



Antibiotic Use in Poultry Production and Its Effects on Bacterial Resistance

Zeinab M. S. Amin Girh¹, Nagwa S. Rabie¹ and Mona S. Zaki²

¹Department of Poultry Diseases, National Research Centre, Dokki, Giza, Egypt.

²Hydrobiology Department, National Research Centre, Dokki, Giza Egypt

Abstract: Antibiotics are increasingly losing their activity against pathogenic microorganisms. The levels of multi-drug resistant bacteria have also increased due to the over use of antimicrobial agents in animal husbandry. It is known that worldwide, more than 60% of all antibiotics that are produced find their use in animal production for both therapeutic and non-therapeutic purposes. Poultry products are among the highest consumed products worldwide but a lot of essential antibiotics are employed during poultry production in several countries; threatening the safety of such products (through antimicrobial residues) and the increased possibility of development and spread of microbial resistance in poultry settings. This review documents some of the studies on antibiotic usage in poultry farming; with specific focus on some selected bacterial species, their economic importance to poultry farming and reports of resistances of isolated species from poultry settings (farms and poultry products) to essential antibiotics.

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1. Introduction

Antibiotic resistance (AR) which is defined as the ability of an organism to resist the killing effects of an antibiotic to which it was normally susceptible (Madigan et al.,2014) and it has become an issue of global interest. This microbial resistance is not a new phenomenon since all microorganisms have an inherent capacity to resist some antibiotics (Hugo and Russel,1998) However, the rapid surge in the development and spread of AR is the main cause for concern (Aarestrup et al.,2008). Poultry is one of the most widespread food industries worldwide. Chicken is the most commonly farmed species, with over 90 billion tons of chicken meat produced per year (Food and Agricultural Organization; 2017). A large diversity of antimicrobials, are used to raise poultry in most countries (Landers et al.,2012). A large number of such antimicrobials are considered to be essential in human medicine (World Health Statistics, 2017). The indiscriminate use of such essential antimicrobials in animal production is likely to accelerate the development of AR in pathogens, as well as in commensal organisms. This would result in treatment failures, economic losses and could act as source of gene pool for transmission to humans. In addition, there are also human health concerns about the presence of antimicrobial residues in meat (Mirlohi et al., 2013), eggs (Goetting et al.,2011) and other animal products (Mehdizadeh et al.,2010) Generally, when an antibiotic is used in any setting, it eliminates the susceptible bacterial strains leaving behind those

with traits that can resist the drug. These resistant bacteria then multiply and become the dominating population and as such, are able to transfer (both horizontally and vertically) the genes responsible for their resistance to other bacteria (Laxminarayan et al., 2013) Resistant bacteria can be transferred from poultry products to humans via consuming or handling meat contaminated with pathogens (van, den Bogaard, and Stobberingh, 2000) Once these pathogens are in the human system, they could colonize the intestines and the resistant genes could be shared or transferred to the endogenous intestinal flora, jeopardizing future treatments of infections caused by such organisms (Hall et al.,2011).

Antimicrobial resistance

Bacteria counteract the actions of antibiotics by four well-known mechanisms, namely; enzyme modification, alteration in target binding sites, efflux activity and decreased permeability of bacterial membrane (Bassetti et al., 2013) This expression of resistance towards antibiotics by bacteria could either be intrinsic or acquired. Intrinsic resistance is due to inherent properties within the bacteria chromosome such as mutations in genes and chromosomally inducible enzyme production (Davies, 2007), whereas acquired resistance could be due to the transmission of resistance genes from the environment and/or horizontally transfer from other bacteria³, (Randall et

al., 2004). Antibiotic resistance of some selected organisms in poultry.

