

*Narrative Review*

# A Brief Review on Foodborne Zoonosis in Pakistan with the Perspective of One Health

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## ABSTRACT

**Background:** Zoonotic diseases pose a significant public health challenge globally, with developing countries like Pakistan facing heightened risks due to various factors such as climate change, environmental degradation, and socio-economic disparities. These diseases, transmitted between animals and humans, have profound implications for healthcare systems, food safety, and public health policies.

**Objective:** This study aims to identify the key risk factors associated with the prevalence of zoonotic diseases in Pakistan and evaluate the effectiveness of the 'One Health' approach in addressing these multifaceted challenges.

**Methods:** A comprehensive review of existing literature was conducted, focusing on zoonotic disease outbreaks in Pakistan, their associated risk factors, and the impact of integrated health strategies. Data from government reports, peer-reviewed articles, and international health organization databases were analyzed to assess the current state of zoonotic diseases in Pakistan.

**Results:** The findings indicate that climate change, environmental issues, lack of public awareness, and socio-economic inequities are the primary drivers of zoonotic disease transmission in Pakistan. Despite some progress in disease surveillance and public health education, gaps in food and water safety practices, vector control, and environmental management persist. The 'One Health' approach has shown potential in improving cross-sectoral collaboration and enhancing disease prevention measures, yet its implementation remains inconsistent.

**Conclusion:** Effective management of zoonotic diseases in Pakistan requires a concerted effort that encompasses improved surveillance, enhanced public awareness, and robust environmental and food safety policies. The 'One Health' approach emerges as a critical framework for fostering collaboration across human, animal, and environmental health sectors to mitigate the risks and impacts of zoonotic diseases.

**Keywords:** Zoonotic Diseases, One Health Approach, Public Health, Pakistan, Climate Change, Environmental Health, Disease Surveillance, Food Safety, Vector Control, Socio-economic Factors.

## INTRODUCTION

Foodborne zoonoses represent a significant public health concern globally, entailing infections and diseases that are transmitted between animals and humans through the consumption of contaminated food. These conditions are precipitated by a diverse array of pathogens, including bacteria, parasites, viruses, and prions, which collectively exert a substantial impact on global health paradigms. Despite advancements in food safety protocols, foodborne zoonoses persist as a prevalent issue, with certain industrialized nations reporting incidences affecting up to 10% of their population annually (1). In the context of Pakistan, the past two decades have witnessed a notable escalation in foodborne disease incidents. Specifically, between the years 2010 and 2020, Pakistani health authorities reported approximately 13,000 cases of foodborne diseases, impacting 289,380 individuals and

culminating in 2,297 fatalities. Notably, a significant proportion of these cases, ranging between 40% to 50%, were attributed primarily to zoonotic pathogens (2).

The agricultural sector, particularly livestock production, constitutes a cornerstone of Pakistan's economy and the livelihood of its rural populace. In the fiscal year 2021-22, livestock production was responsible for 61.9% of the agricultural Gross Domestic Product (GDP) and 14.0% of the national GDP, while also providing approximately 35% to 40% of the income for over 8 million rural families (3). Concurrent with the burgeoning human population, escalating per capita incomes, globalization, and shifts in dietary preferences, there has been a marked increase in the consumption of animal products. This trend has, in turn, spurred a heightened demand for livestock, necessitating an expansion in animal husbandry and processing capacities. However, the intensification of these activities harbors the potential for suboptimal processing practices, which pose a risk for the propagation of foodborne illnesses. The risk factors associated with the transmission of such diseases are multifaceted, encompassing the health status of individuals involved in food handling, their adherence to hygiene standards, and their awareness of food safety measures (4).

This interconnection between animal health, human health, and environmental sustainability underscores the critical importance of adopting a One Health approach. Such an approach recognizes the intertwined nature of human and animal health ecosystems and advocates for integrated efforts to safeguard food safety, enhance public health outcomes, and ensure sustainable agricultural practices. In the case of Pakistan, addressing the challenges posed by foodborne zoonoses necessitates a comprehensive strategy that encompasses improvements in livestock management, food processing, and public health education. By fostering collaboration across sectors and disciplines, it is possible to mitigate the impact of these diseases and protect the well-being of both the population and the economy.

## MATERIAL AND METHODS

The design of this brief review on foodborne zoonosis in Pakistan, particularly focusing on bacterial pathogens, was structured to provide an in-depth analysis of the current state, challenges, and strategies for controlling such outbreaks from a One Health perspective. The primary question guiding this review was to identify the most common zoonotic bacterial pathogens responsible for foodborne illnesses in Pakistan, understand their transmission mechanisms, and evaluate the effectiveness of current control and prevention strategies.

