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Biological Hazard of antimicrobial resistant Foodborne pathogen Zeinab Ahmed Mohammed*; Sahar Gamal Abdelaziz** And Huda Elsayed***

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Review Article

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Abstract

Antimicrobial resistance (AMR) remains of major interest for different types of food, antimicrobialresistant bacteria, and/or antimicrobial resistance genes (transfer in pathogenic bacteria). The spread of pathogenic bacteria from food to consumers may occur by direct or indirect routes. Zoonotic microbes can spread through the environment, animals, humans, and the food chain. Antimicrobial drugs are used globally to treat infections in humans and animals and prophylactically in production agriculture. Research highlights that foods may become contaminated with AMR bacteria (AMRB) through the different stages that food goes through beginning and finally to the consumer. Multidrug -resistant foodborne microorganisms made the food safety situation more vulnerable to public health. Some microorganisms maintain their normal life functions in food and are used in food production, whereas others may cause food spoilage or food poising. Salmonella spp., Campylobacter spp., Staphylococcus aureus, Escherichia coli, and Listeria monocytogenes are the most pathogens causing health hazard. Approximately 1.8 million people die each year due to food-borne diarrheal infections in developing countries. The development of resistant bacteria in food animals can result from chromosomal mutations but is more commonly associated with the horizontal transfer of resistance determinants borne on mobile genetic elements. Food may represent a dynamic environment for the continuing transfer of antibiotic resistance determinants between bacteria.

Keywords: Resistance; Antimicrobial; Foodborne; Microbes.

Introduction

Recontamination of food during postprocessing may be the cause of outbreaks of foodborne disease **Ansari**, (2015). The microbiological safety of food has become an important concern for consumers, various industries, and regulatory agencies because foodborne illness is one of the most significant public health problems worldwide **Bavisetty** *et al.*, (2018).

Antibiotic resistance was confirmed for all major foodborne pathogens: *Staphs, aureus.*, Salmonella spp., *Escherichia coli,* and *Listeria monocytogenes* **Jajere, (2019).** Many deaths accurse annually as a result of infection by antimicrobial-resistant pathogens, and the outlook is bleak, with premature mortality of nearly 300 million people by 2050 Vikesland *et al.*, (2019). Swann was one of the first to sound the alarm about the problems linked to the indiscriminate use of antibiotics, suggesting that the enormous amount of antibiotics used without following norms could be unsafe for human health Swann, (2020).

The Food and Agriculture Organization FAO, (2020) the World Organization for Animal Health (WOIE), and WHO recommended the 'One Health' approach which supporting healthy animals, healthy people, and healthy environments

AMR has become a general threat to the prevention and management of bacterial infections **WHO**, (2022). AMR threats are growing daily due to the occurrence of resistance in the bacterial strains for antibiotics UNEP, (2022). 600 million people are ill worldwide, and the resulting economic losses exceed USD 100 billion WHO, (2022).

The bacterial genera and species most commonly identified as emerging foodborne pathogens in scientific publications include *Escherichia coli*, Salmonella enterica, *Staph aureus.*, *Listeria monocytogenes* **Spernovasilis** *et al.*, **(2022)**. The indiscriminate usage of antimicrobials in human treatment and in animals of food production leads to the emerging and spread of antimicrobial-resistant bacteria (ARB) and AMR genes (ARGs) throughout the food supply chain **Kenyon**, **(2021)**.

Foodborne Microbes Displaying Resistance: Antibiotics are the most prescribed drugs that are used as antimicrobial substances during the production of foods such as meat and milk, and products derived from these are of major concern since antimicrobial residues may remain in foods intended for human consumption **CDC**, (2020) and WHO, (2020).

Escherichia coli Foodborne:

Escherichia coli consider as food spoilage agent and is a is a foodborne pathogen CDC, (2020) and WHO, (2020). *E. coli* is widespread in the environment, and infections usually result from the consumption of fecally contaminated water or food. *E. coli* poisoning comes from contamination fruits, vegetables, poultry, pork, beef, fish, and milk Enciso-Martínez *et al.*, (2022). Shiga toxin produced by *E. coli* strains belonging to the EHEC pathotype, the cause of many foodborne outbreaks worldwide, may lead to bloody diarrhoea, haemorrhagic colitis, and haemolytic uremic syndrome **Asadi** *et al.*, (2022). *E. coli* O157:H7 in the 2011 outbreak led to 50 deaths. *E. coli* strains showed resistance to amoxicillin, tetracycline, cefotaxime, and ciprofloxacine **Smith & Fratamico** (2018).

