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Review

# Screening for Antimicrobial Resistance (AMR) in Poultry Meat and Public Health Implications: A Bibliometric Analysis of Literature

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## Abstract

Antimicrobial resistance (AMR) remains a persistent threat in this century. While public debate often focuses on human medicine, the agricultural sector plays a crucial role in the emergence and mitigation of antimicrobial resistance. The growth of intensive livestock farming has encouraged antibiotic use across all animal sectors, including poultry production. Research on poultry meat in various regions of the world has revealed high levels of AMR, exceeding required standards. Encouragingly, significant progress has been made in recent years in reducing antibiotic use in livestock farming, particularly in poultry production. Despite ongoing efforts, AMR continues to spread in many countries, highlighting the urgent need to implement antibiotic reduction strategies. Robust surveillance systems and responsible antimicrobial use are essential. Without them, progress made in some regions risks being undone by uncontrolled practices. This article summarizes scientific research on antimicrobial resistance in poultry meat in different countries and its consequences for public health.

**Keywords:** antimicrobial resistance (AMR); poultry meat; public health

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## Introduction

Antibiotics are used as the primary means of combating bacterial infections in veterinary medicine, whether in livestock farming or for treating companion animals. In poultry farming in particular, antimicrobial therapy is an essential tool for reducing the enormous losses in the poultry industry caused by bacterial infections (Kozacinski et al., 2006; Castanon 2007; Hue et al., 2010; Heetun et al., 2015;).

In this context, the use of antibiotics has two objectives: therapeutic and zootechnical. Antibiotics are used therapeutically to eradicate an existing infection or prevent a potential infection, such as during transport, vaccination, or other stressors. The main classes of antibiotics are represented, but the number of molecules is very limited compared to those used for human purposes. Alongside this therapeutic use, there is a zootechnical application specific to livestock. Small amounts of antibiotics or coccidiostats are incorporated into the feed during the animals' growth period to improve weight gain (Bornert, 2000; Alvarez et al., 2002; Huart, 2003 Daube, 2005; Hedman, 2020). This effect is primarily observed in farms with poor hygiene and tends to decrease as sanitary conditions improve. The choice of antibiotics is still too often made without prior antibiogram testing. The immediate consequence of AMR in livestock is treatment failure (Institut Pasteur, 2017; Michel Briand, 2012; Sanders et al., 2012;; Abdul Samad, 2022; OMS, 2020). Furthermore, there is growing concern that the use of antimicrobials in animals could impact human health if resistant bacteria develop in these animals and are transmitted to humans through the food chain or the environment. However, there is still no scientific consensus on the precise role of antibiotics administered to animals in the development of resistance and its transfer to bacteria that can affect humans (Alvarez et al., 2002;

OMS and FAO, 2003; ANR 2022; Sharafat et al., 2025). Any indiscriminate use of antibiotics leads sooner or later to the selection of resistant bacteria. Constant changes have been observed in recent years. These include, firstly, an increase in the frequency of resistant bacteria and an increase in multi-resistance. Currently, in intensive livestock farming, bacteria isolated during disease outbreaks are mostly resistant to several antibiotics from different families. Thus, if a bacterium is resistant to several antibiotics from different families, the use of just one of these antibiotics will promote the selection and spread of that bacterium, as well as the various resistance mechanisms to other families. This is known as co-selection. AMR is widespread in bacterial isolates worldwide. Continuous monitoring of these resistances provides useful data for choosing which molecules to use. The gut microbiota is the main reservoir for resistance genes. In short, the more antibiotics are used irrationally, the greater the likelihood that bacteria will acquire resistance. This is how some techniques for producing chicken without antibiotics were developed. The future will reveal their success or failure. (Ajibola et al., 2025).

The objective of this article is to demonstrate the impact of AMR in poultry meat and the consequences for public health, thanks to the different investigations carried out by different researchers around the world.

