Relationship between Zoonotic Diseases and Food Safety

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ABSTRACT

Food safety is a critical global issue impacting economies and human health, with zoonotic diseases posing significant threats. Comprising approximately 60% of all infectious diseases affecting humans, zoonotic diseases significantly add to the burden of infectious diseases worldwide. Limited resources and insufficient healthcare systems intensify the issues resulting from the economic consequences, particularly in developing countries. The food supply chain, which includes primary production, processing, distribution, and consumption, is crucial to the spread of zoonosis. Animals often serve as sources of zoonotic diseases, and various stages of the food chain can facilitate their transmission. The genesis and spread of zoonotic diseases within the food supply chain are facilitated by changes in the environment, globalization, altered food consumption patterns, and socioeconomic factors. To reduce risks, a number of preventive measures have been put in place, including traceability programs, regulatory frameworks, Hazard Analysis and Critical Control Points (HACCP), Good Manufacturing Practices (GMPs), Good Agricultural Practices (GAPs), and GAPs. A number of outbreaks highlight the significance of appropriate food safety procedures at every point in the food supply chain to avert these kinds of occurrences. To treat zoonotic diseases, a One Health approach—which acknowledges the interdependence of human, animal, and environmental health—is crucial. Integrated surveillance systems and cooperative efforts are essential for early detection, risk assessment, and management. Effective methods for disease prevention and control are made possible by the systematic gathering and sharing of data. To reduce the incidence and effects of zoonotic diseases, it is essential to comprehend the variables that contribute to zoonosis and to put thorough food safety procedures in place. Continuous research, robust surveillance systems, and education campaigns are vital for sustaining global efforts to combat zoonotic diseases and ensure food safety in the future.

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1. INTRODUCTION

In recent years, the intersection between human health, animal health, and the environment has garnered increased attention due to the emergence of infectious diseases that cross species barriers (Bartlow et al. 2021). Zoonosis is the term used to describe infectious illnesses that may spread from animals to people through direct or indirect contact. These include bacteria, protozoa, fungus, and viruses (Rahman et al. 2020). Zoonosis has grown to be a serious problem on a global level, endangering food security, socioeconomic stability, and public health (Tirado et al. 2010). Zoonoses, such as the COVID-19 and the H1N1 influenza pandemic, have caused some of the most severe epidemics and pandemics in history (Piret and Boivin 2021). A multifaceted concept, food safety works to protect public health by making sure that food items are suitable for intake by humans. It involves the application of proper handling, preparation, and storage practices throughout the entire food supply chain, from production and processing to distribution and consumption (Raspor and Jevšnik 2008). The goal of food safety is to stop foodborne diseases brought on by bacteria, chemicals and physical hazards (Gizaw 2019). The food production cycle is somehow connected to zoonosis. As a result, many zoonotic diseases use food as an essential transport medium (Wielinga and Schulundt 2013). Many zoonotic diseases have their origins in animals, particularly livestock and wildlife, and can be transmitted to humans through the consumption of contaminated food products. The connection between zoonosis and food safety is critical because health of food animal is intrinsically related to safe food production and human health (Collins and Wall 2004).

This chapter gives a thorough analysis of the connection between zoonosis and food safety. It tries to clarify the routes by which zoonotic illnesses are transferred via the food chain and their potential impact on human health by synthesizing current literature, research findings, and case studies. The vital role that food safety practices and regulations play in avoiding and reducing the spread of zoonotic diseases will be further examined, along with the challenges and inadequacies of the existing system and suggested remedies. The need for a One Health strategy is also emphasized, with a focus on how the human health, veterinary, and environmental sectors can work together to combat zoonotic illnesses.

1. FOOD SAFETY AS A GLOBAL ISSUE

Food safety is a crucial worldwide issue that has an impact on both the economy and human health (Negri 2009). Global public health is greatly impacted by zoonotic infections, which spread from animals to humans. Serious infections, ranging from minor gastrointestinal symptoms to life-threatening problems, can be brought on by these diseases. In addition to their negative health effects, zoonotic illnesses can have significant negative economic effects, especially in underdeveloped nations. Food safety affect the human health by increasing the disease burden. Zoonotic diseases account for a substantial portion of global infectious disease burden (Rahman et al. 2020). The World Health Organisation (WHO) estimates that zoonotic illnesses account for around 60% of all infectious diseases that affect humans. These illnesses have the potential to spread globally and cause major morbidity and death through outbreaks, epidemics, and even pandemics (WHO 2014). Food safety has an influence on the economy as well since zoonotic disease outbreaks can have negative effects on commerce and tourism as well as productivity loss and higher healthcare expenditures. The financial impact is particularly severe in underdeveloped nations, where a lack of resources and a substandard healthcare system make it difficult to prevent and treat diseases (McElwain and Thumbi 2017).

