Salmonellosis in Poultry: A Clinical Perspective

Nabila Qayum[1], Wajid Khan[1], Muhammad Nazir Uddin[1], Taj-Ud-Din[1], Babar Khan[1,*], Nasib Zaman[1], Farmanullah[1,4], Nosheen Khalid[2], Sumayya Qayum[3] and Nisar Ud Din[1]

[1]Centre for Biotechnology and Microbiology, University of Swat
[2]Department of Food Science and Technology, the University of Haripur
[3]Center for Plant Science and Biodiversity, University of Swat
[4]College of Animal Science and Technology, Shandong Agricultural University, Taian, China
*Corresponding author: babarkhan8643@gmail.com

Abstract

Salmonellosis is a critical disease in poultry, caused predominantly by *Salmonella enterica* serovars *Typhimurium* and *Enteritidis*. This infection presents acute and chronic health challenges to poultry, leading to severe economic losses in the poultry industry due to high morbidity, mortality, poor weight gain, and trade restrictions. The infected birds serve as reservoirs, transmitting the bacteria through fecal shedding, contaminating the environment, feed, water, and eggs. This contamination poses significant public health risks, as salmonellosis can be transferred to humans, resulting in foodborne illnesses ranging from mild gastroenteritis to severe, life-threatening conditions, particularly in vulnerable populations. The pathogen's ability to persist in various environments and survive in asymptomatic carriers complicates its control in poultry farms. The effective management strategies include vaccination, strict biosecurity measures, and regular monitoring of poultry flocks. Diagnosing salmonellosis involves serological testing, bacterial cultures, and PCR assays to detect the presence of *Salmonella spp*. However, increasing antimicrobial resistance highlights the need for alternative control strategies, including probiotics and advancements in vaccination. Addressing salmonellosis requires comprehensive prevention and control measures to safeguard both poultry health and public food safety.

Keywords: *Salmonella enterica*, Poultry industry; Biosecurity measures; Foodborne illnesses; Antimicrobial resistance

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Introduction

Salmonellosis is an acute and chronic illness in poultry caused by *Salmonella* species, which is a significant concern for poultry and public health worldwide (Wibisono et al., 2020). Salmonellosis is costly to poultry businesses agriculturally as it leads to poor weight gains for birds, high morbidity and mortality rates, a poor food conversion ratio, and expensive control measures. (Rukambile, 2020). Furthermore, the poultry meat and eggs humans consume are among the most frequently implicated foods in food-borne illness and compromise public health. It has economic losses not only due to the direct effects of poultry production but also due to trade restrictions on related products, product recalls, and costs of medications for food-borne illnesses that have to be incurred. *Salmonella* is a gram-negative, and *S. enterica* is the most prevalent that attacks poultry. The S. *typhimurium and S. enteritidis* are essential serovars implicated in most salmonellosis cases associated with poultry production. These bacteria can become permanent residents of the poultry's intestine, causing low-grade infections or portal infections that can readily cause systemic diseases such as septicemias, increasing the mortality index. During shedding for a bird infected with the bacteria, the bacteria result in faecal shedding, contaminating the environment, feed, water, and eggs, which generally increases the spread of the infection across the flocks. *Salmonella* has high survival capacities and can quickly colonize different target types of hosts, making it hard to control in poultry farms (Foley et al., 2013).

Furthermore, the disease has an immediate relationship with human health since *Salmonella* can be transferred from poultry products to people, leading to food-borne diseases (Foley et al., 2013). This mode of transmission is a significant public health concern since the disease ranges from a simple stomach flu to deadly disease in persons with compromised immune systems, children, and the elderly. The relative popularity of poultry products for consumption worldwide increases the likelihood of outbreaks of salmonellosis, so controlling this factor in the poultry industry is necessary for both economic and sensitive health concerns (Foley et al., 2013).