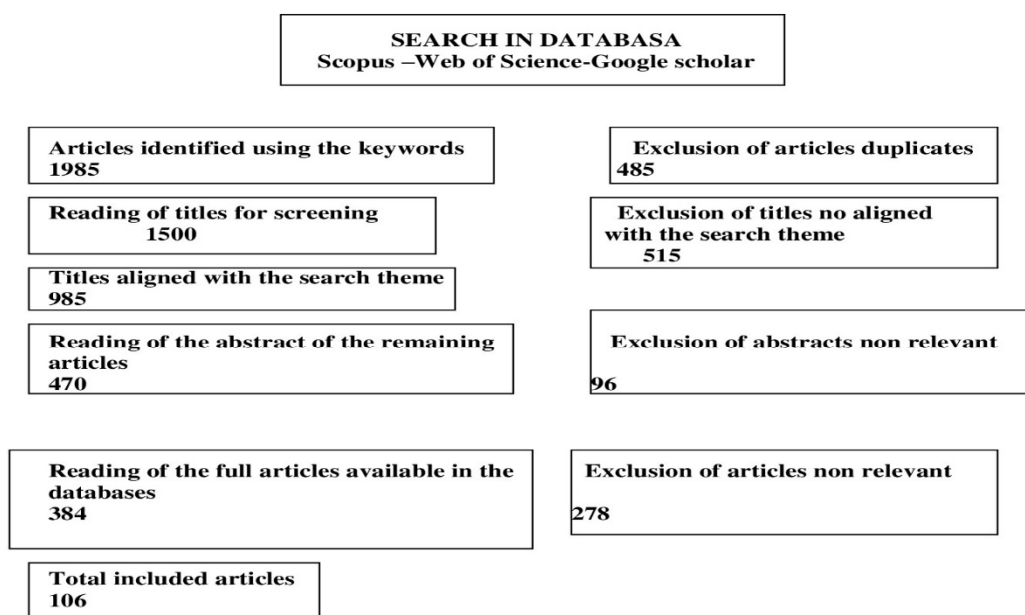


Figure 1. Diagram of the bibliographic research protocol

## Antimicrobial Resistance (AMR) of Bacteria Contaminating Poultry Meat

### *Salmonella Resistance to Antibiotics*

Salmonella is the second leading cause of foodborne illness in humans and remains the most frequent cause of foodborne outbreaks of bacterial origin in Europe (Bornert, 2000b). The main reservoir of Salmonella is the gastrointestinal tract of mammals and birds. Transmission to humans occurs primarily through the consumption of contaminated raw or undercooked food. For the most susceptible individuals, salmonellosis is treated with antibiotics. However, bacteria can acquire antibiotic resistance and thus resist treatment. This phenomenon poses a threat to public health (Abdelli et al., 2011; Marault, 2016; Abba, 2017; Venkitanarayanan et al., 2019; Rau et al., 2021; Tilahun et Efa, 2025).

Controlling salmonella in the field to ensure food safety is a daunting and costly task. Several authors have demonstrated that salmonella control on the farm is largely ineffective if product integrity is not maintained between the farm and the consumer's table (Colin, 1992; Cardinale et al., 2000a; Heba et al., 2017; Das Mercedes Santos et al., 2022). Achieving food safety (meat, eggs) must be a shared responsibility between the poultry farmer, the slaughterhouse, and the consumer. Epidemiological studies of these pathogens must consider their significant persistence in the environment (Korsak et al., 2014; Lailler et al., 2015; Souza et al., 2020; Van Immersee et al., 2005). Although these salmonella strains are susceptible to various disinfectants, several authors attest to the difficulty of controlling environmental contamination in the field, particularly during disinfection operations in poultry houses and slaughterhouses (Alloui et al., 2005; Delhalle et al., 2008; Mahato et al., 2019). With current technology, the probability of eradicating all pathogens that cause foodborne illnesses is very low. Even the development of new technologies to ensure rigorous biosecurity can sometimes fail, especially during cooking.

The level of resistance to each antibiotic, as exhibited by *Salmonella* isolates from poultry, is detailed in Table 1.