Fig. 1*:* Four Steps to Food Safety

2. ROLE OF FOOD SUPPLY CHAIN IN ZOONOSIS

The practices, processes and circumstances required to guarantee that food is safe for consumption and free from contaminants are referred as food safety. There are four food safety processes as shown in Fig. 1 (CDC 2020).

Throughout the whole chain of food production, processing, distribution, and preparation, hazards are needed to be prevented, controlled, and mitigated. Reduced risk of foodborne infections and assurance that food is healthful, nourishing, and safe to eat are the two main objectives of food safety (Borchers et al. 2010).

The food supply chain connects farmers and consumers. It prepares food for human consumption by bringing it from farm to fork. The production, preparation, distribution, and consumption of food all fall under the umbrella of the food chain (Panghal et al. 2018). It involves various stages, including primary production (farming or fishing), processing, transportation, retailing, and ultimately, consumer consumption. Every stage of the food chain has the potential to transmit zoonotic diseases (Calvo-Porral et al. 2017). Animals frequently serve as the source of zoonotic diseases, which may be spread to people by direct contact, ingestion, inhalation, injection with infected material, or exposure to contaminated animal products. Influenza, brucellosis, salmonellosis, and other diseases can be transmitted to humans via various routes in the food chain (Shaheen 2022). Many foods, such as fruits and vegetables, serve as vehicles for the spread of infectious organisms to people. Consumption of raw or undercooked animal products, such as meat, poultry, seafood, and dairy, is particularly hazardous for the spread of zoonotic diseases. Fruits and vegetables can also get contaminated when they come into contact with animal faeces or polluted irrigation water. This contamination occurs where there is limited knowledge about supply chain contamination (Berger et al. 2010). Animal farming methods are also important in the spread of zoonotic diseases. Intensive agricultural practices, in which animals are confined in close housing, can foster the spread of infectious pathogens (Pesavento and Murphy 2014). Furthermore, the use of antimicrobial drugs in the livestock industry might contribute to the development of antimicrobial resistance, complicating treatment and management of zoonotic infections (Aarestrup 2005).

3. FACTORS CONTRIBUTING TO THE EMERGENCE OF ZOONOSIS IN THE FOOD SUPPLY CHAIN

There are several factors that contribute to the emergence and spread of zoonotic diseases in the food chain. These factors include:

3.1. ENVIRONMENTAL FACTORS

Increased human-wildlife interactions may result from changes in land use, deforestation, and encroachment on natural ecosystems. This contact facilitates the spread of zoonotic infections by opening up isolated areas and introducing more vectors and reservoirs to the new hosts. The distribution and behavior of disease vectors and reservoirs can potentially be affected by environmental degradation and climate change (Muehlenbein 2013).

3.1.1. GLOBALIZATION AND TRADE

Urbanization, population growth, and market forces have led to the global movement of food, including contaminated food. Due to more effective delivery systems, fresh goods are now available all year round. These modifications have helped foodborne illnesses to become more prevalent. The international trade in livestock, animal goods, and food items might hasten the global spread of zoonotic diseases. The interconnectedness of food supply chains increases the likelihood of disease transmission (Broglia and Kapel 2011). For instance, *Cyclospora cayetanensis*, a parasite causing gastroenteritis, gained recognition in the 1990s after an outbreak linked to imported Guatemalan raspberries (Almeria et al. 2019).

3.1.2. CHANGES IN FOOD CONSUMPTION PATTERNS

Dietary selection and preparation procedures are greatly influenced by customs, traditions, cultural beliefs, and dietary preferences, which can in turn increase the risk of acquiring foodborne illnesses. As a result, the availability of a wide range of food alternatives from other countries has increased the risk of exposure to infectious pathogens. Factors such as the consumption of raw or undercooked foods, the popularity of street food and takeaways, and the growing interest in healthy and ready-to-eat products also contribute to the risk of foodborne infections (Broglia and Kapel 2011).

3.1.3. SOCIOECONOMIC FACTORS

Lack of access to safe water and poor food safety infrastructure in some areas can worsen the spread of zoonotic illnesses. Inadequate sanitation facilities foster an environment where faecal contamination of water sources and food is more likely to occur. (Todd 2014).
Understanding these factors and their interactions is crucial for developing preventive measures and interventions to minimize the occurrence and impact of zoonotic diseases in the food chain.

