Zoonotic pathogens: the current situation in poultry production

Zoonotic pathogens are bacterial, viral, fungal or parasitic agents that cause diseases shared between animals and humans. Infection occurs from the consumption or handling of raw or undercooked poultry products. Infection may also result from direct contact with, or proximity to, live poultry or their environments.

by Hailu Kinde, Professor Emeritus, University of California, Davis, USA.

People may also be infected indirectly through environmental pathways, such as the wind, water, produce contaminated with manure or farming practices.

Salmonella

Salmonella enterica subsp. enterica consists of over 2,500 genetically different serovars. In poultry, the host-adapted, non-motile Salmonella gallinarum and Salmonella pullorum cause fowl typhoid and pullorum disease, respectively.

Paratyphoid is the name given to infections of poultry caused by non-host adapted motile salmonellae. Poultry may be affected by many serovars of paratyphoid salmonella among which S. typhimurium, S. enteritidis, and S. heidelberg are of significant economic and public health significance worldwide.

Paratyphoid salmonella in young chickens causes clinical signs of diarrhoea and dehydration with a high mortality rate. In adult hens, the paratyphoid salmonella does not cause significant clinical signs or death.

However, the organisms will localise in the ovary or oviduct and may result in the contamination of egg contents which constitute a risk to public health. If the transovarial infected egg is fertilised salmonella colonises the reproductive tissues of the chick embryo and reach the next generation, while in the unfertilised table egg, salmonella can multiply in the yolk and infect humans if a raw or undercooked egg is consumed.

Most people infected with salmonella develop diarrhoea, fever, and abdominal cramps 12-72 hours after infection. However, in some people, diarrhoea may be so severe that they require hospitalisation. The illness usually lasts 4-7 days, and most people recover without treatment.

The European Union estimates over 90,000 salmonellosis cases every year; the overall economic burden could be as high as €3 billion a year.

In the US the cost of salmonellosis is estimated at $11.39 billion annually surpassing the cost of other bacterial foodborne infections and making non-typhoidal salmonella the costliest zoonotic pathogen regarding health outcomes with a loss of $3.7 billion.

In the European Union in 2015, 21.2% of the human cases of salmonellosis associated with a known food source were linked with eggs and egg products, and 9.2% with broiler meat. Salmonella was most frequently detected in broiler meat (6.5%), turkey meat (4.6%), and table eggs (0.9% in single samples).

S. infantis, S. enteritidis, and S. mbandaka were the most frequent serovars from broilers, accounting for 38.7%, 11.6% and 7.2% of the isolates, respectively.

In laying hens, S. enteritidis and S. typhimurium were the two most frequently reported serovars accounting for 41.2% and 11.1% of the isolates, respectively.

Recent outbreaks of human salmonellosis due to S. enteritidis

S. enteritidis was most frequently reported among the top 20 serovars that caused human salmonellosis in the EU/EEA for the period 2013-2015 representing, 39.5%, 44.4%, and 45.7%, respectively.

In 2015, outbreaks of human salmonellosis due to S. enteritidis associated with the consumption of egg and egg products represented 29.3%.

In 2014, an outbreak of salmonellosis associated with eggs from a German producer was linked to S. enteritidis phage type 14b in the UK and several other European countries on trace back investigation. Molecular characterisation of the S. enteritidis of the outbreak strain (MLVA profile of 2–11–9-7–4-3–2-8–9), or a single locus variant thereof (the MLVA outbreak profile) from the German producer (eggs, environmental samples), food trace back in several premises were highly similar.

In 2016, a multi-country outbreak of Salmonella enteritidis phage type (PT) 8 with multiple locus variable number tandem repeat analysis (MLVA) profiles 2-9-7-3-2 and 2-9-6-3-2, was linked to the consumption of table eggs.

From 1 May 2016 to 24 February 2017, 14 EU/EEA countries have reported 218 confirmed cases belonging to two distinct whole genome sequence (WGS) clusters, and 252 probable cases sharing the S. enteritidis MLVA profiles 2-9-7-3-2 or 2-9-6-3-2. Authorities have identified eggs originating from three Polish packing centres as the vehicle of infection.

They have also found 18 S. enteritidis-positive laying hen farms in Poland. Most of these farms, as well as the three packing centres, belonged to the same Polish consortium and were considered to be interlinked.