**Table 1. Antibiotic resistance of salmonella isolated from poultry meat taken from butcher shops.**

Groups	Antibiotics	Prevalence (%)	Country	Reference
Quinolones + Fluoroquinolones	Ciprofloxacin	18,9	China	(Yang et al., 2020)
		17,24	Bangladesh	(Rahman et al., 2018)
		3,5	Vietnam	(Ta et al., 2014)
	Nalidixic Acid	100	Brazil	(Souza et al., 2020)
		72,3	China	Yang et al., 2020)
	Enrofloxacin	20	Brazil	(Souza et al., 2020)
		21,1	China	(Yang et al., 2020)
	Norfloxacin	0	Egypt	(Awad et al., 2020)
Aminoglycosides	Amikacin	7,5	China	(Yang et al., 2020)
		34,48	Bengladesh	(Rahman et al., 2018)
	Kanamycin	19,2	China	(Yang et al., 2020)
		3,1	Vietnam	(Ta et al., 2014)
	Streptomycin	95	Brazil	(Souza et al., 2020)
		48,7	China	Yang et al., 2020)
		80,65	Egypt	(Awad et al., 2020)
	Gentamicin	17,9	China	Yang et al., 2020)
		3,23	Egypt	(Awad et al., 2020)
		13,79	Bangladesh	(Rahman et al., 2018)
5,7		Vietnam	(Ta et al., 2014)	
Pénicillins	Ampicilin	85	Brazil	(Souza et al., 2020)
		55	Chine	(Yang et al., 2020)
		41,6	Vietnam	(Ta et al., 2014)
	Amoxilin	85	Brazil	((Souza et al., 2020)
		67,8	Egypt	(Awad et al., 2020)
		44,83	Bangladesh	(Rahman et al., 2018)
Carbapenem	Imipenem	0,3	China	((Souza et al., 2020)

Cephalosporins	Ceftiofur	75	Brazil	(Souza et al., 2020)
		14,5	China	(Yang et al., 2020)
	Cefotaxim	85	Brazil	(Souza et al., 2020)
		14,8	China	(Yang et al., 2020)
	Cefoxitin	85	Brazil	(Souza et al., 2020)
		1,9	China	(Yang et al., 2020)
B- Lactam/B- Lactamase Inhibitor	Amoxilin-Clavulanate	85	Brazil	(Souza et al., 2020)
		9,7	China	(Yang et al., 2020)
		83,88	Egypt	(Awad et al., 2020)
Nitrofurans	Nitrofurantoin	45	Brazil	(Souza et al., 2020)
Phenicol	Chloramphenicol	25,8	China	(Yang et al., 2020)
		37,4	Vietnam	(Ta et al., 2014)
Tetracycline	Tetracycline	100	Brazil	(Souza et al., 2020)
		47,8	China	(Yang et al., 2020)
		66,67	Bangladesh	(Rahman et al.,2018)
		59,1	Vietnam	(Ta et al., 2014)
Sulfonamides	Sulfamethoxazole-Trimethoprim	93,55	Egypt	(Awad et al., 2020)
		75,86	Bangladesh	(Rahman et al.,2018)
		34,6	Vietnam	(Ta et al., 2014)

### Antibiotic Resistance of *Escherichia coli*

*Escherichia coli* (*E. coli*) are Gram-negative bacilli belonging to the *Enterobacteriaceae* family and the *Escherichia* genus. The majority of *E. coli* strains are simple commensals of the digestive tract of humans and warm-blooded animals. However, some *E. coli* strains are enteropathogenic. They can also cause extraintestinal diseases (meningitis, urinary tract infections) (Dromigny, 2011).

*E. coli* can be detected in animal feed, in animals used for food production, and in animal products intended for human consumption. This bacterium is frequently used as an indicator in surveillance and monitoring programs because it provides information on potential reservoirs of antibiotic resistance genes that can be transferred to pathogenic bacteria (OIE, 2000a).

In poultry, while some strains of *Escherichia coli* are truly pathogenic, this bacterium is most often opportunistic, associating with other pathogens. Antibiotic treatment greatly improves the health of the animals, but careful antibiotic selection is crucial because resistance is common (Malcolm-Reid, 2001).

Multidrug resistance appears to be common for *E. coli* and geographically widespread. The emergence of multiple antimicrobial-resistant strains is often coupled with resistance to quinolones and third-generation cephalosporins in some regions (Gad, 2018, Liu et al., 2025).

