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Emerging Avian Microbial Pathogens: A Systematic Review on Epidemiology and Control

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ABSTRACT

Microbial infections in birds, including bacterial, fungal, and viral diseases, pose significant challenges to avian health, public health, and environmental sustainability. Birds, both caged and free-living, act as hosts and vectors for various pathogens, with environmental factors playing a key role in disease prevalence. Migratory birds are key vectors, spreading pathogens across regions through their extensive travel patterns, while urban birds and exotic pets contribute to zoonotic transmission in domestic and urbanized environments, emphasizing the need for rigorous epidemiological studies. Risk factors such as overcrowding, poor sanitation, and inadequate biosecurity measures exacerbate the spread of infections. Additionally, the rise of antimicrobial resistance further complicates treatment and increases zoonotic risks. Advanced diagnostic methods and effective biosecurity, vaccination, and prevention strategies are essential for managing these diseases. A One Health approach, which emphasizes the interconnection between avian, human, and environmental health, is essential for mitigating the risks of microbial infections. By prioritizing research, implementing robust control measures, and fostering global cooperation, it is possible to mitigate the risks associated with avian microbial infections and protect both avian and human populations from their consequences.

Keywords: Avian microbial infections, risk factors, antimicrobial resistance, biosecurity, caged and free-living birds.

INTRODUCTION

The term pet birds are used to refer to any type of bird species that are primarily feeders of seeds and grains, and which are allowed to be kept in captivity, often staying a lot of time in cages. Awareness of zoonosis and veterinary treatment associated with pet birds is of great importance, as evidenced by the recent increase in the popularity of pet birds. Today, many of the pet birds are members of the family in many cultures (Butterworth et al., 2010; Veladiano et al., 2016). Microbial infections in birds present serious health risks to both avian species and humans,

particularly through zoonotic transmission. With the growing popularity of pets, the potential for zoonotic diseases those that can be transmitted from animals to humans has become a major concern. Birds are susceptible to a number of microbial infections/ diseases which are common in people and domestic animals (Nuttall, 1997; Smith et al., 2020; Smith et al., 2011;). These diseases can be parasitic, bacterial, viral or fungal. Common bacterial pathogens such as *Escherichia coli*, *Salmonella spp*., and *Chlamydia psittaci* are frequently implicated in avian diseases. Two specific diseases tied to pet birds and their owners, salmonellosis, which can be contracted by coming into contact with infected birds or contaminated environments, and psittacosis, which is primarily associated with parrots, are two of the most notable zoonotic diseases. Recent research has demonstrated the prevalence of *E. coli* and extended-spectrum beta-lactamase producing *E. coli* (ESBL-*E. coli*) in various avian species in Pakistan, which could pose a potential threat of spreading to other birds and human populations (Mohsin et al., 2017; Khalid et al. 2023). With the increased popularity of pet birds, more attention has to be paid to bio-security in preventing zoonotic transmission. Adoption of prevention measures such as protective clothing when working with birds and cleaning and sanitizing cages on a regular basis are examples of good practices (Shannon et al., 2009).

The movement of birds between different habitats may be expected to increase the geographical spread of these infections, with consequent "spill-over" events from animals to humans (Shah et al., 2022). Moreover, it is widely recognized that wild birds are significant reservoirs for many diseases, such as multi-drug resistant bacteria, which have the potential to impact public health (Sousa et al., 2021). The frequency of contact between birds and people is increasing due to the effects of urbanization resulting in an increase of danger of the exchange of diseases between ecosystems (Araujo et al., 2018). Increased interaction among infected birds confinement and overcrowding and stress environment likely to increase in pathogens in the population (Benskin et al., 2009). Migratory birds serve as reservoir, carrier, and vectors of pathogens (bacteria, fungi and viruses etc.) in different ecosystem and thus source of transmission to various regions around the globe. Since, these birds may act as growing and emerging and remerging of pathogens to humans, farm animals, birds and wildlife in different territories (Olowu et al., 2025). The evidence of interaction among avian, animal and human populations had been recognized in transmissions and emerging of pathogens (Hogerwerf et al., 2020; Siraj et al., 2018) Davis, 202). Further, it has been highlighted hazards of the pathogen emergence and health risk to birds, humans and farm animals (Alger et al., 2017; Islam et al., 2022). The negligence and ignorance of bird population living in natural and confined environments pose risk and threat to avian and human health. Improved surveillance, monitoring and investigation of the relationships between wild and domestic bird populations are crucial for comprehending and managing the transmission of infectious illnesses.

1. Overview of microbial infections in birds

Microbial infections in birds pose significant health risks, both to avian species and to humans, particularly through zoonotic transmission. Common bacterial pathogens such as *Escherichia coli*, *Salmonella spp*., and *Chlamydia psittaci* are frequently implicated in avian diseases. Free-living birds are one of the main source of carrying/spreading several type of pathogens that can pass to birds and humans at long distance in diverse environments. Similarly, birds living in urban environments may spread and grow pathogen and increase population due environmental factors including overcrowding, stress and interaction to humans and birds (Kobuszewska and Wysok, 2024). Furthermore, common migratory vertebrates such as bats and birds may likely to spreed/transmission of microorganisms/pathogens via across the different border countries (Poosakkannu et al., 2025). Therefore, there may be a need for good husbandry practices, since pathogens can be transmitted through direct or indirect sources from infected birds and can contaminate environment (Kumar et al., 2021). The rate of dissemination/transmission of pathogen in

birds can vary due to nutritional deficiencies, overcrowding, and sanitation in their environment (Heddle et al., 2017).