4. FOOD SAFETY MEASURES AND ZOONOTIC DISEASE PREVENTION

The lack of food safety measures in industrial systems contributes to the spread of many diseases, including the swine flu and Ebola. In order to stop the spread of zoonotic diseases and safeguard public health, it is crucial that food safety regulations are upheld in food systems. For the purpose of avoiding outbreaks, reducing the burden of illness, and sustaining public trust in the food supply, it is essential to ensure the safety of food items along the whole food supply chain (Aiyar and Pingali 2020). Some of food safety practices and regulations that have been established to mitigate the risks are as follows:

4.1. GOOD AGRICULTURAL PRACTICES (GAPs)

It is crucial to protecting the health of consumers. Integrated pest management (IPM) and integrated crop management (ICM) are used to enhance farming practices. The guidelines and requirements for safe

and sustainable agricultural production are also included, with an emphasis on good farm management, cleanliness, and the control of potential hazards (Akkaya et al. 2005).

4.2. GOOD MANUFACTURING PRACTICES (GMPs)

The cornerstone of the integrated management system is GMP. GMPs are a set of uniform policies and processes that guarantee the secure production, handling, and processing of food items. These procedures are intended to reduce the possibility of contamination, uphold product quality, and guarantee customer safety. The design and upkeep of facilities, staff health and safety, sanitation procedures, equipment calibration and maintenance, record-keeping, and quality control are only a few of the components of food manufacturing that are covered by GMPs. Compliance with GMPs is essential to meet regulatory requirements and maintain high standards of food safety (Blanchfield 2005).

4.3. HAZARD ANALYSIS AND CRITICAL CONTROL POINTS (HACCP)

These are a series of internationally recognized recommendations for managing food-borne infections. It is a crucial component of food safety management procedures that may be used at any point in the food supply chain. It is a methodical, scientific approach to manage food safety. The goal of HACCP is to recognize, assess, and manage any risks that could arise throughout the manufacturing, process, handling, and distribution of food (Fig. 2). In addition to lowering the risk of foodborne diseases and assuring the manufacture of safe and high-quality food products, it offers a systematic framework for recognizing and mitigating risks across the food chain (Kafetzopoulos et al. 2013; Wallace and Mortimore 2016).

Fig. 2: 7 Principles of HACCP

4.4. TRACEABILITY SYSTEMS

With the use of traceability, producers and consumers may now be linked, resulting in safer food supply. Traceability is the ability to use recorded identifications to gain access to any or all information about the item under consideration across its entire life cycle (Olsen and Borit 2018). This system tries to track and gather data on various items as they move through the supply chain. This approach makes it possible to quickly identify and recall items that could be contaminated (Dabbene and Gay 2011).

4.5. REGULATORY FRAMEWORKS

In order to assure compliance and enforcement, there are a number of national and international rules that establish standards for food safety, labelling, and inspection (Omojokun 2013). Regional regulations in Pakistan are provided by the Punjab Food Authority Act of 2011 and the KPK Food Authority Act of 2014. According to the ISO (International Organization of Standardization), Codex Alimentarius Commission, and World Health Organization, food standards are harmonized globally (Ibrahim et al. 2021).

The prevention of zoonotic disease supports a diversified approach at each stage of the food chain, from farm-level preventative measures through retail and food service practices (Mardones et al. 2020). To lessen the danger of zoonotic diseases in animal populations, farm-level solutions include applying biosecurity practices, such as vaccination campaigns, illness monitoring, and appropriate waste management (Robertson 2020). Additionally, high hygiene standards are followed throughout food preparation, storage, and delivery to reduce the possibility of food contamination. The danger of transmission of zoonotic infections to humans can also be reduced and minimized by following food safety regulations in restaurants, food institutions, and retail stores (Trienekens and Zuurbier 2008).

5. ONE HEALTH APPROACH TO ZOONOSIS AND FOOD SAFETY

The One Health approach recognizes the interconnectedness of human, animal, and environmental health and emphasizes the need for collaborative efforts to address zoonotic diseases and ensure food safety. Understanding the interdependencies and interactions between these three domains is essential for effective disease prevention and control strategies. To improve health through food safety, there is a need for increased awareness among consumers, producers, and governmental agencies (Garcia et al. 2020). The One-Health approach involves improved communication and collaboration among different disciplines including human health, veterinary medicine, and environmental management (Lammie and Hughes 2016). One-health dissolves the boundaries between the sectors and all relevant stakeholders are involved in the management of health problems (Bordier et al. 2020). Collaborative initiatives facilitate the identification and implementation of effective control measures, such as integrated disease surveillance systems, joint investigations of outbreaks, and the development of shared protocols and guidelines for disease management (WHO 2019).

