edzart Gompper. "Co-infection and wild animal health: effects of trypanosomatids and gastrointestinal parasites on coatis of the Brazilian Pantanal." *PLoS One* 10, no. 12 (2015): e0143997. https://doi.org/10.1371/journal.pone.0143997

[18] Pal, Mahendra. "Amoebiasis: an important foodborne disease of global public health concern." *Archives of Nutrition and Public Health* 2, no. 1 (2020): 1-3.

[19] Rasetti-Escargueil, Christine, Emmanuel Lemichez, and Michel R. Popoff. "Public health risk associated with botulism as foodborne zoonoses." *Toxins* 12, no. 1 (2019): 17. https://doi.org/10.3390/toxins12010017

[20] Senthil, T. "Assessing the Impact of Invasive Species on Food Security: A CLIMEX-Based Modelling Approach." *National Journal of Food Security and Nutritional Innovation* 3, no. 1 (2025): 1-8. https://doi.org/10.17051/NJFSNI/03.01.01

[21] Warwick, Clifford. "Gastrointestinal disorders: are health care professionals missing zoonotic causes?." *The journal of the Royal Society for the Promotion of Health* 124, no. 3 (2004): 137-142. https://doi.org/10.1177/14664240041240 0316

[22] World Health Organization. "WHO estimates of the global burden of foodborne diseases: foodborne disease

burden epidemiology reference group 2007-2015." (2015).

[23] Zaidi, Mussaret B., Freddy D. Campos, Teresa Estrada-García, Flor Gutierrez, Magda León, Rodolfo Chim, and Juan J. Calva. "Burden and transmission of zoonotic foodborne disease in a rural community in Mexico." *Clinical Infectious Diseases* 55, no. 1 (2012): 51-60. https://doi.org/10.1093/cid/cis300