Thus, the emergence of strains carrying extended-spectrum beta-lactamases (ESBLs) was first observed in clinical isolates of *E. coli* and then, shortly thereafter, through monitoring systems at slaughterhouses. Resistance rates to cefotaxime in *E. coli* are increasing very rapidly in poultry production, as this type of resistance was not observed before 2005 and affected more than 4% of strains isolated from ceca of broiler chickens randomly sampled at slaughterhouses in 2007. The risks associated with the emergence of this new resistance phenotype are twofold:

For animal health, there is a risk of loss of clinical efficacy of beta-lactams used to treat colibacillosis in animals, with the possibility of developing multidrug-resistant strains that are impossible to treat.

For public health, the spread to humans of resistant *Salmonella* and/or transmissible resistance genes occurs either through contact with animals or via food. Indeed, a large proportion of *E. coli* present in the human intestinal flora originates from our diet (Sanders, 2010; Ajibola et al., 2025). The level of resistance to each antibiotic, as exhibited by *E. coli* isolates from poultry, is detailed in Table 2

**Table 2. Antibiotic resistance of *E. coli* isolated from poultry meat taken from butcher shops.**

Groups	Antibiotics	Prevalence (%)	Country	Reference
Quinolones and Fluoroquinolones	Ciprofloxacin	96	India	(Hussain et al., 2017)
		26,66	Égypt	(Moawad et al., 2017)
		33,33	Romania	(Dan et al.,2015)
	Nalidixic acid	75,5	Korea	(Kim et al.,, 2020)
		33,33	Égypt	(Moawad et al.,2017)
		44,44	Romania	(Dan et al.,2015)
Enrofloxacin	13,33	Égypt	(Moawad et al.,2017)	
Aminoglycosides	Kanamycin	0	Romania	(Dan et al.,2015)
	Streptomycin	60	Égypt	(Moawad et al.,2017)
	Gentamicin	11,11	Romania	(Dan et al.,2015)
		23	India	(Hussain et al, 2017)
Penicillins	Ampicilin	69,1	Korea	(Kim et al,2020)
		80	Égypt	(Moawad et al, 2017)
		27,7	Romania	(Dan et al,2015)
	Amoxilin	27,7	Romania	(Dan et al.,2015)
Céfalosporins	Cefotaxim	40	Égypt	(Moawad et al.,2017)
		0	Romania	(Dan et al.,2015)
	Ceftazidim	33,33	Égypt	(Moawad et al.,2017)
	Ceftriaxon	20	Égypt	(Moawad et al.,2017)
B- Lactamase	Amoxilin-Clavulanate	66,66	Égypt	(Moawad et al.,2017)
Phenicol	Chloramphenicol	9	India	(Hussain et al, 2017)
		20	Égypt	(Moawad et al.,2017)
		22,22	Romanie	(Dan et al., 2015)
Tetracycline	Tetracycline	64	Korea	(Kim. et al.,2020)
		80	Égypt	(Moawad. et al.,2017)
		93	India	(Hussain. et al.,2017)
		66,66	Romania	(Dan et al.,2015)
Sulfonamides	Sulfamethoxazole-Trimethoprim	61	India	(Hussain. et al.,2017)
		66,66	Égypt	(Moawad et al.,2017)
		22,22	Romania	(Dan et al.,2015)

#### *Antibiotic Resistance of Staphylococcus aureus*

While it is one of the most common commensal bacteria in our normal flora, *Staphylococcus aureus* is a formidable pathogen that has developed resistance to every new antibiotic introduced over the

past half-century (Benrabia et al., 2011; Titouche et al., 2016). The plasticity of its genome allows it to adapt to all environmental conditions, and in particular to acquire antibiotic resistance genes and develop regulatory mechanisms to adapt to increasing antibiotic concentrations. Thus, penicillin-resistant staphylococci appeared as early as 1941, thanks to the acquisition of a plasmid-mediated penicillinase, an enzyme that degrades penicillin. Penicillin resistance initially confined to hospital settings, spread very quickly in the community and now affects more than 90% of *S. aureus* strains. During the 1950s, multidrug-resistant strains of *Staphylococcus aureus* emerged: resistance to penicillin was associated with resistance to streptomycin, erythromycin, tetracycline, chloramphenicol, and sulfonamides. The introduction in 1959 of methicillin, a semi-synthetic derivative of penicillin, for the treatment of staphylococcal infections raised great hopes. But barely a year later, the first hospital-acquired strains of methicillin-resistant *Staphylococcus aureus* (MRSA) appeared in a hospital in Great Britain.