Because of the close relationship between the health of birds and the safety of food for humans, salmonellosis is a concern that needs an effective control measure such as adequate implementation of bio-security, vaccination schedule, and proper inspection of poultry products. Informing the interventions need more implementation. The disease dramatically threatens the poultry farming business and global public health (Pulido-Landínez, 2019).

Etiological Agents

Salmonellosis in poultry is caused mainly by the *Salmonella enterica* complex with serotypes *Typhimurium* and *Enteritidis* (Velge et al., 2005). These serovars are the most prevalent in poultry and significant agents for zoonotic transmission to humans, resulting in foodborne diseases. Other serovars, including *Gallinarum* and *Pullorum*, cause diseases such as fowl typhoid in chickens and Pullorum disease in poultry, and although humans can be infected, it is scarce.

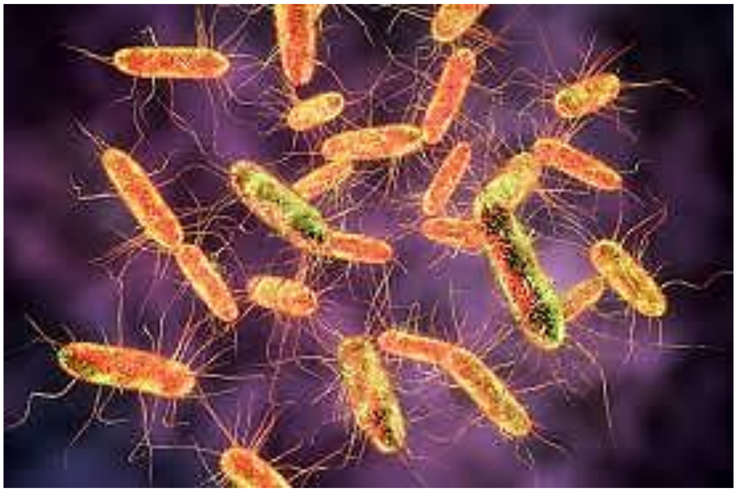

Fig. 1: Salmonellosis (Made through Biorender)

Major Serotypes of *Salmonella* Affecting Poultry

Salmonella enterica serovar *Typhimurium*: This is closely related to serogroup D D and is one of the most widespread and pathogenic serotypes distributed among a wide range of animal species, including poultry. It is forcible and causes systematic and local infections (Rabsch et al., 2002).

Salmonella enterica serovar *Enteritidis*: This serovar, mainly found in chickens and eggs, is one of the significant causes of foodborne illness in humans and is a menace to human health.

Salmonella enterica serovar *Gallinarum*: Associated with fowl typhoid, this serovar principally infects adult birds and potentially causes high morbidity in the affected poultry stock.

Salmonella enterica serovar *Pullorum*: This serovar has a high mortality rate among young chicks, making it dangerous and expensive to the poultry industry because of pullorum disease (Wigley et al., 2001).

Biology of the Bacterium:

Salmonella spp. are negative stained rods (Fig. 1), bar-shaped bacteria of the *Enterobacteriaceae* family (Wong, 2012). This means that they are facultative anaerobic bacteria capable of living both in the presence and absence of oxygen. The bacteria have flagella through which they can swim, which also helps them infect and establish themselves in the host’s intestines. See Fig 2.