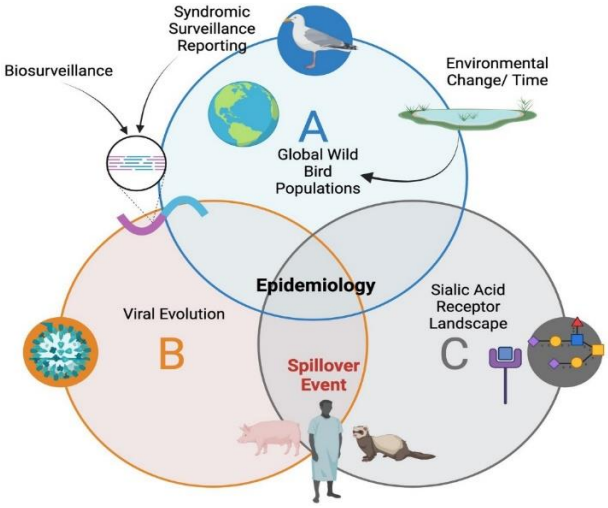

Figure 1: The epidemiology landscape for microbial infections in migratory / caged birds (Fair et al., 2024)

2. Avian Infectious Diseases: Environmental Exposure and Epidemiological Trends

Epidemics and environmental exposure may influence in diversity, spread, pathogenesis and origin of infectious diseases in humans and animals. Geographical niches and distribution of host animals and infection incidence may relate to climate-correlated risk shifts of main zoonotic diseases (Cao et al., 2023). The relation particularly ecological, health perspectives and conservation are key factors in surveillance and distribution trends of pathogens in avian species. The ability of free-living/migratory birds, to disseminate pathogens to long distances and risk to farm animals, wild life and human populations (Elmberg et al., 2017).Since sensitivity and susceptibility of pathogens in birds in that may show variations across the living environment (Wang et al., 2022). Bird natural-micro biota may affect pathogen susceptibility and immune response. Since differences in microbial communities differences in environment associated to pathogenicity (Garcia-Amado et al., 2018). To understand the role of pathogen to biodiversity and their effects on birds and human heath, different tools are needed for diagnosing, epidemic, preventing, and controlling infections (Taylor et al., 2001). Therefore, dynamics of microbial epidemic could be helpful in tracing the pathogen diversity in avian species.

3. Diversity of Avian Pathogens and Zoonotic Aspects

Pet birds are considered as one of the best companion of humans. However, these birds can be potential source of transmission/ carrier of pathogens and infections such as salmonellosis, Chlamydophilosis, bird flu in humans (Boseret et al., 2013; Sohaili et al., 2025). Exotic pet species may function as natural reservoirs facilitating zoonotic spill over events. Wild life trade contributes to epidemics (Bara et al.). In addition, free-living birds have been recognized as their involvement in dissemination of pathogen population in humans and environmental contamination (Hubálek, 2004). However, certain avian diseases for example bird flu outbreaks can cause huge financial losses for the poultry, human health and associated industry. Moreover, negatively impact farming community, food security and global trade. There is drastic efforts are needed to control and prevention of the infections (WOAH, 2024).

4. Infectious Diseases and Its Environmental Exposure in Avian Species

Infectious diseases in avian species are, in most instances, affected by several environmental factors such as habitat destruction, invasion, and climatic change. A critical predictor of avian health and disease patterns includes habitat conditions such as fragmentation and habitat alteration. (Gumede et al., 2022) study shows that marginal aspects of the forest including vegetation structure and patch size are important factors that determine the functional and species-based bird diversity. These can influence the prevalence of infectious diseases because density and interactions of the hosts which are so essential in disease transmission models may be affected. Other hosts and increases in avian species susceptibility are other adverse effects of urbanization to the avian species. Research shows that avian diversity varies inversely with urbanity density, whereby heightened urbanity intensity hinders avian species infection control mechanisms making it easy for diseases to

spread within bird populaces (Bhatt & Joshi, 2011). Global warming brings other variables into focus as influences on avian health and the environment. Therefore, climatic shifts such as temperature and precipitation concerns alter the ranges for distribution of both the avian host and associated pathogens. Chosen changes in the climate affect changes in the migration patterns and birds may be forced to face new diseases that were not present in their immediate environment before. Moreover, severe disturbances may affect birds either through increased death rates or low reproductive capability as a result of stress at its peak (Marzluff, 2001; McKinney, 2006). In general, there is multiple correspondence between avian species, infections, and environmental factors.

The discovery of new diseases in animals and their potential to jump to humans as zoonosis has urged the interest on birds as carriers of disease vectors and their contribution to disease outcome. Birds are prone to bacterial diseases familiar to man and domestic animals (Nuttall, 1997) and to other infective organisms such as protozoa and viruses inclusive of the influenza A virus. Wild waterfowl in their natural habitat relax and several species are highly pathogenic and immensely transmissible to man act as natural reservoirs of this virus (Capua and Alexander, 2002). The organisms can cross the species barrier from birds to swines; from swines to humans (Trampuz et al., 2004); it can also be transmitted directly from birds when bird and human are close to another (Webster, 2004). Likewise, by natural reservoir host, wild birds may feed mosquitoes that can cause WN virus in other birds, horses, and humans resulting to fatal encephalitis (Reed et al., 2003). Thus, regardless of the differences in viral transmission as compared to bacterial transmission, knowing how avian bacterial pathogens disseminate might prove insightful in studying spread of other pathogens amongst birds and in extrapolation from birds to other phyla.