Methicillin Resistant Staph. aureus Foodborne:

Staph. aureus (MRSA) may resist methicillin and several other vital antibiotics. Staph aureus is a foodborne pathogen that causes food poisoning due to toxin production in food **Pourmand** et al., (2017). Staph aureus food poisoning is caused by enterotoxins produced in consumed food poisoning caused by Staph. aureus is characterized by a short incubation period (from 30 minutes to 8 hours), a rapid course, and frequent remission after 24 hours. The main symptoms include abdominal pain, nausea, vomiting, and diarrhoea. Grispoldi et al., (2021).

Salmonella Foodborne:

Salmonella typhi and S. paratyphi, causing typhoid fever and paratyphoid fever, respectively, are responsible for infections only in humans. Salmonella enteritidis and Salmonella. typhimurium contribute to human digestive tract infections, with vomiting, diarrhoea, and fever; they are usually self-limiting but may also lead to extremely dangerous bacteraemia and intravascular and focal infections (Marchello et al., 2022). Infections caused by resistant strains of Salmonella may be more severe and result in higher rates of hospitalization. Almost all AMR Salmonella infections are foodborne and linked to the consumption of contaminated pork, turkey, beef, and chicken Nair *et al.*, (2018). The most common sources of infection are poultry meat, pork, eggs, dried food, infant formulas fruit and vegetable products Krzyżewska-Dudek et al., (2022).

Listeria monocytogenes Foodborne:

The major sources of Listeria are milk raw fruits and vegetables, raw and smoked fish, raw meat, and ready-to-eat food. *Listeria mon*- ocytogenes is tolerant to changing environmental conditions and can grow in a wide range of temperatures (0–45°C), pH (4.3–9.6), and salinity (10.0% NaCl) **Skowron** et al., (2019). Due to its high adaptability, in recent years, there have been several major listeriosis outbreaks, including those associated with readyto-eat processed meat products in 2017–2018 in the Republic of South Africa (200 deaths) **Smith** et al., (2019).

Antimicrobial resistance:

AMR is defined as the inability or reduced ability of an antimicrobial agent to inhibit the growth of a bacterium, so that it can lead to therapy failure. Resistance to bacteria has occurred due to mutation, the uptake of exogenous genes by horizontal transfer from other bacterial strains, or the activation or triggering of a genetic cascade, thereby inducing the expression of resistance mechanisms **EFSA**, (2008). The spread of AMR through relevant sectors occurs in two ways: first through the spread of the bacteria that carry resistance genes, and second through the spread of resistance genes between bacteria via horizontal gene transfer (HGT) Patricia *et al.*, (2019); Wang *et al.*, (2012) and Wooldridge (2012).







Fig. (2). AMR is a One-Health issue. Network diagram showing the settings where AMR may emerge, persist, or spread. The bold type indicates areas where antimicrobial use or exposure may occur. Green areas and arrows have a direct link to the foodborne pathway. Adapted from Smith & Fratamico (2018). AMR, antimicrobial resistance.

Mechanisms in Antimicrobial Resistance Bacteria (AMRB):

Microbes utilize various mechanisms to counteract antimicrobial agents, such as the breakdown of antibiotics or antibacterial agents by enzymes, modifications of antibiotic targets, changes in cell wall permeability, and the activation of alternative pathways Verraes et al., (2013). Antimicrobial resistance (AMR) is a globally recognized threat and exemplifies the rapid adaptation of microbes to new environments. A prevalent mechanism of bacterial resistance is the enzymatic degradation of antimicrobial agents. Resistance to aminoglycosides is predominantly driven by enzymatic degradation through acetyltransferases, nucleotidyltransferases, and phosphotransferases Grudlewska-Buda et al., (2023) and Pires et al., (2017).

Antimicrobial Resistance of food born bacteria:

Antimicrobial Resistance of E. coli

The wide variety of pathogenic *E. coli* strains and the emergence of multiple AMR mechanisms contribute to antibiotic resistance in E. coli, a frequently encountered issue. Currently, the most concerning isolates are those producing extended-spectrum β -lactamases and carbapenemases (such as KPC-2, NDM, and OXA -48-like), which often show resistance to cephalosporins, quinolones, and aminoglycosides **Alegría** *et al.*, (2020) and Sivakumar *et al.*, (2021).