Thus, apart from spontaneous mutations, *S. aureus* diversifies its genome through the exchange of genetic material with other bacterial species via horizontal gene transfer (Dumitrescu, 2010; Khalaf et al., 2014).

In recent years, studies conducted in the European Union have shown the presence of methicillin-resistant *Staphylococcus aureus* (MRSA) strains in animals. Numerous studies carried out in the Netherlands and Germany have contributed to a better characterization of this risk. Most strains belong to a specific clonal complex (CC398) found in carriage in pigs and other animal species, posing a risk of carriage for people working in contact with animals (farmers, veterinarians, slaughterhouse workers). The potential risk to public health is that these strains may acquire virulence factors, making them more pathogenic to humans or animals (Sanders, 2010; Faraj et al., 2025).

The level of resistance to each antibiotic displayed by *Staphylococcus aureus* isolates from poultry is detailed in Table 3

**Table 3. Antibiotic resistance of *Staphylococcus aureus* in poultry meat samples taken from butcher shops.**

Grups	Antibiotics	Prevalence (%)	Country	Reference
Beta-lactams	Methicillin	0	Italy	(Pesavento et al., 2007)
		76,4	Turkey	(Gundogan et al., 2005)
	Oxacillin	7,89	Thailand	(Akbar et Anal., 2013)
		70	Spain	(Miranda. et al.,2008)
		66,66	Italy	(Pesavento et al., 2007)
	Ampicillin	55,26	Thailand	(Akbar et Anal., 2013)
		58,33	Italy	(Pesavento et al.,2007)
	Penicilin G	25	Italy	(Pesavento et al., 2007)
		52,9	Turkey	(Gundogan et al, 2005)
	Cefalotine	0	Italy	(Pesavento et al.,2007)
Quinolones	Ciprofloxacin	7,89	Thailand	(Akbar et Anal, 2013)
		17,8	Spain	(Miranda et al., 2008)
Aminosides (Aminoglycosides)	Gentamicin	13,15	Thailand	(Akbar et Anal, 2013)
		0	Spain	(Miranda et al.,2008)
		16,66	Italy	(Pesavento. et al.,2007)
	Streptomycin	18,42	Thailand	(Akbar et Anal, 2013)
Phenicol	Chloramphenicol	21,05	Thailand	(Akbar et Anal, 2013)
		2	Spain	(Miranda et al.,2008)

Sulfonamides	Sulfamethoxazole/ trimethoprim	28,94	Thailand	(Akbar et Anal,2013)
		8,33	Italy	(Pesavento. et al.,2007)
	Sulfisoxazole	24,8	Spain	(Miranda et al.,2008)
Cyclin	Tetracycline	44,73	Thailand	(Akbar et Anal,2013)
		8,33	Italy	(Pesavento et al., 2007)
	<u>Doxycycline</u>	58,4	Spain	(Miranda et al.,2008)
Lincosamides	Clindamycin	67,3	Spain	(Miranda et al,2008)
		8,33	Italy	(Pesavento et al,2007)
Macrolides	Erythromycin	20,8	Spain	(Miranda. et al.,2008)
		8,33	Italy	(Pesavento et al., 2007)
		5,8	Turkey	(Gundogan et al., 2005)
Nitrofurans	Nitrofurantoin	28,7	Spain	(Miranda et al.,2008)
Glycopeptides	Teicoplanin	0	Italy	(Pesavento. et al.,2007)
	Vancomycin	0	Italy	(Pesavento et al.,2007)
Polypeptides	Bacitracin	100	Turkey	(Gundogan et al.,2005)

#### *Listeria monocytogene Resistance to Antibiotics*

*Listeria monocytogene* is a bacterium responsible for a zoonotic disease called listeriosis (Genigeoris et al., 1990; Gohil t al., 1995). This bacterium is naturally present in the environment and in some foods consumed by humans. This Gram-positive bacterium is the causative agent of listeriosis. Ingestion of food contaminated with *Listeria monocytogenes* leads to septicemia, severe gastroenteritis, and central nervous system infections, particularly in the elderly and immunocompromised individuals. In pregnant women, *Listeria* infection can result in miscarriages, premature births, and perinatal infections (AFSSA, 2000, Ribet, 2010).