To gather relevant literature, a comprehensive search strategy was employed across multiple databases including PubMed, Scopus, Web of Science, and Google Scholar. Keywords such as "foodborne zoonosis," "bacterial pathogens," "Pakistan," "public health," "animal products," "disease control," and "One Health" were used in various combinations to ensure a broad capture of relevant studies. The search was limited to studies published in English, within the last two decades, to ensure the relevance and timeliness of the data reviewed.

Eligibility criteria for the studies included in the review were strictly defined. The selected studies had to focus on foodborne zoonotic

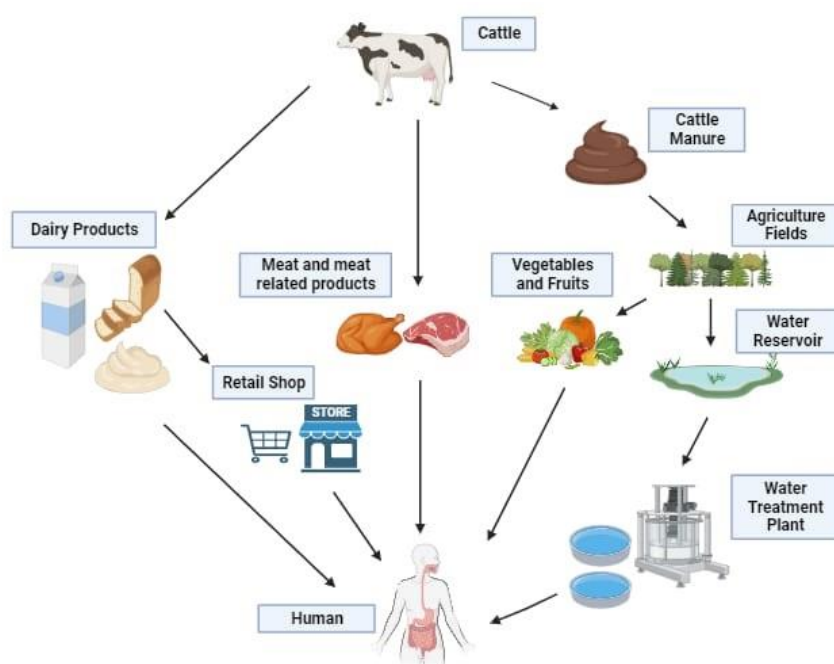


Figure 1 Indicates Transmission of Food-borne Zoonoses

diseases in Pakistan, involve bacterial pathogens, and include data on disease incidence, transmission, control measures, or public health implications. Studies were excluded if they were not directly related to foodborne zoonosis, did not involve Pakistan, or focused solely on non-bacterial pathogens such as viruses or parasites.

The evidence synthesis process involved a thorough examination of the gathered literature to extract data relevant to the review's objectives. This included information on the prevalence of different zoonotic bacterial pathogens, their impact on public health, identified sources and modes of transmission,

and the effectiveness of existing control measures like hygiene practices, Good Manufacturing Practice (GMP), sanitation procedures, Hazard Analysis and Critical Control Point (HACCP) implementation, and pasteurization processes. Additionally, the review paid special attention to the issue of antibiotic resistance, which poses a significant challenge to the control of zoonotic bacterial diseases.

To ensure a comprehensive understanding of the topic, the review also incorporated data from governmental and non-governmental reports, policy documents, and other grey literature that provided insights into the national context regarding foodborne zoonotic diseases and their management in Pakistan. The synthesis of evidence from these various sources was critical in developing a holistic view of the challenges and strategies for controlling foodborne zoonotic bacterial pathogens within the framework of One Health in Pakistan.

## FINDINGS AND DISCUSSION

The increasing prevalence of foodborne diseases presents a significant challenge to public health systems globally, with a particularly acute impact on developing nations such as Pakistan. According to the World Health Organization (WHO), contaminated food and water are the conduits for pathogens that lead to diseases impacting millions worldwide, underscoring a growing public health and economic concern. These diseases are responsible for the morbidity and mortality of a substantial portion of the population, with WHO estimating that 30% of individuals in developed countries and up to 2 million people in developing countries succumb to food-related illnesses annually (5). This alarming statistic is further compounded by the emergence of new pathogens and the evolution of transmission modes, often linked to novel food vehicles, highlighting the dynamic and complex nature of foodborne zoonoses.