1. *Staphylococcus species*

The bacterial genus *Staphylococcus* is a Gram-positive cocci and a facultative anaerobe which appears in clusters when viewed under the microscope (Barrow et al., 2009) they are etiological agents of staphylococcosis, pododermatitis (bumblefoot) and septicaemia which affect mostly chicken and turkeys. Coagulase-negative species have also been implicated in human and animal infections (Koksal et al., 2009). β -lactams were considered the first line of drugs for treatment of staphylococcal infections but due to emergence of high level of resistance to these and other drugs, there are currently very few drugs available for treatment of these infections (Mamza et al., 2010). Methicillin resistant *Staphylococcus aureus* (MRSA), now known as a superbug, is resistant to almost every available antibiotic used against *Staphylococcus* (Stapleton and Taylor, 2007) *Staphylococci* are susceptible to amoxicillin/clavulanic acid, amikacin, ciprofloxacin, gentamycin and cephalexin (Friese et al., 2013), most of the staphylococcal isolates were susceptible to rifampin, cotrimoxazole, gentamycin, vancomycin and chloramphenicol I (Abdalrahman et al., 2015), it is worth noting that most of these organisms showed a high level of resistance to oxacillin and tetracycline, which would be disastrous if these oxacillin-resistant strains are transferred to humans (Waters et al., 2011).

2. *Pseudomonas species*

Pseudomonas (*P.*) is a genus of Gram-negative, aerobic bacteria that belongs to the family Pseudomonadaceae (Skerman et al., 1989). The genus *Pseudomonas* is ubiquitous in soil, water and on plants. It consists of 191 subspecies belonging to species groups including *P. fluorescens*, *P. pertucinogena*, *P. aeruginosa*, *P. chlororaphis*, *P. putida*, *P. stutzeri* and *P. syringae*. Pseudomoniasis, which is an opportunistic *P. aeruginosa* infection, is common in poultry birds like chickens, turkeys, ducks, geese and ostriches where infections in eggs destroy embryos (de Vos et al., 2009). *P. aeruginosa* causes respiratory infection, sinusitis, keratitis/keratoconjunctivitis and septicemia and responsible for pyogenic infections, septicemia, endocarditis and lameness along with many diverse diseases. (Sams, 2001) Infections may occur through skin wounds, contaminated vaccines and antibiotic solutions or needles used for injection. The disease may be systemic, affecting multiple organs and tissues or localized in tissues as infraorbital sinus or air sacs producing swelling of the head, wattles, sinuses and joints in poultry birds. *P. aeruginosa* has been isolated from many poultry farms and birds worldwide

(Sams, 2001) *P. aeruginosa* isolated from poultry litter were all susceptible to levofloxacin in the range of 20–100% and nearly 75% demonstrated intermediate susceptibility to aztreonam. The organisms showed resistance to cephalosporins, carbapenems, penicillins, quinolones, monobactam and aminoglycoside. Metallo β -Lactamase encoding genes (*blaIMP*, *blaVIM*) were not detected in any of the isolates but the class 1 integron which is known to carry multiple antibiotic resistant genes were detected in 89.4% of the multi-drug resistant strains (Odoi, 2016). *P. aeruginosa* isolates were highly resistant to β -lactams, tetracycline, tobramycin, nitrofurantoin and sulfamethoxazole-trimethoprim, while ofloxacin, imipenem and ertapenem were highly effective against the bacterial pathogens (Aniokette et al., 2016).

3. *Escherichia species*

Escherichia coli (*E. coli*) is a Gram-negative bacterium that has been known for ages to easily and frequently exchange genetic information through horizontal gene transfer with other related bacteria. Hence, it may exhibit characteristics based on the source of isolation. *E. coli* is a commensal organism living in the intestines of both humans and animals. However, some strains have been reported to cause gastrointestinal illnesses (Tenailon et al., 2010) Tetracycline which is commonly used in poultry has been reported to be one of the drugs bacteria are most resistant to. There is a reported tetracycline resistance in poultry even without the administration of this antibiotic (van, den Bogaard and, Stobberingh, 2000).

4. *Salmonella species*

Salmonella (*S.*) spp. are Gram-negative, facultative anaerobic, non-spore forming, usually motile rods belonging to the Enterobacteriaceae family, which are found in the alimentary tract of animals (Bell and Kyriakides, 2007). Fecal shedding allows *Salmonella* to be transmitted among birds in a flock. *Salmonella* spp. is widespread in poultry production. Prevalence varies considerably depending on country and type of production as well as the detection methods applied. It is known to be the etiological agent responsible for salmonellosis by *Salmonella* spp. in both humans and animals. Food-borne salmonellosis caused still occurs throughout the world (Bell and Kyriakides, 2007). The risk factors associated with *Salmonella* infections and contamination in broiler chickens include contaminated chicks, size of the farm and contaminated feed and these risk increase when feed trucks are parked near the entrance of the workers' change room and when chicken are fed with meals (Marin et al., 2011). It also depends on age of the