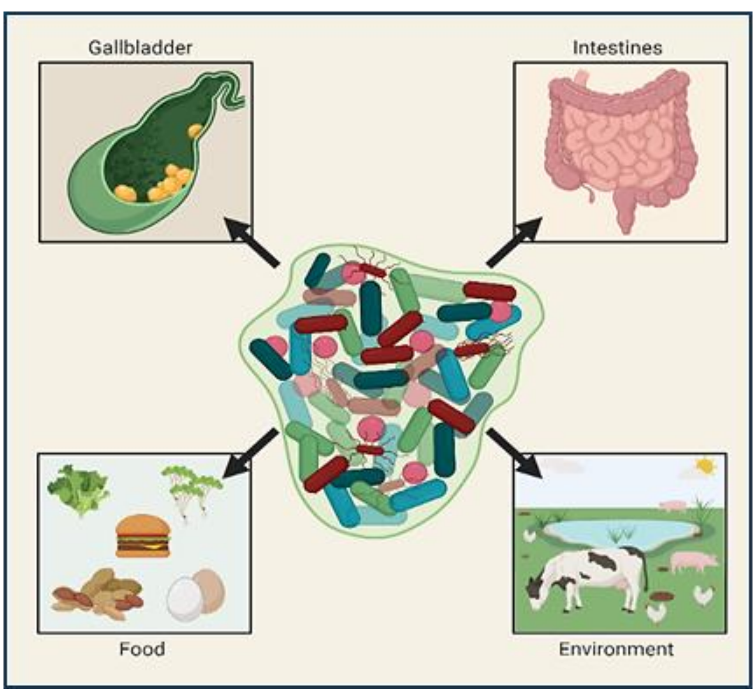

Fig. 2: Transmission routes of Salmonella: from the environment, food, intestines, and gallbladder. (Pic made from Biorender)

Once in the poultry host, *Salmonella* can penetrate the bird's intestines and cause infection by excusing more of the bacteria in the fecal matter. The disease can be asymptomatic, which means birds are infected but do not demonstrate clinical signs; infected birds can spread the bacteria to others, or the infection can result in diarrhea, weight loss, septicemia, and other clinical signs depending on the serotype and resistance of birds' immune systems (Kinde & Atwill, 2000).

Transmission Pathways

Salmonella is transmitted through several routes, making it difficult to control in poultry production systems (Russell, 2012):

Environmental Contamination: *Salmonella* is present in the poultry farm environment, litter, and equipment and can also be present in the housing. More importantly, the bacteria can survive in the environment through dust, feces, insects, or rodents, resulting in constant transmission between and within flocks (Wray et al., 1999).

Vertical Transmission: As observed with group *Enteritidis*, *Salmonella* can be passed vertically from infected hens to their offspring through eggs. This is a significant concern for poultry health, food quality, and hygiene (Figure 3) (Wray et al., 1999)

Because salmonellae are easily transmissible and can survive in different environmental substrates, preventing their spread to chicken production units requires sound biosecurity measures, good hygiene practices, and routine bird screening.

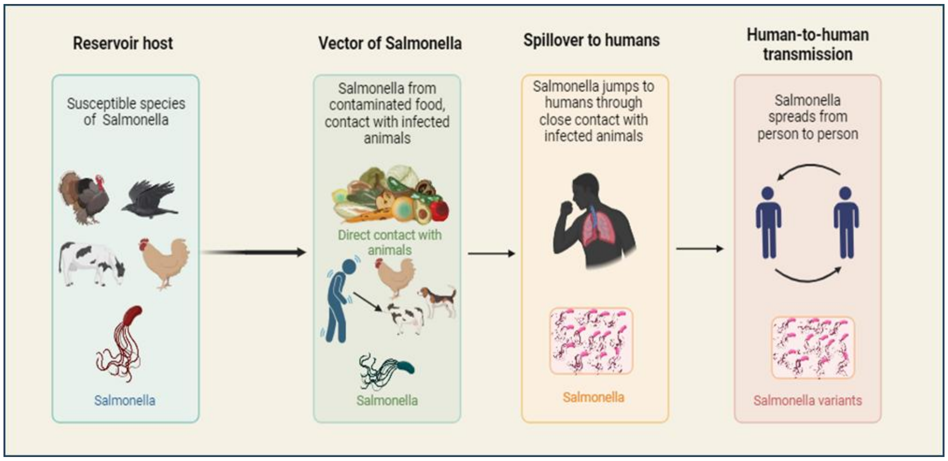

Fig. 3: Zoonotic transmission of *Salmonella* (Pic from Biorender)

Pathogenesis

Salmonella bacteria are facultative intracellular parasites that can infect poultry by ingesting contaminated feed or water or indirectly through the infected environment. Once ingested, the bacteria start their pathological process of colonization of the gastrointestinal tract, enteritis, and, in some instances, systemic infection (Shaji et al., 2023).