In Pakistan, the surge in foodborne diseases can be attributed to multiple factors, including inadequate food safety practices, insufficient regulatory frameworks, lack of investment in safer food production technologies, and a shortfall in training for food handlers. Compounding these issues are cultural practices such as the consumption of raw beef, conditions of overcrowding and poverty, and substandard hygiene practices, which together create a fertile ground for the proliferation of foodborne pathogens (6). Despite the recognized threat posed by certain bacterial pathogens, which are known to cause severe diseases when transmitted through contaminated food, the scope of foodborne illnesses remains difficult to ascertain accurately due to the deficiencies in reporting and surveillance systems, particularly in developing countries like Pakistan (7).

Zoonoses, diseases transmitted from animals to humans, represent a significant fraction of infectious diseases, with approximately 60% of known infectious diseases being zoonotic and animal-borne infections accounting for 75% of emerging infectious diseases (8). The transmission of zoonotic diseases is facilitated by various factors, including climate change, population growth, urbanization, movements of animals, and tourism, underscoring the intricate interplay between humans, animals, and the environment in the epidemiology of these diseases. The One Health initiative, which promotes a collaborative approach among different sectors to enhance health outcomes, is crucial in addressing the multifaceted challenges posed by zoonotic diseases (9).

Pakistan, with its vast population, diverse natural landscapes, and significant livestock resources, is uniquely positioned at the nexus of human, animal, and environmental health. The country's situation is further complicated by challenges such as climate change, biodiversity loss, poverty, conflict, and political inertia, which collectively hinder effective disease surveillance and public health interventions. The recent outbreaks of Chikungunya virus and Crimean-Congo Hemorrhagic Fever (CCHF) in Pakistan exemplify the urgent need for integrated disease control strategies that can mitigate the spread of zoonotic diseases and minimize their impact on human health (11).

The interdependence of human, animal, and environmental health necessitates a synergistic approach to disease prevention and control. Government entities, including the Ministries of Climate Change and Education, alongside non-governmental organizations (NGOs), are pivotal in developing and implementing strategies that leverage the One Health concept. Such collaborative efforts are essential for addressing the complex dynamics of zoonotic diseases in Pakistan and for fostering a sustainable and effective public health response (12). This review underscores the critical importance of adopting the One Health framework in mitigating the burden of zoonotic diseases in Pakistan, emphasizing the need for a concerted effort among the public and private sectors to safeguard health at the intersection of humans, animals, and the environment (13).

The proliferation of food-borne zoonotic diseases in Pakistan constitutes a significant public health challenge, exacerbated by the country's diverse epidemiological landscape and socio-economic conditions. Diseases such as tuberculosis (TB), rabies, encephalitis, Lyme disease, foot and mouth disease, and a spectrum of soil-borne zoonoses including brucellosis, leishmaniasis, Chagas disease/trypanosomiasis, balantidiasis, bird flu, giardia, and anthrax underscore the multifaceted nature of zoonotic threats facing the population. Notably, *Bacillus anthracis*, the causative agent of anthrax, has been identified as particularly prevalent in the Punjab province, signaling a critical area for intervention (14).

The livestock sector, a cornerstone of the Pakistani economy, is a double-edged sword in this context. While it is highly adaptable to the local environment and produces approximately 1.6 million tons of meat annually, it has historically been a source of significant zoonotic disease transmission to humans, notably tuberculosis in the late 19th and early 20th centuries through the consumption of raw cow milk (15). The persistence of TB, compounded by inadequate veterinary inspection and surveillance in slaughterhouses, underscores a systemic challenge in managing zoonotic disease risks.

The bacterial foodborne diseases, including typhoid fever caused by *Salmonella typhi*, are particularly concerning due to their high incidence and the critical need for robust surveillance, monitoring programs, and vaccination strategies to mitigate their spread (16). Similarly, the spread of CCHF, a tick-borne virus, is facilitated by climate change, urbanization, and inadequate hygiene practices, highlighting the need for comprehensive public health education and tick control programs to address this deadly disease (17).

The prevalence of campylobacter in food items such as meat and milk, as reported by Husain et al., further exemplifies the widespread risk of bacterial foodborne diseases in Pakistan. The significant presence of campylobacter in meat samples, especially chicken, beef, and mutton, alongside vegetable/fruit salads, sandwiches, cheese, and raw bulk milk, underscores the urgent need for improved food safety practices (18).