The main source of *Listeria monocytogenes* contamination of food before distribution to consumers appears to be the production environment ( Bouhamed, 2010; Bouayad , 2012; Messad, 2016). *Listeria monocytogenes* can survive for a long time, sometimes from one to three years, or even longer, or even indefinitely. Furthermore, some *Listeria monocytogenes* clones may be better adapted to raw meat and to the environments and finished products in the meat industry (Dromigny, 2011; Chen et al, 2024).

This pathogenic bacterium possesses an extraordinary capacity to adapt to both environmental stresses, allowing it, for example, to survive and multiply in soil, and to the various treatments it encounters in the food chain (salt addition, freezing, etc.). This adaptability results from an arsenal of genes it possesses, the expression of which it finely regulates through various mechanisms that allow it to detect its entry into an organism and thus express genes critical for its virulence (Duval, 2019; Zhang et al., 2023).

The level of resistance to each antibiotic exhibited by *Listeria monocytogenes* isolates from poultry is detailed in Table 4.

**Table 4. Antibiotic resistance of *Listeria monocytogene* in poultry meat samples taken from butcher shops.**

Grups	Antibiotics	Prevalence (%)	Country	Reference
Beta-lactams	Oxacillin	82,9	Japan	(Maung et al.,, 2019)
	Ampicillin	27	Turkey	(Gucukoglu et al., 2020)
		3,63	Turkey	(Cadirci et al., 2020)

		0	Japan	(Maung et al., 2019)
	Penicilin G	12,5	Turkey	(Gucukoglu et al., 2020)
		18,18	Turkey	(Cadirci et al., 2020)
	Amoxicillin/ Clavunate	9,3	Turkey	(Gucukoglu et al., 2020)
		1,81	Turkey	(Cadirci et al., 2020)
	Cefoxitin	100	Japan	(Maung et al., 2019)
Phenicol	Chloramphenicol	3,1	Turkey	(Gucukoglu et al., 2020)
		14,54	Turkey	(Cadirci et al., 2020)
Sulfonamides	Sulfamethoxazole/ Trimethoprim	13,5	Turkey	(Gucukoglu et al., 2020)
		45,45	Turkey	(Cadirci et al., 2020)
Cyclin	Tetracycline	14,5	Turkey	(Gucukoglu et al., 2020)
		3,63	Turkey	(Cadirci et al., 2020)
	<u>Oxytetracycline</u>	5,2	Turkey	(Gucukoglu et al., 2020)
		1,81	Turkey	(Cadirci et al., 2020)
Macrolides	Erythromycin	4,1	Turkey	(Gucukoglu et al., 2020)
		1,81	Turkey	(Cadirci et al., 2020)
Glycopeptides	Vancomycin	7,2	Turkey	(Gucukoglu et al., 2020)
Carbapinem	Merpenem	23,9	Turkey	(Gucukoglu et al., 2020)
		14,54	Turkey	(Cadirci et al., 2020)
Cephalosporin	Céfoxitin	100	Japan	(Maung et al., 2019)

## Practices Promoting the Emergence of AMR in Poultry Farming

Increasing the size of animal groups or raising animals at high densities increases the risk of disease emergence and therefore antibiotic consumption (Sanders et al., 2012; ANSES, 2014; EFSA, 2015; OIE, 2020b).

The increased prevalence and spread of resistance is a predictable outcome of the growing use of antibiotic therapy (Muylaert et Mainil, 2012).

The use of antibiotics in animal husbandry to increase productivity also represents a major challenge. (Daube, 2002; Cardinal et al., 2000b ; Chanteau, 2008; Djeffal, 2010; Weiss, 2002).

