Hepta-Academic Group* "Antimicrobial Resistance"
All actors for antimicrobial resistance in a one health approach (human, animal, environment)

Episode 4: After selective pressure, the spread of resistant bacteria is the second driver of acquired bacterial resistance to antibiotics (March 2026)

Regardless of the biological mechanisms involved in the acquisition of antibiotic resistance in bacteria and the genetic events that lead to this acquisition, it is essential to understand **which factors drive the evolution towards acquired antibiotic** resistance in bacteria. The two main factors, both directly linked to human activities, are: (a) **the pressure exerted by antibiotics on the bacterial world**, which favors the survival of resistant bacteria (and the disappearance of susceptible bacteria) ("selective pressure"), discussed in Episode 3; (b) the **dissemination** of resistance (of resistant bacteria or their resistance genes) in different ecosystems (human and animal populations, the environment, etc.), which is addressed in this episode. Understanding these factors is key to identifying corrective actions to be implemented.

The spread of resistance is an essential complement to selective pressure in the dynamics of resistance. **The first mechanism of dissemination** is linked to the unique ability of certain bacterial species to exchange genes, including antibiotic resistance genes. This is the "**horizontal transfer of resistance**," which involves mobile genetic elements (plasmids, transposons) capable of "passing" (being transferred) from a "donor" bacteria to a "recipient" bacteria. **The second**, highly effective mechanism of resistance dissemination is the transmission of resistant bacteria themselves (and therefore also their resistance genes). This **"vertical" transmission** can be direct from individual to individual ("**cross-transmission**") within populations (in healthcare facilities, communities, families, etc.) or animals (in livestock farms), and sometimes between humans and animals. This type of transmission can also be indirect, occurring **via the environment** when it is contaminated by human or animal organic waste (excreta). This leads to the spread of resistant bacteria (and their resistance genes) into nature, potentially returning them to individuals through water or food. The dynamics of antibiotic resistance dissemination thus take on a different dimension and must be considered at the ecosystem level (human, animal, environmental) within which resistant bacteria circulate.

The spread of resistant bacteria can be quite **visible** when it involves bacterial species that cause contagious infections (tuberculosis, gonorrhea, etc.) due to the infections they cause. Conversely, the spread can be largely **invisible** in the case of bacterial species whose natural ecological niches are the **microbiota** (**commensal bacteria**), particularly the intestinal microbiota, of humans or animals. These commensal bacteria that have become resistant are the source of **epidemics** that develop insidiously because they initially manifest as asymptomatic colonization (simple carriage, such as multidrug-resistant *Staphylococcus aureus* in humans or certain animals), but also as opportunistic infections. It is this type of dissemination that explains the global success of certain commensal bacteria that are multi-resistant to antibiotics and pose serious therapeutic difficulties in human medicine such as staphylococci and enterobacteria (family of coliform bacteria).

Overall, the evolution towards antibiotic resistance must be considered across all bacterial populations (human, animal, environmental) within which resistant bacteria circulate. It is essential to understand that **without dissemination, antibiotic-resistant bacteria selected under antibiotic pressure would not achieve epidemiological success**. This justifies limiting antibiotic use to the minimum necessary to reduce selective pressure, but also implementing measures to limit the spread of resistant bacteria, such as individual and collective hygiene, particularly fecal hygiene: handwashing, management of human and animal excreta, wastewater and drug residue management, and, in veterinary medicine, the strict application of biosecurity.

Follow our episodic story that will explore the different facets of antibiotic resistance. The next episode will be released in Autumn 2026.

**As early as 2012, the Academies of Medicine, Pharmacy, Veterinary Medicine and Agriculture were committed to the fight against antibiotic resistance, later joined by the Academies of Sciences, Surgery and Dental Surgery. This seven-academic monitoring group, through a global, concerted and multidisciplinary health approach, is continuing its initiative on antimicrobial resistance, particularly for the benefit of the general public.*

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