Egg recalls, and trace back investigations following an outbreak of egg associated human salmonellosis can do extensive damage to the brand and the company, affecting future sales. It is very likely that both outbreaks related to table eggs originating from German and Polish layer farms and were a result of a breakdown in biosecurity and hygienic procedures.

A successful biosecurity program has many components. It includes movement control of people and equipment, cleaning and disinfecting as well as securing buildings from pests (rodents/insects) and wild birds. Salmonella free feed, managing moisture of litter and continuous education of staff should be part of the overall biosecurity plan.

Other zoonotic diseases from direct contact with poultry

Erysipelas

Erysipelothrix rhusiopathiae is the causative agent of erysipelas in animals. The disease is seen most commonly in pigs and poultry. In humans it causes a skin rash (erysipeloid). The disease is known to occur regularly in abattoir workers, and there have been many cases associated with poultry plant personnel.

The organism enters most commonly through skin wounds and creates a local infection that may spread to the draining lymph nodes and create a lymphadenopathy.

Ornithosis

Ornithosis, caused by Chlamydophila psittaci is an often unapparent infection in more than 400 species of birds, except in turkeys where it is manifested as a mild respiratory infection.

In humans and other birds, the disease may be unapparent because there are several genotypes of C. psittaci which tend to infect only certain species and these species-specific genotypes vary in their virulence.

Infection is acquired in turkeys or humans through inhalation of contaminated aerosols. There is a very high rate of human infection, with up to 70% of turkey slaughter plant employees being seropositive.

Newcastle disease

This is another viral disease which has a zoonotic potential, but is much less severe in humans, causing mild conjunctivitis and mostly self-limiting.

Newcastle disease in poultry is classified based on clinical signs and lesions vary in virulence and severity from mild subclinical infections to velogenic strains where mortality approaches 100%.

Emerging pathogens with potential transmission through poultry products

This refers to potential zoonotic pathogens for which transmission through poultry products has not yet been established, or identified as previously emerged or potential emerging hazards to the poultry industry.

These potential zoonotic agents, which may be transmitted through the consumption of poultry products, include Arcobacter butzleri, Clostridium difficile, Helicobacter pullorum and multi-drug-resistant Staphylococcus aureus (MRSA) (dermal transmission) (and Staphylococcus aureus food poisoning via cross-contamination during food preparation).

Potential zoonotic agents that can be transmitted from direct contact with poultry or handling poultry products are Erysipelothrix rhusiopathiae, Chlamydophila psittaci, Avian influenza virus, and Avian Paramyxovirus serotype 1.

Arcobacter butzleri

The genus Arcobacter is relatively new and encompasses a group of organisms formerly known as aerotolerant campylobacter. The genus Arcobacter has 25 species with different genetic diversity that are identified from chickens and various domestic animals.

A. butzleri is the most prominent of the group and more often associated with persistent, watery diarrhoea than bloody diarrhoea.

Arcobacter is an emerging foodborne pathogen causing gastroenteritis, diarrhoea, bacteraemia, endocarditis, and peritonitis and is primarily transmitted to humans through contaminated food and water sources.

Arcobacter has never been confirmed to be a zoonotic agent, but the organism was isolated from meats including raw chicken, pork, beef, and lamb, with the highest prevalence among them in chicken.

Arcobacters are recoverable from throughout poultry processing plants and are present on birds before evisceration.

Implementing biosecurity measures at the farm, hygienic practices in poultry processing plants, and at home during cooking as well as general awareness about the route of transmission of arcobacter will eliminate contamination.

Clostridium difficile

Clostridium difficile has been isolated from the faeces of production animals, retail meats, poultry, seafood, and vegetables.

Some, but not all, molecular studies have found similar strains in humans and animals, suggesting zoonotic transmission or a shared environmental reservoir.

C. difficile infection has been recognised as a cause of diarrhoea in patients and persons with no obvious contacts with health facilities or health workers.

Recent studies have demonstrated the isolation of C. difficile from foods in the US, Canada, and Europe and meat products intended for consumption by pets.

However, the foodborne transmission of this pathogen to humans through consumption of contaminated products is yet to be established.