Therefore, in the case of prophylaxis, the goal is to protect a group against infection before it occurs within the group, and in the case of metaphylaxis, to protect a group against infection after it occurs within the group (ANSES, 2014; FAO, 2019)..

The uncontrolled use of antibiotics can lead to the selection of resistant pathogenic bacteria (Sanders et al., 2012).

The types of antibiotic treatments can influence the risk of developing antibiotic resistance (ANSES, 2014, EFSA, 2015).

The most significant consequence of using low-dose antibiotics in poultry is the development of multidrug-resistant strains of bacterial pathogens (Venkitanarayana, 2019).

Antibiotics are a powerful factor in the selection of AMR in bacteria. (Acar et Moulin, 2012). During preventive treatment, the risk associated with the selection pressure exerted on commensal bacteria is present in all treated animals, whereas the therapeutic benefit depends on the actual presence of the pathogenic bacterium, which is only suspected. Risks associated with the use of antimicrobials in poultry as a growth promoter

More than 110 assessed countries, mostly developing and emerging economies, still lack rigorous and relevant legislation regarding the appropriate conditions for the import, manufacture, distribution, and use of veterinary products, including antimicrobials.

Legislation is sometimes completely absent. When it exists, it is very often not enforced due to a lack of public resources for monitoring. (OIE, 2020b)

In Africa, 16 countries authorize antibiotics as growth promoters, primarily due to a lack of legislation, and tetracyclines are the most commonly used. (OIE, 2017)

In these countries, antimicrobials are most often directly or indirectly accessible to everyone without restrictions. Even more seriously, these products, circulating like ordinary goods, are most often adulterated (lower dosage than indicated on the bottle, different active ingredient, or a complete placebo). Thousands of tons of adulterated antimicrobial products intended for animals are in circulation worldwide. (OIE, 2020b).

Food additives containing antibiotics for animal feed have been banned in Europe since January 1, 2006 (Sanders et al., 2012), but are still permitted for preventive and curative purposes, particularly collectively for groups of animals, due to the close quarters in industrial farming, which make individual treatment impossible (Courvalain, 2008).

The cessation of the use of growth promoters in Europe in 2006 led to a decrease in bacterial resistance isolated in animals, food, and humans (Molbak, 2004).

## Transmission to Humans via Poultry Consumption

Concern about AMR in bacteria and the resulting difficulty in treating certain human infections has led to a surge in research in recent years focusing on resistance in livestock, food, the environment, and humans (Bantawa et al., 2018; Cohen et al., 2007). Similarly, investigations have focused on the mechanisms of transfer between bacteria of genetic traits encoding resistance, as well as the risk factors and/or parameters that promote the spread of resistance (Wooldridge, 2012).

The gut microbiota of animals can constitute a reservoir of antibiotic-resistant bacteria capable of infecting or colonizing humans through the food chain (van Vuuren, 2001).

The risk of transfer of genetic elements encoding resistance between bacteria in mixed populations can open up diverse, numerous, and complex pathways for transmission (Allerberger, 2016). Currently, considerable evidence suggests that direct transfer of resistance traits to humans, via the food chain and animal products, is one of the pathways for resistance spread.

According to Ajiboye (2009), multidrug-resistant (MDR) bacteria can be transmitted between animals and humans. Furthermore, there is a risk of transfer to humans of resistant bacteria present in animals, which generally occurs through food (Aidara-Kane, 2012). These strains are frequently found in animals intended for human consumption, including poultry (Faye 2005; AFSSA, 2006).

It is clear that some human resistance problems originate directly from the animal world (*Salmonella*, *Campylobacter*, *Enterococcus*...) (Weiss, 2002).

Currently, considerable evidence indicates that the direct transfer of resistance traits to humans, via the food chain and animal products, constitutes one of the pathways for the spread of resistance (Mahbub, 2019).

The use of antimicrobial agents in humans, as well as in animals raised for human consumption, has major consequences for human and animal health, as it can promote the development of resistant bacteria (pathogenic and/or commensal bacteria carrying genes encoding resistance) (Aidara-Kane, 2012).