Parasitic diseases, though often overlooked due to their insidious nature and diagnostic challenges, pose a significant global health burden. Parasites such as *Taenia Saginata*, *Taenia Solium*, *Toxoplasma gondii*, *Trichinella spiralis*, and *Cryptosporidium parvum*, transmitted through the consumption of contaminated animal-origin foods, require greater attention and acknowledgment within public health strategies (19).

The role of foodborne viruses in disease transmission, though less recognized compared to bacteria and parasites, is increasingly acknowledged. Viruses like the hepatitis E virus (HEV), associated with pigs, boars, and deer, and the impact of novel viruses such as SARS and H5N1 Avian Influenza, illustrate the complex interface between human health and animal diseases. The outbreaks of HEV in Pakistan, along with the incidence of HPAI and LPAI viruses in poultry, highlight the critical need for robust biosecurity measures and surveillance networks to manage these threats effectively (20, 21).

Norovirus, primarily spread through the fecal-oral route, exemplifies the transmission dynamics of gastrointestinal viruses, necessitating stringent infection control and prevention measures to mitigate its spread (22).

In summary, the management of food-borne zoonotic diseases in Pakistan requires a concerted effort across multiple sectors, leveraging the One Health approach to integrate human, animal, and environmental health strategies. The government's response to the coronavirus pandemic, through the establishment of dedicated healthcare facilities, testing laboratories, quarantine centers, and public awareness campaigns, exemplifies the type of comprehensive response needed to address the broader spectrum of zoonotic diseases impacting the country.

Table 1 Food-borne Diseases in Pakistan

Illness	Type	Pathogen	Common Source	Incubation Period	Typical Symptoms
<b>Campylobacteriosis</b>	Bacterial	<i>Campylobacter jejuni</i>	Dairy products, Poultry, Meat	2-5 days	Fever, Nausea, Abdominal cramps, Diarrhea
<b>Listeriosis</b>	Bacterial	<i>Listeria monocytogenes</i>	Unpasteurized milk, Cheese, Ready-to-eat meals	3 days- 10 weeks	Fever, Muscle aches, Meningitis, Headache
<b>Salmonellosis</b>	Bacterial	<i>Salmonella</i>	Undercooked meat, Raw eggs desserts, Seafood	6-72 hours	Vomiting, Nausea, Headache, Fever, Abdominal pain
<b>Brucellosis</b>	Bacterial	<i>Brucella abortus</i>	Raw milk, Unpasteurized dairy products, Undercooked meat	2-4 weeks	Weight loss, Fever, Abdominal pain, Weakness
<b>Bovine TB</b>	Bacterial	<i>Mycobacterium bovis</i>	Unpasteurized milk, Direct contact with infected cows	6-8 months	Intermittent cough, Enlarged lymph nodes, Fever, Weakness
<b>E.coli O157H7 Infection</b>	Bacterial	<i>E.coli</i>	Improperly cooked meat, Unpasteurized milk and	2-10 days	Diarrhea, Abdominal pain

Illness	Type	Pathogen	Common Source	Incubation Period	Typical Symptoms
			juice, Vegetables and fruits		
<b>Anthrax</b>	Bacterial	Bacillus anthracis	Direct contact with infected animals/products, Inhalation of spores, Ingestion of contaminated meat	1-7 days	Flu-like symptoms (fever, fatigue, muscle aches, malaise), Skin lesions, Cough, Chill, Sore throat
<b>Shigellosis</b>	Bacterial	Shigella spp.	Raw products, Dirty water, Uncooked food	24-48 hours	Abdominal cramp, Fever, Blood and mucus in stools, Diarrhea
<b>Botulism</b>	Bacterial	Clostridium botulinum	Improper canned food, Especially home canned vegetables, Fermented fish, Baked potatoes in foil	12-72 hours	Vomiting, Blurred vision, Double vision, Muscle weakness, Difficult swallowing
<b>Taeniasis</b>	Cestode	T. saginata and T. solium	Undercooked and raw meat	8-16 weeks	Abdominal pain, Nausea, Diarrhea, Weight loss, Weakness
<b>Trichinellosis</b>	Nematode	T. spiralis	Undercooked and raw meat	1-2 days	Abdominal discomfort, Diarrhea, Vomiting, Fever, Myocarditis, Encephalitis
<b>Toxoplasmosis</b>	Parasitic Protozoan	T. gondii	Contaminated food or water, Handling contaminated soil/cat litter	5-23 days	Fever, Muscle aches, Headache, Blurred vision or even blindness
<b>Cryptosporidiosis</b>	Parasitic	C. parvum	Contaminated water, food, or fecal matter	7 days	Watery diarrhea, Stomach cramps, Weight loss, Nausea and vomiting, Dehydration