Helicobacter pullorum

Helicobacter pullorum is an emerging zoonotic pathogen which commonly causes gastroenteritis in poultry.

The organism is transmitted to humans through the consumption of poultry meat and has been associated with colitis and hepatitis.

H. pullorum has been isolated from human diarrhoeal samples with a 6% prevalence rate, and 4.3% prevalence in faecal samples from patients with gastroenteritis compared to clinically healthy individuals.

Variable prevalence rates of H. pullorum have been recorded from various parts of the world; 23.5% from fresh chicken meat samples, and 57.1% (free range farm birds) and 100% (broilers, layers, and organic chickens) were infected with H. pullorum.

Despite the high prevalence of H. pullorum observed in poultry, little is known about the mechanisms by which the bacterium establishes infection in the host and its virulence determinants.

MRSA and Staphylococcus aureus

Staphylococcus aureus is the second most common cause of foodborne diseases worldwide. S. aureus may be transmitted to humans from meat products by the handling of contaminated poultry products or by the cross contamination of household surfaces (such as countertops and sinks), which are then touched by family members.

S. aureus food poisoning usually causes mild gastroenteritis but, depending on the amount of toxin ingested, the condition resolves within one or two days.

In contrast, invasive methicillin-resistant Staphylococcus aureus (MRSA) is a serious and emerging public health threat with potential but unconfirmed foodborne exposure. MRSA can cause skin and wound infections, or illnesses such as pneumonia and septicaemia.

MRSA has been found in broilers, isolated from raw chicken meat or carcases in Korea and Japan; however, these strains were human-associated and not the livestock-associated strains.

The possibility of human contamination of poultry carcases by slaughterhouse employees cannot be ruled out, and livestock may become a primary source of community acquired MRSA.

In recent years, livestock-associated S. aureus has been recognised as an emerging category of S. aureus throughout the world. However, these strains appear to be less likely to cause infections and spread person-to-person than the typical strains.

Avian influenza virus

Avian influenza A viruses do not normally infect people, but sporadic infections in people have occurred with some avian influenza A viruses.

Most infections in humans were caused by high pathogenicity avian influenza virus in The Netherlands (2003) and Asia (1997-2005), and later in Africa and the Middle East.

Contact with live or dead birds, their respiratory secretions, blood, faeces, organs, or their environment is believed to be the primary risk factor for human infection, with a few cases also linked to consuming food made from raw poultry blood.

Avian influenza or look-alike diseases in poultry are promptly reported to the regulatory authorities. The first line of defence is early detection of disease outbreaks followed by a rapid response.

High level of awareness among veterinarians and poultry producers and high-quality veterinary infrastructure is essential for the successful control and eradication of the disease.

Biosecurity, education, and training of employees are critical for all zoonotic diseases.

Strategies to control salmonella

To eliminate salmonella contamination in the food-chain, control strategies should focus on the breeding farm, broiler farm, catching and transport, slaughterhouse, retail store and the consumer's kitchen or restaurant.

● Biosecurity measures:
The biosecurity program should encompass people movement control, access to shower and changing room facilities for employees and visitors. Personnel should wear clean clothes and use foot baths and exercise personal hygiene. Equipment should not move between different houses. Surfaces of fans, cooling pads, and equipment should be cleaned and disinfected properly. Vegetation around buildings should be removed to discourage rodents and houses should be cleaned and sanitised after each production cycle.

● Salmonella-free, day-old-chicks and replacement pullets:
It is essential that the overall biosecurity plan should include a salmonella-free breeding flock. Day old chicks and replacement pullets are obtained from salmonella-free flocks and hatcheries.

The use of an all-in/all-out system for raising birds and appropriate lag times between flocks is essential. The overall management plan should include rodent and insect vector control measures as well as minimise access of wild birds and visitors to the farm.

● Salmonella-free water and feed:
The goal of pathogen control in feed should be to ensure that feed contaminants are below a threshold level that will minimise the risk to public and bird health. This can be achieved by following a salmonella monitoring program, good manufacturing practices, and application of intervention strategies such as chemical and physical treatments to control pathogens in feed. The use of competitive exclusion products, mannan-oligosaccharides and organic acids, are proven to reduce colonisation of salmonella in the gut. Drinking water should be appropriately sanitised.