5. Bacterial Diseases in Birds: Adverse Effects on Avian Health

Bacterial diseases in birds are not rare and raise an alarm on avian health as well as public health since transmission of these diseases is transmissible between animals and humans. Many research have reported presence of different bacterial pathogens in wild and domestic birds and described them as potential carriers of disease. Typical bacterial agents identified in birds include *Escherichia coli, Salmonella enterica, Campylobacter jejuni and Clostridium perfringens*. These bacteria can cause enteritis and systemic disease, and these diseases are most common in young or immunocompromised birds (MSD Veterinary Manual, 2024). Details on avian-bacterial relationships based on original studies published in the last 15 years show that about 54% of described bacterial strains are pathogenic to humans. The study further noted that higher number of pathogens were recovered in tropical zones rather than in temperate zones, Moreover, the study confirmed that the natural ecosystem shed higher density of the pathogenic bacteria as compared to suburban and urban settings (Lacroix et al., 2021). Further, investigations suggest that cross continental moving birds can transfer specific bacterial strains from one geographic region to another irrespective of whether such bacteria exist in the new region or not (Guirado et al., 2022).

The effects of bacterial diseases in birds are not only for birds but also for human beings as well. The possibility of zoonotic transmission both directly and through intermediate hosts indicates that bacterial pathogens in wild birds' merit tracking. For instance, the *Salmonella spp.* if ingested, it can be passed from birds to man through food or water (Craven et al., 2000). The disease is most devastating in neonates and young birds. Reactive GI and respiratory infections are rife and can cause systemic effects. The main pathogens reported are gram negative (Klebsiella, Pseudomonas, Aeromonas, Enterobacter, Proteus and Citrobacter, and Escherichia). *Pasteurella spp.* are known to exist as potential septicaemic pathogens in birds which have been attacked by pet cats or rats. Mycobacteria and Chlamydial belong to the intracellular bacterial organisms. *Salmonella spp.* infections are now and then reported (Harlin and Wade, 2009). The frequently isolated gram-positive bacterial pathogens include Staphylococci, Streptococci, Clostridium, Enterococcus and another Staphylococcal spp.

Though, rarely MRSA strains were reported in Nigeria. Pyrogenic Mycoplasmal organisms are known to cause chronic sinusitis, more especially in cockatiels. This organism is generally not easily cultured, and the endemic status of this infection is still uncertain. Coagulase-positive Staphylococci and Haemolytic Streptococci especially and Bacillus spp. are believed to be involved in few skin disorders of psittacine birds. Staphylococci have been frequently identified in lesions of pod dermatitis, also known as bumble foot, in many psittacine birds. In this compendium, *C. psittaci* infection in birds is termed avian Chlamydioses. Ornithosis (psittacosis or parrot fever) is the severest zoonotic disease inflicted by a bacterium *Chlamydophila psittaci*. Chlamydophila affect Psittaciformes bird more than Passeriformes bird (Balsamo et al., 2017). The clinical signs of human illness varied from simple respiratory manifestations to severe pneumonic process accompanied by diarrhoea, conjunctivitis, arthritis, and infection of the genital organs. Owners of veterinarian and pet birds or birds that they breed are the first susceptible hosts for Chlamydophilosis (Alcaraz et al., 2016). Currently zoonotic Chlamydophila cloud also adds to antibiotic resistance in humans (Vanrompay et al., 2007).

The majority of pet birds, particularly Passeriformes and Psittaciformes, may contract various salmonella species. From birds with severe clinical signs such diarrhoea, septicaemia, osteomyelitis, depression, crop stasis, dehydration, and anorexia, the illness may be categorized as asymptomatic carriers. According to the current research, Salmonella is a possible zoonotic infection that might harm humans and is closely related to the Passeriformes family of birds. Salmonellosis in humans may occur often, exhibiting severe symptoms such as diarrhoea and vomiting (Cavallo et al., 2015). It is now believed that tuberculosis linked to Mycobacterium species, particularly Psittaciformes, is zoonotic from pet birds. *Mycobacterium avium* and *Mycobacterium genavense* are the two species that are most often cultivated. *Mycobacterium tuberculosis*, the main human infection, is seldom discussed as a possible zoonotic pathogen that is linked to birds. Mycobacterium species-induced tuberculosis is also thought to be zoonotic in pet birds, particularly Psittaciformes. Other bacterial infections that are considered zoonotic species that are discovered in pet birds include Escherichia, Pasteurella, Klebsiella, Yersinia, and Pseudomonas. According to (Gioia-Di Chiacchio et al., 2016), pet birds like ostriches are known to host toxic strains of *E. coli* that cause zoonosis. All things considered, bacterial infections are beneficial to pet bird owners and breeders.

6. Fungal Infections in Birds: Detrimental Impacts and Health Risks

Fungal infections are an important disease factor in birds, including both wild and domestic species. The fungal pathogens that are commonly found include Aspergillus; of which *Aspergillus fumigatus* is major & causes respiratory disorders in birds. These fungi are generally present in the environment and can be isolated from soil, decaying organic matter and bird dropping (Barton et al, 2010). Mature birds normally possess impenetrable immune systems, but elements like high stocking density, unhygienic conditions, poor air quality and inadequate nutrition reduce the birds' ability to combat infections and make serious diseases commonplace (Malekifard et al., 2023; Shaapan and Girh, 2024). A sample collection survey that was undertaken on parrots to reveal that one of the most often found filamentous fungi in faces is *Aspergillus flavus*, greatly affecting birds (Mirhosseini and Khosravi, 2023).