This table summarizes key food-borne diseases prevalent in Pakistan, highlighting bacterial, cestode, nematode, and parasitic protozoan pathogens responsible for a range of illnesses. Campylobacteriosis, caused by *Campylobacter jejuni*, typically stems from dairy products, poultry, and meat, leading to fever, nausea, abdominal cramps, and diarrhea within 2-5 days. Listeriosis, associated with *Listeria monocytogenes*, can arise from unpasteurized milk, cheese, and ready-to-eat meals, with symptoms like fever, muscle aches, meningitis, and headache emerging between 3 days and 10 weeks. Salmonellosis, due to *Salmonella*, is linked to undercooked meat, raw egg desserts, and seafood, causing vomiting, nausea, headache, fever, and abdominal pain within 6-72 hours. Brucellosis, Bovine TB, *E.coli* O157H7 infection, and Anthrax are bacterial diseases associated with animal products and direct contact with infected animals, presenting various symptoms from weight loss and fever to flu-like symptoms and gastrointestinal distress. Parasitic diseases like Taeniasis, Trichinellosis, Toxoplasmosis, and Cryptosporidiosis are caused by ingestion of contaminated meat or exposure to contaminated water and fecal matter, leading to symptoms ranging from abdominal pain and nausea to severe dehydration and blurred vision. The diversity of these diseases, their sources, and their symptoms underscore the importance of food safety and public health measures in Pakistan to mitigate the risk of food-borne illnesses.

The escalating prevalence of zoonotic diseases in Pakistan is intricately linked to various risk factors spanning climate change, environmental challenges, public awareness, and socio-economic conditions. Climate change has emerged as a pivotal driver,

influencing the spread of vector-borne and waterborne infections through alterations in temperature, precipitation, and extreme weather events, thereby affecting the lifecycle and distribution of pathogens, vectors, and hosts. The environmental landscape, particularly concerning the management of waste and the interaction of wildlife with human habitats, further exacerbates the risk of disease transmission. Public awareness and behavior play a critical role in disease prevention, with educational initiatives showing some positive impact on rural populations' understanding of zoonotic diseases. However, gaps in knowledge, particularly regarding bacterial transmission from livestock to humans, remain a concern.

Surveillance of disease outbreaks is paramount for understanding and mitigating zoonotic diseases, yet Pakistan faces challenges due to insufficient data and integration of environmental health and veterinary insights. Food and water safety are central to controlling food-borne illnesses, with pasteurization and standard operating procedures for animal handling and slaughter being key preventive measures. The control of vectors, exacerbated by climate change, necessitates a comprehensive approach to mitigate the spread of diseases like malaria, leishmaniasis, and CCHF.

Environmental changes, including deforestation, urbanization, and pollution, contribute to the altered interactions between humans and animals, increasing the risk of zoonotic diseases. The 'One Health' concept emphasizes the interconnectedness of human, animal, and environmental health, advocating for integrated approaches to tackle these challenges. Health education, addressing population density, poverty, and socio-economic inequities, is essential for enhancing public understanding and engagement in preventive practices.

Improving food and water safety through hygiene practices and infrastructure development is critical to reducing the incidence of zoonotic diseases. Government and non-governmental initiatives aimed at improving water quality and sanitation are vital for preventing contamination and ensuring the health of the population.

## CONCLUSION

In conclusion, tackling the complex issue of zoonotic diseases in Pakistan requires a multifaceted strategy, incorporating disease surveillance, public health education, environmental management, and the implementation of the 'One Health' approach to foster collaborative efforts across various sectors. This comprehensive approach is imperative for addressing the root causes of zoonotic diseases and ensuring the health and well-being of both humans and animals in the face of environmental and socio-economic challenges.

Addressing zoonotic diseases in Pakistan necessitates a holistic 'One Health' approach that integrates human, animal, and environmental health strategies to mitigate these complex challenges. Enhanced surveillance, public awareness, environmental stewardship, and improved food and water safety practices are crucial. By fostering cross-sectoral collaboration and adopting comprehensive preventive measures, we can significantly reduce the incidence of zoonotic diseases, thereby improving public health outcomes, ensuring food security, and safeguarding the wellbeing of both humans and animals in Pakistan. This concerted effort will also contribute to reducing healthcare burdens and advancing towards a more sustainable and health-conscious society.

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