Entry and Colonization

Salmonella enters the host through the mouth when contaminated food products or drinking water are ingested. The bacteria can pass through the stomach's acid environment and reach the small intestine, where they start invading the mucosa. Due to flagella and other structures, they can attach themselves to the intestinal epithelium cells the first step of infection (Mkangara, 2023).

Invasion of the Intestinal Lining

Even after colonization of epithelial cells of the intestinal tract after colonization, *Salmonella* has to employ unique methods to penetrate these cells (Knodler, 2015). The bacteria use a Type III secretion system (T3SS), a needle-like structure that transfers bacterial proteins into the host cell. This process results in the cell wrapping around the bacteria in a process known as endocytosis. This leads to the uptake of *Salmonella* into the intestinal cells to replicate in vacuoles within these cells (Galle et al., 2012).

Salmonella, a pathogen in intestinal epithelial cells, affects the bowel's normal function in the following ways: inflammation, damage to the epithelial layer, and dysfunctional nutrient absorption. This results in diarrhea, one of the main manifestations of salmonellosis in poultry, and hence, the bacteria spread through fecal droppings. The inflammation resulting from the *Salmonella* infection also directs immune cells to the site. However, the bacteria have acquired traits that counteract or can survive the immune attack (Schultz et al., 2017).

Systemic Infection

In some instances, especially for the most potent serotypes such as STm, the bacterium crosses through the intestinal wall and spreads to the bloodstream (Uzzau et al., 2000), leading to a systemic disease. After entering the bloodstream, *Salmonella* can pass to other organs, such as the liver, spleen, reproductive system, etc. In such instances, septicemia may develop, which proves fatal to poultry, especially when young or birds with a suppressed immune system are involved.

Disease Mechanism

The disease outcomes caused by *Salmonella* are primarily due to the bacteria's localized pathogenicity and immune-avoiding ability. Is T3SS involved in the invasion of host tissues and the immunomodulation of host and tissue responses to *Salmonella* infection? *Salmonella* shed in tissues and feces owing to inflammation enhances bacterial release into the flock, increasing the spread of the disease (Rietschel et al., 1991).

Furthermore, the organism harbors endotoxins, acknowledged as the bacterial cell wall component. When the bacteria die, these endotoxins are shed, and these are linked to systematic inflammation that results in fever and septic shock in severe conditions associated with bacterial infection (Rietschel & Westphal, 2020).

Spread within Flocks

After the bird has been infected, it discharges *Salmonella* in its faecal matter, and the droppings in the soil and the environment infect other birds. Poultry can become re-infected with the bacteria at any time through its environment. It can survive long periods in environments where poultry carcasses drop, feed, and water coffins. Consequently, whether clinical or subclinical, infected birds can also continue to excrete the bacteria, thereby maintaining the infection status within a flock (De Lucia, 2020).

Impact

The pathogenic process of *Salmonella* not only strongly impacts the health or performance of broiler and laying hens but also poses threats to human food safety. Whether clinically or sub clinically infected with the bacteria, birds can become chronic carriers that contaminate poultry meat and eggs. This shows why relatives of *Salmonella* infections in poultry must be surreptitiously managed to eliminate foodborne diseases in human beings (Sharma, 2018).

Clinical Signs and Symptoms

The clinical manifestations of salmonellosis in poultry may also depend on the type of *Salmonella* that has affected them and the birds' age and level of immunity. In general, the disease presents in two forms, primary and secondary, and it causes a broad spectrum of diseases, from mild digestive upset to severe systemic disorders (Poppe, 2000).