Besides the Aspergillus, other group of fungal pathogens, which include *Candida and Cryptococcus species*, have been reported in birds. Some species such as *Cryptococcus neoformans* have zoonotic character and can be identified in different birds like pigeons and psittacine (Jones et al., 2020. Perhaps this organism can also result to systemic infection in birds and human including those humans being immuno-compromised. The possibility of these fungi spreading are obvious, meaning that there is need to observe cleanliness standards in case of bird contained places (JPSAD, 2021; Hani et al., 2015). Besides this, an element of high humidity and the deposition of organic matter can lead to fungal growth and subsequently enhanced exposure to birds. Avian Aspergillosis is particularly devastating in

birds in captivity that are resident in zoological gardens and wildlife treatment centres. It is characterized by high mortality among species such as penguins during rehabilitation processes. Aspergillosis poses major threats to production systems in poultry by raising mortality rates and amount of poultry carcasses rejected by spoilage from fungal pneumonia (Shaapan and Girh, 2024). Cryptococcus and Aspergillus are two of the most common fungal illnesses that humans may get from pet birds. The former is an opportunist for humans, while the latter is more often isolated from pet birds (Evans, 2011).

7. Viral Diseases in Birds: Serious Health Consequences

Avian viral diseases remain a daunting health problem at both individual bird and human populations. One of significant viral infections threatening people's life is avian flu, especially the H5N1 strain that spread in birds and in recent years more and more in mammals. According to the CDC, 2024, the H5N1 virus has affected 36 humans in the USA after April 2024, all seeming to have come into contact with infected birds, and dairy cattle in particular. Newcastle disease is another deadly viral disease which targets different birds across the world. It is a disease that results from ND virus, and the symptoms include respiratory, neurological and digestive. Transmission occurs through aerosol in the respiratory tract or from contact with contaminated surfaces while infecting wild birds and poultry (MSD Veterinary Manual, 2024). Vaccination continues to be one of the best tools available for use in case of outbreak control in poultry.

Some of the other viral diseases associated with birds include; Avian encephalomyelitis and Fowlpox. Avian encephalomyelitis is an acute disease of young chickens and turkeys which shows neurological signs including tremors and ataxia. A US Animal Health Certificate shall state that: Fowlpox virus results in skin and mucous membrane lesions; the mode of transmission is by biting insects or direct contact with infected lesions (MSD Veterinary Manual, 2024). The infectious bursal disease virus, also known as Gumboro disease, which is an acute contagious viral ailment that affects young chickens. According to (Veladiano et al., 2016), the illness causes increased immunosuppression and mortality in chicks between the ages of three and six weeks. (Hess, 2016) identified two strains of IBDV: IBDV I, which is a virulent serotype, and IBDV II, which is an avirulent serotype. The most frequent way that IBD is contracted is via the faecal-oral route. With a specific affinity for bursal follicle, the IBDV is very effective in destroying lymphoid cells, infecting immature B lymphocytes and causing bursal lesions (Hacioglu et al., 2017). But IBDV has also been shown to impact other lymphoid organs, such as the thymus, spleen, caecal tonsils, Payer's patches, Harderian gland, and bone marrow (Cray, 2011). Although turkeys and chickens are thought to be the natural hosts of IBDV, additional species have been shown to have serologic evidence of the illness, despite the fact that they did not exhibit clinical symptoms throughout the research period (Kuhnen et al., 2012). IBDV has been shown to produce latent infection in naïve perching wild birds, exhibiting modest signs such as lymphoid depletion in BF pigeons and guinea fowls. The whole genome of IBDV has also been found in the cloaca of infected birds (Balsamo et al., 2017). Newcastle Disease virus, West Nile Fever virus, and Avian Influenza virus are further subgroups of viral agents that are present in pet bird zoonosis. The international pet bird trade also increases the risk of transmission and spread of highly pathogenic zoonotic AI viruses, such as the highly pathogenic H9N2 strain that was found in parakeets imported from Pakistan to Japan (Lenny et al., 2015). Wild migratory birds are recognized to be a major contributor to the spread of influenza virus infections in many regions of the globe, which has led to high rates of morbidity and death in people in recent years (Amonsin et al., 2008; Imperia et al., 2023; Palù et al., 2024). One of the surveillance programs that should take place are the surveillance for continuous identification of any outbreak. Several strategies have been successful in controlling viral diseases in domestic poultry although immunization is not very frequently used in wild birds because of field constraints.

8. Bird Migration and Their Role as Potential Disease Vectors

Thus, migratory birds can act as reservoirs of a number of pathogens that may affect not only birds but people as well. Movement of great distances enables them to interconnect complex ecosystems and hence transport diseases across regions. To this end, this review aims to discuss migration and disease movements with special emphasis on bacteria and viruses.

Diseases which can be passed directly from birds to humans are described as zoonotic and birds are reported to smuggle many of these diseases. Due to their extensive geographical distribution and movements, association with human populations and habitat destruction migratory birds have become reservoirs of pathogens. Research incorporating avian-bacterial co-isolation trials spanning 15 years, showed most of the wild birds that were analysed were migratory birds especially of the Passeriformes order. Such birds can be found in the temperate climatic condition and prefer areas of human and agricultural interference; in other words, they are excellent candidates for integration with human and domestic animals (Hernandez et al., 2019).