Antimicrobial Resistance of *Staphylococcus. aureus*

The antimicrobial resistance (AMR) in *Staph. aureus* has led to the emergence of methicillinresistant *Staph. aureus* (MRSA) strains, which are resistant to almost all beta-lactam antibiotics and, in some cases, to many other antibiotic and chemotherapeutic groups. Due to *Staph. aureus* high survival rate outside a host (even for several months), multidrug-resistant strains present a significant issue not only in hospitals but also in the food production environment. *Staph. aureus* is a foodborne pathogen responsible for food poisoning due to its production of enterotoxins in food **Grispoldi** *et al.*, (2021).

Antibiotic Resistance of Salmonella spp.

Recently, the most pressing concern has been the increasing resistance of non-typhoidal *S. enteritidis* and *S. typhimurium* to antibiotics. Salmonella cells acquire mobile genetic elements, including plasmids with IncA/C, B/O, HI1, HI2, I1, N, F, and P replicons, which are often linked to multidrug resistance (MDR) Chen *et al.*, (2016); Jacob *et al.*, (2022) and Nadi *et al.*, (2020).

Antimicrobial Resistance of *Listeria mono-cytogenes:*

The preferred antibiotic therapy for treating listeriosis includes gentamicin or ampicillin, as well as rifampicin, vancomycin, linezolid, and carbapenem. If the patient is allergic to betalactam antibiotics, trimethoprim is used Maury et al., (2016). In recent years, resistance to various antibiotics, including those used to treat listeriosis, has been observed in strains of Listeria monocytogenes. These strains have shown resistance to rifampicin, vancomycin, ampicillin, gentamycin, erythromycin, chloramphenicol, sulfamethoxazole, amoxicillin, and trimethoprim. The first multidrug-resistant strain of Listeria monocytogenes was identified in 1988 from a patient with meningitis in France Unrath et al., (2021).

Different Strategies to Control Antimicrobial Resistance Bacteria (AMRB):

Foodborne infections caused by AMR are among the most critical public health concerns. Infections caused by AMRB significantly increase morbidity and mortality rates, particularly in developing countries, while in developed nations, they lead to higher therapeutic costs **Harbarth** *et al.*, (2015). The WHO established a 'Strategic and Technical Advisory Group' on AMR and recommended that WHO should play a leading role in forming the action plan. The FAO initiated its Plan for Antimicrobial Resistance to support WHO's global action plan in the food and agricultural sectors **FAO**, (2020).

The One Health approach was proposed by international organizations to mitigate AMR risks, forming an alliance between WHO, FAO, and OIE as a 'tripartite alliance.' WHO also launched a plan to address this global issue in collaboration with tripartite partners and released a 'Global Action Plan' on AMR **WHO**, (2020).

Highlighting possible strategies to address AMR concerns, WHO Global Action Plan outlines five strategic objectives as follows:

Increase Awareness: Awareness campaigns supported by mass and frequent messaging on social media about AMR can reduce antibiotic usage and mitigate the risks posed by AMR.

Promote Knowledge through Survillance: Governments, NGOs, industry, and academia can enhance their practical knowledge to tackle AMR issues

Hygiene, and Preventive Measures: Maintaining proper hygiene and cleanliness by adhering to recommended guidelines and good practices can help reduce AMR concerns.

Regulate Antimicrobials Use: Implementing mandatory guidelines, particularly for antibiotics used in treating infections in animals and humans, and banning the use of drugs as growth promoters in animals are essential.

Boost Economic Investment: There is a need for investments in the development of new antimicrobial treatments, green technology, analytical tools, and vaccines. A lack of such investments highlights the ongoing trend of persistent AMR Samtiya *et al.*, (2022) and WHO (2023)

World Antibiotic Awareness Week:

The objective of World Antibiotic Week is to emphasize the importance of using antibiotics prudently, promote education on proper usage, and encourage research for alternative antibiotics. World Antimicrobial Awareness Week has been renamed to World AMR Awareness Week (WAAW) after global consultations with participants from various sectors and regions. The decision to rename the campaign was driven by the need for a more accurate term that encompasses the concept of resistance, which is the primary challenge to be addressed. **Kujat Choy et al., (2023) and WHO, (2023)**.

Conclusion

Foodborne bacteria, encompassing both pathogens and commensal bacteria, are showing a growing, extensive, and varied range of resistance to antimicrobial agents that are crucial for human and veterinary medicine. Preventing the spread of foodborne bacteria through food is vital for controlling the dissemination of antimicrobial-resistant pathogenic bacteria. Ensuring proper hygiene and cleanliness, along with reducing the use of antibiotics in humans and animals, can be achieved by using vaccines, probiotics, and vitamins to boost immunity, thereby minimizing the reliance on antibiotics

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The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

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