Common Clinical Signs

Diarrhea: A peculiar feature of salmonellosis is that diarrhea may be watery or mucoid and contain greenish or yellowish feces. In occasional instances, diarrhea may be blood-stained, which is an indication of severe intestinal irritation (Kemal, 2014).
Dehydration: Diarrhea leads to quick dehydration of the bird owing to their continuous defecation. This can be seen in dryness of the mucous membranes, pits in the eyes, and loss of the skin's tone (Wray, 2019).
Lethargy: Affected birds may be emaciated, have pale combs and wattles, lack energy and alertness, and may be less sensitive to their surroundings. They may cluster together, especially without much physical activity (Hill, 1884).
Respiratory Issues: In severe cases, especially young chicks, respiratory distress may ensue. Clinical signs are systemic inflammation, anorexia, diarrhea, vomiting, dyspnea, coughing, and nasal discharge. In birds with septicemia, signs may also include labored breathing (Tarr et al., 2009).
Weight Loss and Poor Growth: This is true mainly in young birds, where the infections cause poor feed conversion, leading to slow growth rates.
Mortality: Rare complications of salmonellosis include lesions on internal organs and sudden death, usually in young chicks or immunocompromised birds (Noormohammadi, 2021)

Onset of Symptoms

The onset of clinical disease, salmonellosis in poultry is 6 to 72 h after exposure to the bacteria, and depending on the ingested dose and the virulence of the organism belonging to serotype D. A rash typically develops at 1-3 days of the onset of the infection. The acute infection hosts show clinical signs of diarrhea and dehydration, which may appear within a short duration. In contrast, in chronic disease, clinical signs are not easily seen for some time. (Sharma, 2018)

Variations Based on Age and Immune Status:

Young Chicks: Chicks are generally more sensitive to salmonellosis, and infections of young birds are usually more lethal to them. These people are likely to develop severe system infections such as septicemia, which could result in imminent death (Sharma, 2018).
Adult Birds: In addition to the nestlings, adult birds appeared to have more mild clinical signs or became latent cases. However, they may develop diarrhea, weakness, and a reduced egg-laying rate in severe instances (Noormohammadi, 2021).
Immunocompromised Birds: Stressed, poorly nourished birds already infected with other diseases can develop severe forms of the disease, including septicemia and death.

Transmission and Epidemiology

Salmonella is easily transmitted and has a short incubation period; thus, it can spread within and across different poultry types through various methods, making its management difficult in poultry production (Kinde & Atwill, 2000).

Modes of Transmission

Feco-Oral Route: The main route of transmission is feco-oral. *Salmonella* bacteria are excreted through the feces of infected birds; they pollute feed and water and contaminate equipment. Other avian species get ill via the consumption of items containing the virus see table 1
Vertical Transmission: Hens with *Salmonella*, particularly *Salmonella Enteritidis*, expel the bacterium to their offspring through eggs. This is a considerable danger since a chick can be affected even before laying (Sharma, 2018).
Asymptomatic Carriers: Controlling *Salmonella* is challenging since many asymptomatic carriers exist worldwide. These birds remain reservoirs of the bacteria without being affected by any sign of disease but keep discharging the pathogen within the flock, promoting its spread.
Environmental Contamination: This study shows that the farm environment, namely the poultry housing, the litter, and farm equipment, may become effectively colonized by *Salmonella* and thus act as a source of the bacteria. The pathogen is long and survives in the environment

the longer it is not washed, especially with poor hygiene (Sharma, 2018).

Vectors: Thanks to mechanical transmission, insects, rodents, and wild birds may mechanically transmit *Salmonella* from farm to farm or from one flock to another, being endorsements of the bacterium on their body surface or in their droppings.

Table 1: Mode of Transmission (Rukambile et al., 2019)

Mode of Transmission	Description
Fecal-Oral Route	*Salmonella* bacteria are excreted through feces and contaminate feed, water, and equipment. Other birds become infected by consuming contaminated items.
Contaminated Feed and Water	*Salmonella* can survive for extended periods in feed, water, and litter, a common way the bacteria spread within a flock.
Vertical Transmission	Hens with *Salmonella* can transmit the bacteria to their offspring through eggs. This poses a significant risk as chicks can be infected before hatching.
Asymptomatic Carriers	Many birds can carry *Salmonella* without showing symptoms. These birds can spread the bacteria within the flock.
Environmental Contamination	The farm environment, including poultry housing, litter, and equipment, can become contaminated with *Salmonella*. Poor hygiene and inadequate cleaning can contribute to the survival of the pathogen.
Vectors	Insects, rodents, and wild birds can mechanically transmit *Salmonella* from farm to farm or between flocks.