Migratory birds themselves are also responsible for the development of new infection diseases through ecological change. Increasing temperatures will shift bird distribution ranges, habitats, and contact rates with hosts or vectors may increase the exposure to zoonotic pathogens. This phenomenon puts emphasis on the need to establish the relationship between migration and diseases and associated environment (Bodewes and Kuiken, 2018). Flights of migratory birds bring them into contact with humans and thus can act as vectors of some diseases of public health importance. Avian movement one of the most dramatic natural phenomena, explains why millions of birds fly every fall from the north and east of Europe to the Mediterranean and the African continent, and from North America to Central and South America, and why such journey is repeated in the opposite direction in the spring. Periods of stress, most notably during migration, resulted in immunosuppression and increased illness incidence and recurrence of latent infections (Reed et al., 2003). Migratory birds also encounter domestic and free living sedentary birds during the migratory cycle during resting or feeding or at the time of arrival or departure. This is why the concentration is important at the points along the migration paths (for example, the Sinai desert and the Gibraltar strait, Messina and Bosphorus). The likelihood of birds as carriers of disease, particularly to human beings, is very significant. Children, elderly are particularly interested to keep pet birds, there is potential ability to transmit mentioned pathogens to humans. Water and food borne diseases: infectious diarrhoea is a killer disease that affects the global health and it is caused by contamination of water and food by pathogenic bacteria, viruses or parasites. Gastroenteritis disease particularly diarrheal disease is the main cause of morbidity and mortality in children especially in the developing world as highlighted by (Kotloff et al., 2013). The dietary mediated bacterial pathogen causing diarrhoea are *E.coli, Salmonella, and Campylobacter spp.* and of less significance is *Aerobacter spp.* (Neupane et al., 2017).

9. Urban and Exotic Pet Birds: Their Epidemiological Role in Zoonotic Disease Transmission

Wild birds living in cities and exotic pet birds constitute an essential source of zoonosis and have the potential of being reservoirs and transmitters of pathogenic agents that do affect both birds and man. The expansion in the landscapes is predominantly in urban areas, which has called for new habitats where birds may come into contact with people and therefore increase the chance of disease spread. Chicago based research also confirmed the view that Wild birds can be good indicators of zoonotic diseases such as Salmonella, WNV, and tick-borne diseases. The study established that birds from more urbanized environment had higher prevalence levels to these pathogens than those from a less urban environment (Hamer et al., 2012). This show why urban birds provide a significant role in surveillance of zoonotic diseases and their possible threat to human beings.

(Din et al., 2025)

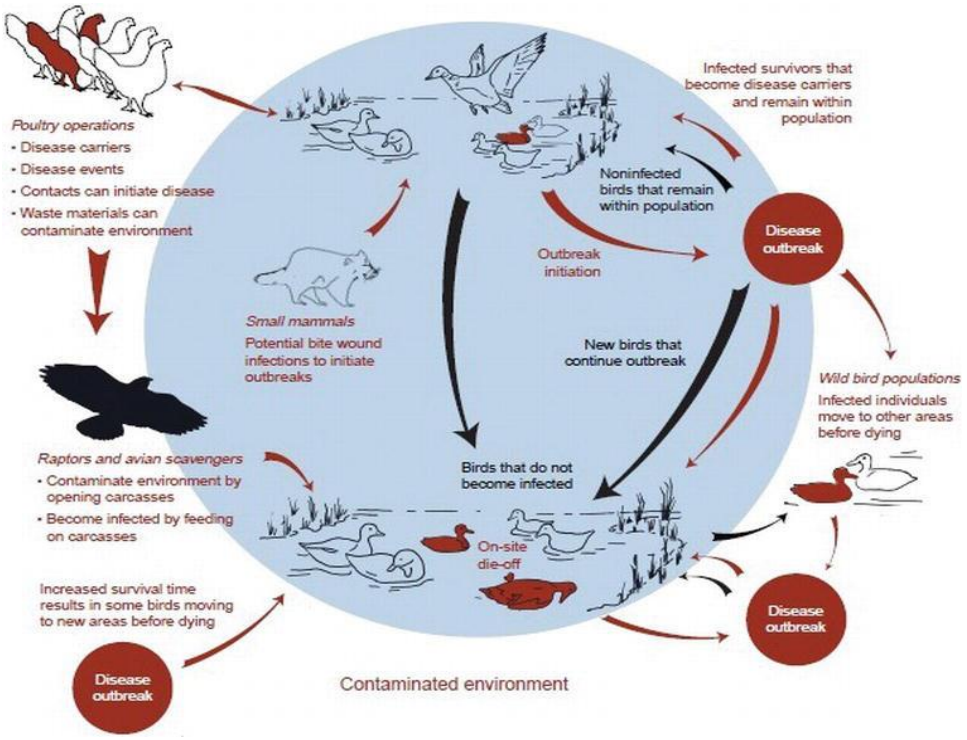

Figure 2: Disease cycle of migratory / caged birds (Friend, 1999)