The systemic collection, validation, analysis, and interpretation of data and dissemination of collected information come under the umbrella of one-health surveillance. Surveillance systems are critical components of the One Health approach to zoonotic disease control. Early detection of zoonotic diseases is crucial for prompt response and intervention to prevent further spread. Integrated surveillance systems enable the early identification of emerging zoonotic diseases, facilitate risk assessments, and guide the implementation of targeted control measures (Stärk et al. 2015). A collaborative approach is necessary to undertake a risk assessment. Risk assessment and management strategies form the cornerstone of the One Health approach to zoonosis and food safety. Risk assessment involves identifying and evaluating potential hazards, assessing their likelihood of occurrence, and estimating the

associated consequences. Risk management strategies focus on implementing measures to mitigate and control identified risks (Liu et al. 2013). This includes interventions aimed at reducing exposure to zoonotic pathogens, enhancing biosecurity measures, improving food safety practices, and promoting awareness and education among stakeholders (Murphy et al. 2017).

6. NOTABLE OUTBREAKS

There are certain outbreaks that illustrate the range of pathogens and food products involved, emphasizing the importance of proper food safety practices at all stages of the food supply chain to prevent the occurrence of such incidents and safeguard public health as shown in Table 1;

Table 1: Notable Outbreaks involving the food products contamination

No.	Pathogen	Food Product Involved	Outbreak Year	Reference
1.	E. coli O157:H7	contaminated spinach	2006	Gelting et al. 2011
2.	Salmonella	contaminated peanut butter	2008-2009	Medus et al. 2009
3.	Listeriosis	contaminated cantaloupes	2011	Laksanalamai et al. 2012
4.	Campylobacter	raw milk consumption	-	Kenyon et al. 2020
5.	Hepatitis-A	contaminated green onions	2003	Chancellor et al. 2006
6.	E. coli O104:H4	contaminated sprouts	2011	Grad et al. 2012
7.	Listeriosis	contaminated ice cream products	2015	Chen et al. 2015
8.	Salmonella	contaminated papayas	-	Whitney et al. 2021
9.	Norovirus	contaminated oysters	2010	Westrell et al. 2010
10.	Shiga toxin-producing E. coli	contaminated ground beef	-	Butt et al. 2021
11.	Cyclospora	contaminated produce, such as lettuce and cilantro	-	Hadjilouka and Tsaltas 2020
12.	Salmonella	contaminated pet food	2006-07	CDC 2008
13.	Hepatitis A	contaminated frozen berries	-	Tavoschi et al. 2015
14.	Clostridium perfringens	improperly stored and reheated foods	-	Wittry et al. 2022
15.	Staphylococcus aureus	contaminated food prepared by infected food handlers	-	Kadariya et al. 2014
16.	Listeriosis	contaminated cheese products	-	McIntyre et al. 2015

These case studies highlight the need for continuous improvement in food safety practices which include:

6.1. ENHANCED HYGIENE PROTOCOLS

Rigorous adherence to good manufacturing practices (GMPs) and standard operating procedures (SOPs) for cleaning, sanitization and personal hygiene can significantly reduce the risk of contamination in food processing environments (Blanchfield 2005).

6.2. ROBUST CONTROL MEASURES

Implementation of hazard analysis and critical control points (HACCP) systems can help identify potential hazards and establish preventive measures at critical stages of food production, processing, and distribution (Wallace and Mortimore 2016).

6.3. STRENGTHENED SURVEILLANCE AND MONITORING

Implementation of comprehensive surveillance systems, including routine testing and inspections, can facilitate early detection of contamination and prompt intervention to prevent the spread of zoonotic pathogens (Stärk et al. 2015).

6.4. EDUCATION AND AWARENESS

Educating consumers, food handlers, and producers about the risks associated with zoonotic diseases and the importance of proper food safety practices can help prevent outbreaks and promote responsible food handling and consumption (Trienekens and Zuurbier 2008).

7. CONCLUSION

The connection between zoonotic illnesses and food safety is, therefore, a complicated and vitally essential problem. The investigation of notable zoonotic disease outbreaks connected to problems with food safety has exposed the disastrous repercussions that can occur when food safety procedures go wrong. Through the analysis of these outbreaks, identified various factors have been identified that contribute to their occurrence, such as inadequate hygiene practices, insufficient control measures, and limited surveillance and monitoring. To safeguard the public's health and to ensure the security of the food supply and handle the difficult problems brought on by newly developing zoonotic illnesses, it is crucial to comprehend the connection between zoonosis and food safety. We can make substantial progress in avoiding zoonotic infections, enhancing food safety, and ensuring the welfare of both humans and animals by adopting a multidisciplinary strategy that involves collaboration between the human health, veterinary, and environmental sectors. Continued research, robust surveillance systems, and ongoing education and awareness campaigns are vital for maintaining and improving global efforts to combat zoonotic diseases and ensure food safety in the future.

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