Major Outbreaks

Outbreaks of *Salmonella Salmonella* in poultry flocks have occurred in many parts of the world, with controllable effects depending on the level of the biosecurity measures taken or available. Where the biosecurity measures are not well practiced, as in some parts of Asia and Africa, the disease occurs after infecting many people, leading to severe outcomes (Hazards et al., 2019).

Patterns in Different Geographical Regions

North America and Europe: *Salmonella Enteritidis* and *Typhimurium* are typical, with cases associated with eggs and poultry meat. High surveillance, enforcement mechanisms, and strict biosecurity measures have prevented massive outbreaks (Galán-Relaño et al., 2023).

Role of Asymptomatic Carriers:

Lastly, this paper postulates that *Salmonella* is transmitted through direct contact with feces and the environment and from one animal to another through transferred eggs. Silently infected individuals and contaminated surfaces and objects are part of LT; therefore, it is a big problem for poultry farmers worldwide. Salmonellosis is best managed by vaccination, enforcement of biosecurity measures, and constant surveys of poultry stocks (Hilbert et al*.,* 2012).

Diagnosis

In poultry, salmonellosis is diagnosed using a combination of clinical signs and laboratory work. Therefore, it becomes essential to diagnose salmonellosis imprecisely when controlling and treating affected poultry flocks. Blood tests include serology, cultures, PCR, and rapid tests, each of which has a set strength based on the diagnostic requirement, including specificity, sensitivity, and time (Crump et al*.,* 2015).

Diagnostic Techniques

Serology

The serological testing identifies antibodies that usually form in the body when *Salmonella* infects it. These tests are beneficial for confirming *Salmonella* exposure at the flock rather than the bird level (Gast & Porter Jr, 2020).

Enzyme-linked immunosorbent assay (ELISA) is a simple and widely utilized serological test to detect the presence of *Salmonella* exposure in flocks. This method identifies specific serum antibodies against *Salmonella* antigens in blood, thus giving a picture of the flock's exposure history (McCarthy, 2003).

The serological testing helps assess the prevalence of *Salmonella* in a group of birds, but it does not show the current outbreak. It also identifies carriers.

Culture Methods

Blood bacterial culture is the definitive method of diagnosing *Salmonella* infection. It involves identifying bacteria in blood, fecal samples, tissues, or feed or water samples (McCarthy, 2003) Samples are also inoculated on selective media, which inhibit non-*Salmonella* bacteria while *Salmonella* bacteria grow; the common ones are XLD Agar, SS Agar, or Brilliant Green Agar. Positive colonies can be recognized based on their unique color and morphology (Taskila et al., 2012).

After isolation, *Salmonella* is identified using biochemical tests. This process is specialized and, therefore, takes much time days, to be precise (Tarr et al., 2009)

Polymerase Chain Reaction (PCR)

PCR is an enzymatic method employed to identify the presence of *Salmonella* DNA in stool, tissue, or swab samples. The PCR assay provides high sensitivity and specificity for detecting *Salmonella* in food samples, even when the target organism is in low concentration (Wigley et al., 2001).

PCR can be designed to differentiate various species of *Salmonella* or various serovars; for example, the invA gene is typically used to detect Salmonella. PCR yields result in hours or within one day and is progressively adopted in diagnostic procedures and monitoring programs (Poppe, 2000)

Rapid Tests

Rapid immunoassay tests have been developed to determine the *Salmonella* antigens in poultry samples. These tests are convenient and relatively simple, offering results in less than an hour.

A rapid test is most advantageous in cases of on-farm diagnosis and when prompt action is needed. Although Abbott rapid tests are convenient, they have disadvantages associated with low sensitivity compared to culture and PCR; most positive results require confirmation in other ways (Rajashekara et al., 1999).