Furthermore, by growing interactions between humans and urban birds and hence raise the chance for zoonotic diseases transmission. Streets, roadsides, or home gardens that are common habitats for urban birds, are sites that are influenced by anthropogenic activities include parks and waste disposal sites that can expose birds to pathogens from domestic animals or contaminated food sources. This interaction raises concern since many of the urban bird species that come into contact with humans are known vectors for antibiotic resistant bacteria, creating a public health concern (Hernandez et al., 2019). It is, therefore, impossible to ignore the migratory birds as vehicles of zoonosis. When these birds pass through urban scenes during migration, they are likely to spread these diseases to resident poultry and other birds, and humans. Globally Campylobacteriosis is the most reported enteric bacterial infection illness in human population in the developed nations (Lyngstad et al., 2008)(Grzybowska-Chlebowezyk et al., 2013;. Birds are potential hosts of Campylobacters because of their fairly raised body temperature (42ºC). The presence of *Campylobacter spp.* in the gut of apparently sound avian species has often been identified (Vázquez et al., 2010). Although other animals have been reported to carry antibodies to the virus without exhibiting any clinical symptoms of sickness, chickens and turkeys are thought to be the natural reservoir of IBDV, generate a subclinical infection, and this infection was linked to lymphoid depletion (Eterradossi et al., 2008).

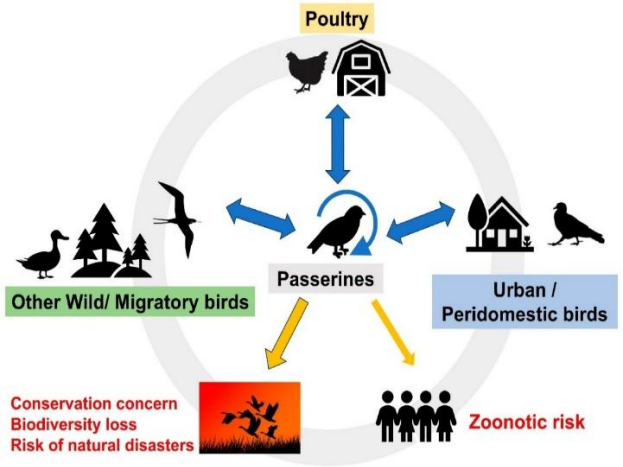

Figure 3: Zoonotic disease transmission (Williams et al., 2023)

According to study by (Kasanga et al., 2008), the genome of IBDV has been found in the cloaca of pigeons and Guinea fowls. Since pigeons are being kept for human food, their numbers are increasing.

Additionally, it has been found that pigeons interact closely with both commercial poultry on farms and local live birds in live bird markets (Shapiro et al., 2013). According to some experts, these animals and their products are reservoirs for several illnesses that afflict poultry and may play a role in the cycles of transmission of various zoonosis (Kaminjolo et al., 1988). According to several serological investigations, (Chukwuedo et al., 2016) suggest that these birds may be exposed to IBDV when migrating and interacting.

10. Antimicrobial Resistance: A Growing Threat to Global Health

Antimicrobial resistance is a leading cause of mortality globally, with low-resource environments bearing the brunt of its effects. The spread of microbes and genes across people, animals, and the environment is a worldwide health concern (Larsson and Flach, 2022). The acquisition of resistance genes is thought to enhance the pathogenicity of microorganisms and the severity of illness, with a high likelihood of therapeutic failure (Abd El-Baky et al., 2020).

Wild birds have been identified as sentinels, reservoirs, and potential spreaders of antibiotic resistance. It is crucial to remember that little is known about the transmission of bacteria, especially antimicrobial-resistant bacteria (AMR), from humans to pets, wild animals, and agricultural animals. Due to their long-distance mobility, wild birds may spread antimicrobial resistance bacteria over large areas, thus propagating these strains (Silva et al., 2022). By ingesting contaminated food or water, birds are thought to acquire resistant germs from people and other sources. When medicated animal manure and urban effluents move onto agricultural land, antibiotic residues and microorganisms exhibiting antibiotic resistance may end up in the environment (Foti et al., 2017).

The occurrence of resistant bacterial strains in wild birds is also influenced by human density, livestock presence, and environmental pollution (Blanco et al., 2009; Skurnik et al., 2006).

Campylobacter species are among the most important zoonotic pathogens associated with multidrug-resistant diseases in humans and birds. Campylobacter spp. live in the digestive tracts of wild birds, migratory wild birds may significantly affect the transmission of these bacteria to farm animals and their habitats, especially chicken farms (Neogi et al., 2020). Consequently, the prevalence of antibiotic-resistant Campylobacter is increasing, posing a threat to the effectiveness of antibiotic treatments and causing significant public health issues (Tacconelli et al., 2018). Fluor quinolones and macrolides are often regarded as the first line of therapy for human Campylobacteriosis. (Casalino et al., 2022) report that the majority of Campylobacter isolates from wild birds exhibit resistance to trimethoprim (52.1%), ciprofloxacin (43.7%), and norfloxacin (31.2%). According to (Casalino et al., 2022), the multidrug resistance of Campylobacter strains ranges from 21.56% in Italy to 72% in Egypt (Tawakol et al., 2023). A new and increasing threat to human and animal health is the ability of the *Staphylococcus aureus* to rapidly develop resistance to any antibiotic therapy, as has been shown with other human-important illnesses. It is important to remember that the main source of methicillin resistance in *Staphylococcus aureus* is the mecA gene, which codes for the penicillin binding proteins that make beta-lactam drugs ineffective. *Staphylococcus aureus* has developed strong resistance mechanisms against therapeutically important antibiotic classes, such as penicillin and glycopeptides, which are the preferred treatments for Staphylococcal infections (Tareen and Zahra, 2023). According to a research by (Kutkowska et al., 2019), passerine birds from the natural habitat and urban rooks may carry antibiotic-resistant strains of *S. aureus*, which is likely due to the presence of these isolates in ambient food sources. Methicillin-resistant *S. aureus* isolates were found in 19.5% of rook samples and 37.5% of wild-living birds, according to their testing (Pandey and Cascella, 2023). *E. coli'* resistance to antibiotics is a global public health problem. This infection is the most prevalent opportunistic enterobacteria in confined