● Vaccination
The goal of vaccination in the broiler breeder farms is to reduce the vertical transmission of Salmonella spp. to the hatching progeny and ultimately to reduce the incidence of the organisms being carried into the processing plant.

In order to reduce salmonella shedding and egg contamination, both inactivated and live vaccines can be used throughout the life of the birds except during the withdrawal period before slaughter.

Vaccination in broilers presents a unique challenge to those that have a short life span (5-6 weeks) as their immune system is not fully developed. There are no registered vaccines available for broilers or turkeys at the moment in the EU.

● Farm and farm environment
Flocks should be regularly monitored through environmental samples throughout the production cycle as specified by the regulation. The poultry litter should be managed to reduce the emission of ammonia by modifying the litter pH, and kept dry as much as possible. Studies found that salmonella found on broiler litter was a reliable indication of both flock infection and carcase contamination. Another study revealed that the same salmonella serotypes in litter samples at broiler farms were found on carcases during processing.

● Take prompt action against salmonella when detected:
Determining the source of infection and taking quick action is critical. Flocks at the end of the production cycle are sent for slaughter or destroyed, and potentially contaminated poultry waste should be disposed of safely.

Proper cleaning and disinfection should be carried out; samples for salmonella testing should be performed routinely and ample lag time allowed before the house is restocked again.

● At the processing plant:
The flocks to be slaughtered are tested at the farm to determine the status of salmonella. Feed should be withdrawn from birds 8-12 hours before slaughter time to reduce the amount of defecation and contamination of the carcase. It has been shown that salmonella positive broilers result in carcase contamination.

Defeathering, evisceration, scalding and chilling are critical control points of the processing stages where cross contamination may occur.

Insufficient scalding temperature (50-52°C), crop leakage and intestinal content contamination from salmonella positive birds may contribute to carcase and equipment contamination leading to cross contamination of carcases of subsequent flocks. To prevent cross-contamination, flocks proven to be salmonella negative are slaughtered before those found to be salmonella positive.

Fresh broiler meat is rapidly chilled, and average storage temperature does not allow salmonella outgrowth. Only when temperate abuse above 10°C takes place may salmonella be able to multiply.

● At retail and in the consumer's kitchen
Product transport by the consumer and storage temperature at home are critical points in the food chain. Poultry meat should be separated from other foods, grocery bags, kitchen, and refrigerator.

Under-cooked poultry meat and cross-contamination in the kitchen/restaurants are the two venues that the consumer can acquire salmonella infection from contaminated broiler meat.

Thus the preventive measure to avoid infection in humans in the kitchen should include proper storage conditions and to adequately cook products.

Basic hygienic exercises such as washing hands, kitchen work surfaces, cutting boards and utensils with soap and hot water immediately after they have been in contact with raw meat or poultry before and between handling different food items will reduce contamination. Raw poultry should not be rinsed in the sink as it allows bacteria to spread. Bacteria in raw poultry can only be killed when cooked to a safe internal temperature (74°C).

● Table eggs
At the farm, crates that are used to transport shell eggs should be thoroughly washed and sanitised. Eggs as soon as they are laid should be refrigerated to lower internal temperature to 7.2°C or lower to prevent S. enteritidis multiplication from potentially infected flocks.

At home table eggs should always be refrigerated and any cracked and dirty eggs discarded. After handling eggs wash hands and utensils with soap and water. Avoid eating raw eggs (as in homemade ice cream).

● Staff education – preparing food
Kitchen staff should be required to wear disposable gloves, aprons, and headwear to protect food from outside contaminants.

Foods should be prepared on clean, separate surfaces to prevent cross-contamination. Staff should wash their hands thoroughly, especially before and after handling raw foods. Sick employees should be given ample time to recover before handling foods again.

● Legislation
Keeping the food supply free of salmonella is a shared responsibility of farmers, slaughterhouses, veterinarians but also the government and the consumers. The success factors in the EU that are attributed to the reduction of salmonella in broiler meat and table eggs, and consequently in human salmonellosis, are a result of the EU Regulations (Directives 2160/2003 and 1168/2006).

These regulations played a pivotal role to require monitoring for S. enteritidis and S. typhimurium, initially of breeder and layer flocks and eventually also of broilers and turkeys. ■

References are available from the author on request