Treatment and Management

Once a *Salmonella* infection is confirmed in a poultry flock, healing and prevention measures must be taken to overcome it. Specifically, treating *Salmonella* in poultry mainly involves the use of antibiotics. However, due to increased concerns about antimicrobial resistance, prevention and management are gradually shifting to prevention and biosecurity measures See table 2.(Gwenzi et al., 2021)

Table 2: Diagnosis of Salmonellosis in Poultry (Gwenzi et al., 2021)

Diagnostic Technique	Principle	Advantages	Disadvantages
Serology (ELISA)	Detects antibodies against *Salmonella* antigens in blood.	Can assess flock-level exposure and identify carriers.	Does not indicate a current outbreak.
Culture Methods	Isolates and identifies *Salmonella* bacteria from samples.	Definitive diagnosis can identify specific serotypes.	It is time-consuming and requires specialized techniques.
Polymerase Chain Reaction (PCR)	Detects *Salmonella* DNA in samples.	Susceptible and specific, rapid results.	It may require specialized equipment.
Rapid Immunoassay Tests	Detects *Salmonella* antigens in samples.	Convenient, rapid results.	It may have lower sensitivity than culture or PCR.

Treatment Options

Antibiotics

Currently, antibiotics are often administered to treat severe *Salmonella* challenges in poultry. The antibiotics used to treat *Salmonella* infections in birds include fluoroquinolones, aminoglycosides, and cephalosporins (Khan & Rahman, 2022).

Antibiotics can lower clinical scores, amplify life expectancy, and reduce bacterial shedding, but antibiotics must be used appropriately to avoid AMR (Sharma et al., 2018).

Hitherto, the antibiotics used in food-producing animals are increasingly controlled to prevent the development of AMR. The misuse of antibiotics, particularly the medically important ones used in animal feeding programs, has been prohibited in many countries (Pérez-Rodríguez & Mercanoglu Taban, 2019).

Probiotics and Prebiotics

Antibiotics, probiotics, good bacteria, and prebiotics, some substances that support good bacteria in the gut, are being tested because they know how to crowd out *Salmonella*.

Probiotics play an essential role in decreasing the risks of colonization by pathogenic bacteria such as *Salmonella* in the GIT. At the same time, prebiotics help improve the growth of friendly GIT bacteria that prevent infection (Lin et al., 2014).

Vaccination

Vaccines work on preventing a specific serogroup of *Salmonella spp*, specifically *Salmonella Enteritidis* and *Salmonella Typhimurium*. Vaccines may also help lower the impact of infection, decrease bacterial release, and prevent future losses in the flock (Barrow, 2007).

It has both live-attenuated and inactivated forms. Live-attenuated vaccines are more effective for some diseases due to prolonged immunities; however, inactivated vaccines can be more secure in some environments.

Management Strategies

Biosecurity Measures

Risk reduction measures must be implemented to control the biosecurity challenges threatening poultry farms, especially the introduction of *Salmonella* (Andres & Davies, 2015). The key biosecurity measures include:

Controlling farm access: Barriers to infection control, which means allowing only those who need to be present in the theatre to have direct contact with sterile garments, gowns, or any equipment and obtaining strict measures to clean all these to avoid contracting new infections (Alliance, 2016; Gwenzi et al., 2021)

Quarantine new birds: Birds bought should be isolated for some time before being added to poultry houses to avoid spreading diseases like *Salmonella*.

Rodent and pest control: Poultry flocks can become infected with *Salmonella* from contaminated feed and water or direct contact with rodents, insects, and wild birds. This risk, however, can be minimized by scheduling proper pest control inspections and practicing good farm hygiene (Alliance, 2016)

Good Farm Practices

Clean feed and water: Most importantly, feed and water must be uncontaminated. One should use quality feed free from *Salmonella* and ensure a proper, clean water system to avoid infection (Bryden, 2012).