(Din et al., 2025)

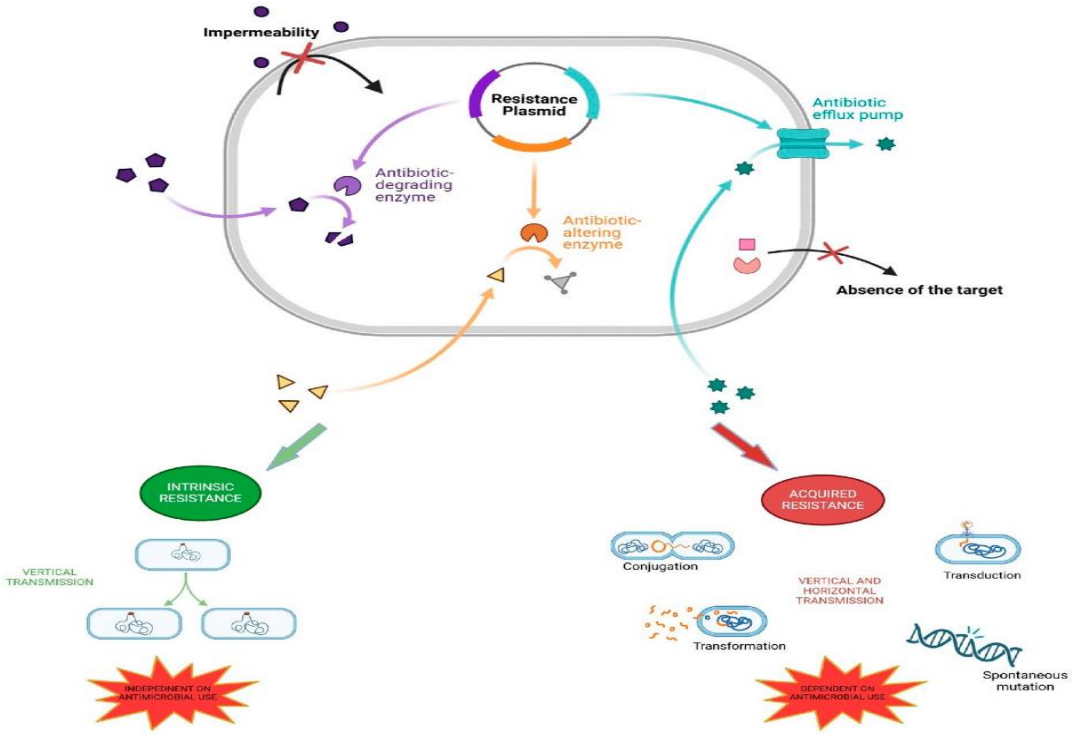

Figure 4: Mechanism of antibiotic resistance (Ponzo et al., 2024)

animals and has been connected to systemic sickness in birds (Sanches et al., 2017). In order to isolate Escherichia spp., (Shobrak and Abo-Amer, 2014) collected nine non-migrating bird species and six migratory wild bird species from the Taif region. The range of prevalence was 94% in migratory birds and 92% in non-migrating species. While all isolates recovered from migratory birds showed resistance to oxytetracycline, lincomycin, chloramphenicol, and oxacillin, all isolates recovered from non-migrating birds were found to be resistant to oxacillin. Furthermore, certain antimicrobial drugs used in veterinary and human medicine could not be completely eradicated, which might lead to their environmental dispersion via soil and wastewater (Sarmah et al., 2006). However, the development and dissemination of multiresistance to these widely used antimicrobial drugs has made controlling *E. coli* infections more difficult (Arbab et al., 2022). Concern has been raised by the increasing worldwide incidence of antibiotic resistance in *E. coli* over time, which highlights the need of taking the right precautions to stop transmission (Salleh et al., 2022).

11. Comprehensive Diagnostic Strategies for Infections in Birds

Diagnosis of infection in avian species is often challenging as clinical presentation, laboratory examination and, in some cases, necropsy findings are needed. Exotic diseases which spread among birds are often caused by such pathogens as bacteria and fungi, viruses, and parasites which precisely identify is a significant problem. Chlamydioses in birds is one of the most important bacterial diseases called avian chlamydioses and it is transmitted by *Chlamydia psittaci*. Of the greatest importance is serological testing along with bacterial culture and polymerase chain reaction (PCR) assays. Clinical manifestations which can be attributed to chlamydioses are often inapparent, including anorexia, respiratory distress, or diarrhea thus not presenting clinical characteristics specific enough to be used for a diagnosis. As for asymptomatic carriers or patients with doubtful suspicion of infection, PCR or culture from conjunctive or cloacal swabs, preferably. Mycobacterial infection can be confirmed using acid-fast staining, though culture is still the best even if there are drawbacks due to slow-growing organisms (Soler et al., 2009).