chicken, animal health, survival of organism in the gastric barrier, diet and genetic constitution of the chicken could also affect the colonization ability of *Salmonella* spp. in poultry (Cosby et al.,2015). Pullorum disease in poultry is caused by the *S. pullorum*. Transmission of the disease in birds can be vertical (transovarian) but also occurs through direct or indirect contact with infected birds via respiratory route or fecal matter or contaminated feed, water, or litter. Antimicrobials used to treat pullorum disease are furazolidone, gentamycin sulfate and antimetabolites (sulfadimethoxine, sulfamethazine and sulfamerazine) (Msoffe et al.,2009).

5. *Campylobacter* species

Campylobacter jejuni (*C. jejuni*) and *Campylobacter coli* (*C. coli*) are the most prevalent disease causing species of the genus *Campylobacter*. They are mostly responsible for foodborne gastroenteritis in humans (Ketley, 1997). *Campylobacteriosis* is often associated with handling of raw poultry or eating of undercooked poultry meat (Altekruse et al.,1999). Cross-contamination of raw poultry to other ready-to-eat foods via the cook's hands or kitchen utensils has been reported. Erythromycin is usually the drug of choice for the treatment of *Campylobacter* infections (Acheson and Allos 2001). However, fluoroquinolones, gentamicin, and tetracycline are also clinically effective in treating *Campylobacter* infections when antimicrobial therapy is required (Moore et al.,2005) Resistance of *C. jejuni* and *C. coli* isolate s to fluoroquinolones, tetracycline, and erythromycin has been reported. The increased resistance is partly due to the wide use of these antimicrobials in animal husbandary, especially in poultry (Wilson et al.,2003).

6. *Clostridium* species

Clostridium (*C.*) is a genus of Gram-positive obligate anaerobic bacteria which includes several significant human pathogens. Spore of *Clostridium* normally inhabits soil and intestinal tract of animals and humans (Péchiné and Collignon,2016). Common infections caused by *Clostridia* include botulism caused by *C. botulinum*, pseudomembranous colitis caused by *C. difficile*, cellulitis and gas gangrene caused by *C. perfringens*, tetanus caused by *C. tetani* and fatal post-abortion infections caused by *C. sordellii* (Num and Useh,2014). High-dose penicillin-G remains sensitive to *Clostridia* species and thus widely used to treat *Clostridia* infections. *Clostridia* species such as *welchii* and *tetani* respond to sulfonamides (Péchinéand, Collignon,2016). Tetracyclines, carbapenems, metronidazole, vancomycin and chloramphenicol are effective options for treatment of *Clostridia* infections (Banawas,2018)

C. perfringens is known to cause necrotic enteritis in poultry. Bacitracin or virginiamycin is an effective treatment option when administered in the feed or drinking water. *C. colinum* is responsible for ulcerative enteritis. Bacitracin and penicillins are the most effective drugs in the treatment and prevention of this infection (Nhung,2017). A study in Egypt, identified 125 isolates of *C. perfringens* from clinical cases of necrotic enteritis in broiler chickens from 35 chicken coops and the all isolates were resistant to gentamycin, streptomycin, oxolinic acid, lincomycin, erythromycin and spiramycin. Over 95% of isolates were resistant to sulfamethoxazole-trimethoprim, doxycycline, perfloxacin, colistin and neomycin. Most of the isolates were susceptible to amoxicillin, ampicillin, fosfomycin, florfenicol and cephradine (Osman and Elhariri,2013). Other species of importance Infections from other bacterial species could also result in the use of antibiotics. These include Mycoplasmosis (caused by *Mycoplasma gallisepticum*, *Mycoplasma meleagridis* and *Mycoplasma synoviae*) (Nhung,2017), *Pasteurella multocida* and *Haemophilus gallinarum* infections (Msoffe et al.,2009). These infections usually require the use broad spectrum antibiotics including tylosin, aureomycin, terramycin, gallimycin, penicillin, erythromycin, sulfadimethoxine, sulfathiazole and other sulfa drugs administered either in the feed, drinking water or by injections (Msoffe et al.,2009).

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