Sanitation: Cleaning and disinfecting poultry production units and other areas on the farm that the birds and their eggs use are vital to controlling *Salmonella* growth.
Litter management: Composting poultry litter and removing fresh droppings is vital in preventing *Salmonella* persistence.

Monitoring and Surveillance

Carrying out tests for *Salmonella* in the flock, feed, water, and environment is helpful in testing and introducing procedures for the disease. Surveillance programmers assist in identifying the trend of the pathogen's spread and assess the impact of control measures. (Wales et al., 2010).

It also entails making susceptible patterns of antimicrobials to warrant proper antibiotics in case they are required.

Prevention and Control

As with other pathogens in pigs, measures to prevent and control *Salmonella* in poultry presuppose a systematic use of vaccination, recognized bio-security measures, and strict adherence to sanitation perimeters. These strategies are intended to safeguard vaccination against disease threats and stop zoonotic transmission from poultry meat and eggs to human beings (Wilhelm et al., 2017).

Prevention Strategies

Vaccination Programs

Vaccination can prevent *Salmonella* infection in poultry, making it an essential preventive measure for poultry production systems. Available preparations include oral live-attenuated and injectable inactivated vaccines, which recognize serotypes such as *Salmonella enteritis* and *Salmonella typhimurium*. These vaccines enable mild infections, lower bacterial shedding, and ultimately minimize the dangers of contamination to other birds and poultry products (Ruvalcaba-Gómez et al., 2022).

Having planned vaccination programs to cover layers, breeders, and broilers may help reduce the incidence of a break in a flock that may take a long time to contain.

Biosecurity

This paper finds out that biosecurity measures are essential in controlling the entry and transmission of *Salmonella* in poultry farming (Andres & Davies, 2015). Effective biosecurity includes:
Controlling access to poultry houses: Limit farming to authorized personnel and ensure that authorized people observe specific measures, including washing or sanitizing their vehicles or equipment that may come into contact with the farm.
Quarantine procedures: Any new birds brought in should be kept isolated for three weeks, or they may introduce infection to the main flock.
Rodent and pest control: Some vehicles carry rodents, wild birds, and insects. More effective measures should always be taken to reduce the chance of contamination through pest attacks.

Sanitation Protocols

Microbes should also be washed appropriately to avoid polluting the environment with Salmonella. Cleaning and disinfection of poultry houses, feed and water troughs, and feeding and watering facilities minimize bacterial contamination (Møretrø et al., 2012)

Proper handling of poultry litter is essential because it becomes a potent source of *Salmonella*. Frequent litter removal and safe disposal help lower the chance of reinfection.

Investigations focusing on noninvasive methods, such as environmental sampling, to enable early sampling methods could minimize invasive sampling (Rani et al., 2021).

Strategies to Manage Antibiotic Resistance

Increased antimicrobial resistance is looming large in the treatment of Salmonella. New drugs, including probiotics, prebiotics, and bacteriophages, may need to be developed and identified to fight AMR (Sannathimmappa et al., 2021).

The prudent use of antibiotics in poultry should be managed through stewardship programs and tracking the resistance pattern.

Additionally, further research on genomic profiles of *Salmonella* strains proves that it will assist in defining the resistance factors and, therefore, improving the control mechanisms.

Conclusion

Poultry flocks' health and human health are at risk when salmonellosis threatens the poultry industry. Serological, culture, PCR, and rapid tests for diagnosis and symptomatic interventions are necessary for early diagnosis of the infections. Vaccination, proper biosecurity, and sanitation measures are critical measures to contain *Salmonella* in poultry and minimize the possibility of zoonotic transmission. The opportunity cost of salmonellosis, which affects productivity, mortality rates, and control measures, provides lessons to the poultry industry. In the future, enhancing the vaccine's quality, inventing more advanced diagnostic assays, and combating the rising problem of AMR will help strengthen the management of *Salmonella* in poultry systems. Prevention strategies skilled with consistent research will maintain both animal health and my food safety in the future.

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