Bacterial contamination of chicken carcasses generally occurs during slaughter and processing. These microorganisms can survive in the product sold to the consumer (vanVuuren, 2001).

The development of resistance in animal bacteria that can lead to foodborne (*Salmonella*, *Campylobacter*) or opportunistic (*E. coli*, *Enterococcus sp.*, *Staphylococcus aureus*) infections must be monitored within the context of a comprehensive public health approach (Sanders, 2012).

Bacteria can be transferred (white arrows) between animals and humans via water and food, direct contact, or the environment. Antibiotic resistance, on the other hand, is exchanged via the transfer of genetic material between bacteria within a single compartment, but also between bacteria in different compartments. (Muylaert et Mainil, 2012).

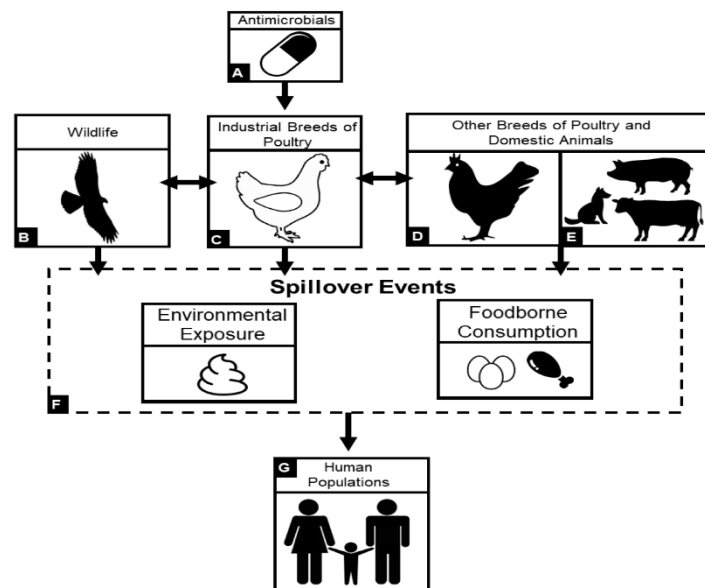


Figure 2. Conceptual graph illustrating AMR associated with intensive poultry production (Hedman et al., 2020).

### Action Plan to Combat AMR

In May 2015, the WHO, FAO and OIE adopted a global action plan to combat antimicrobial resistance within the framework of “One Health “. It is summarized in five key areas:

- raising awareness among healthcare workers and the public
- strengthening surveillance and research
- implementing sanitation, hygiene, and infection prevention measures
- optimizing the use of antimicrobials in human and animal health
- supporting sustainable investments in the development of new treatments, diagnostics, and vaccines

Antimicrobial resistance, considered by the World Health Organization to be critically important in human medicine, particularly with fluoroquinolones, third- and fourth-generation cephalosporins, and macrolides, is evolving in a particularly worrying manner (Carle, 2009; Aidara-Kane, 2012; CDC, 2013; FAO, 2019).

The WHO encourages the agriculture, food production, animal health, and public health sectors to cooperate in order to eliminate the burden of AMR resulting from the misuse of these agents in livestock intended for human consumption (Aidara-Kane, 2012; ).

Therefore, reducing this use is one important lever for action, but it should not be the only one to control the risk associated with AMR in animals (Barthe et Cardina, 2003; ANSES, 2014). Concerted efforts must be made to reduce the inappropriate use of these agents (for example, as growth promoters) and to limit the spread of resistant bacteria (Aidara-Kane, 2012).

The risk of developing antibiotic resistance can only be reduced through appropriate regulations and policies (Thapa, 2019).

Reducing antibiotic use is one way to control resistance to these agents. However, this objective requires the implementation of a wide range of appropriate measures (WHO 2014; Codex alimentarius, 2008; Acar., 2012, Guergueb et al., 2014).

### Conclusion

The fight against AMR is shared a responsibility across sectors, borders, and generations. Agriculture has a critical role to play and the progress made so far proves that change is possible. With continued innovation education and collaboration the poultry industries can protect both public health and food security ensuring a sustainable future for all.

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