Viral diseases also present serious diagnostic hurdles in avian animals too. Post-mortem examination of

affected chicks reveals poorly developed thoracic and abdominal skeletal musculature coupled with petechial hemorrhages. Likewise, in psittacine beak and feather disease (PBFD), which affects birds, the conditions are diagnosed based on clinical presentation, and polymerase chain reaction (PCR) on fecal samples. The virus' shedding can be transitory and therefore repeated testing usually is required to rule out the infection (Hoppes & Boulton, 2024). Diagnosis is made by cytological examination of tissue biopsy or swab samples collected from different organs such as the respiratory and gastrointestinal tracts (Malekifard et al., 2023).

Other respiratory diseases such as aspergillosis are also prevalent in birds and affects immunocompromised persons. Clinical signs include respiratory distress and others that may indicate anemia, shrinkage, or congestive heart failure etc. based on airsacculitis, which is seen on radiographs or CT scans (Hoppes & Boulton, 2024). While serological tests are severely flawed in that they are positive in healthy people and negative in patients who have severe mycotoxin infections, PCR testing for specific fungal DNA is employed more frequently now for more accurate confirmation (Meireles et al., 2009). Diagnosis of viral diseases by detection of virus was traditionally very resource-intensive with virus isolation, the steps involving cell culture, which is inoculation of embryonated hen's eggs, intracerebral inoculation of suckling mice and the use of electron microscopy. Isolation of virus continues to be necessary for accurate characterization of viruses and for vaccine and antiviral drug evaluation. However, faster procedures are there right now like ELISA for the identification of viral proteins and molecular tests like PCR.

12. Effective Biosecurity measures for Combating infectious diseases in birds

Measures implemented in biosecurity are exclusion of wild birds from getting closeness to domestic birds through construction of special wire netting and estimation of bird deaths both in the wild and commercially reared birds. Vaccination, controlling parasites, handling sick birds, avoiding raising birds in multiple-age groups, bio-security measures between groups and between employees and birds are other methods of controlling disease. Treatment depends with the site of infection and the culture and sensitivity reports. Knowledge of some of the ways that microbial pathogens can be spread by birds could be useful for exploring the movement of any other disease organisms among birds or from birds to other animals. Therefore, the objective of the current study will be to establish the microbial infections in birds sold (Williams et al., 2011). Effective biosecurity measures are essential for preventing and controlling infectious diseases in birds, particularly in poultry production and the management of pet birds. The increasing incidence of avian diseases necessitates comprehensive strategies that encompass various aspects of farm management to mitigate disease transmission risks.

Biosecurity plan includes any strategies that can help protect poultry from invading contagious pathogens and they include: restricted access to poultry facilities, strict hygiene practices and regular health assessment of flocks. Wild bird interactions are one critical aspect of biosecurity. Wild birds can also carry several pathogens as reservoirs and may bring them to domestic flocks (Kovács et al., 2025). Producers should close poultry areas from wild bird contamination and secure feed and water from wild bird contamination while minimizing contact with wild birds (UGA Cooperative Extension, 2020). Second, quarantine procedures are another side of biosecurity. The number of days a new bird is quarantined to monitor for disease should be for no less than three to four weeks prior to introducing the bird into an established flock (EFSA, 2024). The importance of observing the new birds for new birds' symptom for symptoms of illness and the test to confirm that they are free from infectious agents are necessary during this period. In addition, mixing different species in the same flock may allow spreading of disease among susceptible populations (Neelawala et al., 2024). Early detection of infectious disease requires surveillance. Among many other things, regular health checks and monitoring for clinical signs of illness can help spot outbreaks before they progress (EFSA, 2024).

Preventive measure against some infectious diseases is via vaccination. Infection of birds with avian

influenza vaccines has been demonstrated to decrease clinical signs and viral shedding in infected flocks (Swayne et al., 2023). Different risks facing individual farms or aviaries require different tailored vaccination programs. Because each vaccination product has varying efficacy against a given disease, and some have a shorter life span than others, it is important to consult with veterinary professionals to determine appropriate vaccination schedules (Hoppes, 2024). In addition, plans for effective rodent and pest control are crucial in cutting down disease conservation vectors. Since rodents are a vector that can carry pathogens that affect both birds and humans, and trapping and monitoring systems could minimize these risks (UGA Cooperative Extension, 2020), the US Geological Survey recommends this. Keeping a bird environment clean of pests goes towards keeping birds' healthy and overall hygiene on the farm. Prevention and control of infectious diseases in avian species is based on biosecurity measures. Disease outbreaks in poultry producers and bird owners can be significantly reduced through comprehensive biosecurity protocols that include risk assessment, quarantine procedures, vaccination programs and effective pest control strategies. Best practices in continued education and surveillance for bird health continue to be key to protecting avian populations from infection.

Conclusion

Microbial infections in birds are a critical concern at the intersection of veterinary medicine, public health, and environmental health. The ability of birds to act as hosts and vectors for pathogens underscores their epidemiological significance, particularly in the context of zoonotic disease transmission. Environmental exposure, migratory movements, and the growing urban presence of birds contribute to the global spread of bacterial, fungal, and viral diseases, emphasizing the need for vigilance and proactive management. Risk factors such as overcrowding, inadequate biosecurity measures, and antimicrobial resistance further exacerbate the challenges of managing avian infections. These factors not only compromise bird health but also pose significant risks to human populations and ecosystems. Advanced diagnostic tools, combined with preventive strategies such as vaccination and stringent biosecurity measures, are essential to mitigate these risks.

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