



**The Fight Against Antibiotic Resistance:  
An Overview of Relevant Concepts**  
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### Abstract:

Antibiotic resistance is a rising global health issue, with an estimated 1.27 million people worldwide dying of antibiotic-resistant infections. In this review article will be discussing what antibiotic resistance is, the ways we can prevent it, and how to combat it. It will discuss the biological factors that can cause bacteria to develop antibiotic resistance, such as natural selection, adaptation, and horizontal gene transfer. It will conclude by talking about the ways you can prevent this growing problem. Even though this is a huge problem worldwide, knowing more information about antibiotic resistance, like the ways we can combat it, can reduce this growing issue.

### Introduction:

Almost 5 million deaths occurred in 2019 from antibiotic resistance worldwide (Centers for Disease and Prevention, 2025). The costs for the healthcare system is \$4.6 billion annually (Centers for Disease and Prevention). Antibiotic resistance develops in bacteria that acquire resistance genes from other bacteria (Habboush). Some bacteria already have a mutation that made them stronger against antibiotics or got a resistance gene from another bacteria that survived the antibiotics and reproduced. Bacteria can acquire antibiotic resistance genes vertically from parent cells, or horizontally from neighboring cells. Horizontal gene transfer allows for the movement of genetic information between organisms, or the ability to get genes from bacteria in the same environment after cells die.

In 1915 the first bacterial isolate was deposited in the United Kingdom's National Collection of Type Culture, *Shigella flexneri*, a strain of the dysentery-causing bacterium, had killed a young soldier during WWI. Even though the first bacterial was isolated in 1915, it was found carrying resistance genes for penicillin and erythromycin when someone revived and sequenced in 2014. During the modern day microorganisms were found in a cave that has been isolated for four millions years and it showed that it harbored functional antibiotic resistance genes.

Antibiotics are misused and overused because people mistake antibiotics to be beneficial for every disease they have and many physicians are willing to prescribe antibiotics to their patients when asked (Habboush). Antibiotics are sometimes prescribed even if the doctor is unsure if the illness is caused by a bacterial or viral infection (Verbanas).

Doctors might prescribe medicines without having a clear diagnosis because patients might expect satisfaction and doctors feel the pressure to satisfy their patients (Hyun). Patients or their parents might expect to receive a prescription after an office visit, and even in cases where antibiotics are not expected, doctors might still think they need medication. Doctors sometimes get pressured to please their patients, to get more business. Another thing that doctors might have is time constraints; the patient could have a limited time, so they have to think on their feet. The doctors also try to avoid telling families lengthy explanations, so they will have a shorter visit at the office (so they get to see more patients, more money). The last possible reason why doctors are so willing to prescribe their patients antibiotics is because fatigue, the process of just repeating diagnosing as well as treating many patients could affect the doctor's capacity to make consistent prescribing decisions (Hyun).

Antibiotic resistance develops more because of the misuse of antibiotics. The bacteria takes advantage of the opportunity to multiply and if you stop treatment or forget to take one or more antibiotics the bacteria will start reproducing. When they are in the process of multiplying

they could mutate (change). A mutated bacteria has the ability to become more resistant to medicine. The more doses you give, the more selection pressure you apply, and the more chances the bacteria will become more resistant (Cleveland Clinic). This research matters because if we do not resolve the issue of antibiotic resistance spreading it can possibly kill people due to antibiotics being unable to be effective because some overuse the product which makes the bacteria get used to it.

#### Methods:

Websites with .edu, .org, and .gov, as well as “National Geographic”, “Britannica”, and “PubMed Central” databases were utilized to find sources. These sources and organizations were used because they are typically seen as reliable sources with accurate information. These key words were searched: natural selection, adaptation, antibiotic resistance, mobile genetic element. A general description/definition of what antibiotic resistance is and how it has been affecting our lives was searched. Sources that explained how you can prevent bacteria from developing antibiotic resistance were included.

#### Results:

Antibiotic resistance arises from many processes like natural selection, adaptation, and horizontal gene transfer, which includes transformation, conjugation, and transduction. Natural selection is when the better adapted organisms have a higher likely chance of survival adaptation. Adaptation is when specific traits help organisms survive and function better in the environment.

Natural selection is the process where the better adapted organisms in the environment will more likely survive and produce more of their offspring (National Geographic). Adaptation is where a specific trait helps a living organism survive and function in the environment better (Britannica). For example, it might help them hide better from predators. What adaptation includes is how animals possess traits of easier access to finding and eating food. For example, like beak types in birds (it changes over time because animals evolve to be better fitted for a living area). In bacteria, a form of adaptation is antibiotic resistance. This is where bacteria evolve so they have the ability to survive when exposed to antibiotics. Usually antibiotics are able to kill bacteria but due to the mutations it becomes more difficult to destroy the bacteria. Through selection and mutation, bacteria have the ability to develop defense mechanisms against the current antibiotics. The bacteria can also create new characteristics that make them resistant to specific antibiotics. This information relates of natural selection and adaptation ties back to how antibiotic resistance is a growing issue that needs to be resolved because natural selection shows how organisms that are born in a specific area are better fitted to survive in the environment (like the color they are for animals or the traits the organism has that makes them survive in the environment).

Bacteria also are able to develop resistance by acquiring resistance genes which are from other bacteria. Bacteria get these resistance genes from other bacteria because they “can be vertically transferred (passing genes from parents) and spread via horizontal gene transfer (HGT, getting genes from “peers”) through mobile genetic elements (MGEs, genes that you can get from your “peers”) among bacteria” (Tao). I will be discussing what transformation, conjugation, and transduction is.

I will give some examples of horizontal gene transfer. Transformation is when the bacteria picks up dna from the environment (like dna dies and takes the gene/trait). DNA can be

transferred with direct physical contact between the bacteria, a process called conjugation (Haavisto). Conjugation between two bacteria connects trade DNA, making a copy. Plasmids are DNA that has resistance genes. Plasmids float around the cytoplasm and bacteria, they can give them out to other bacteria that don't have the resistance gene yet. Transduction involves bacteriophages, which are viruses for bacteria. The viruses sometimes bring genes that were picked up during an infection from another bacterium (might be incorporated into the DNA of the new bacterial host) (React Group). Next I will be discussing examples of mutations that develop antibiotic resistance.

Some specific adaptations that bacteria acquire are through mutation and selection. Bacteria have the ability to develop defense mechanisms against antibiotics. An example is specific "bacteria have developed biochemical "pumps" that have the ability to remove an antibiotic before it has reached its target (Health and Senior Services). The others that already evolved produce enzymes which inactivate the antibiotic (Health and Senior Services). Next I will be discussing the ways we can prevent bacteria from developing antibiotic resistance.

It is important to prevent antibiotic resistance for the sake of our future. Some ways that we can prevent bacteria from developing antibiotic resistance is washing your hands, never sharing or using leftover antibiotics, knowing the symptoms, getting vaccinations, and preparing food safety. Washing your hands is important, as you are regularly exposed to millions of germs. Cleaning your hands properly helps prevent the spread of germs and reduces the risk of illness. Never share or use leftover antibiotics because if you take someone else's medicine, it will most likely not be tailored to your specific needs. I conclude knowing the symptoms can also combat antibiotic resistance because recognizing early symptoms of an infection makes it easier to treat.

Getting vaccinations makes you more immune to a disease and helps you fight it off easier/faster (prepares your body). Preparing food safely can prevent bacteria from developing antibiotic resistance; fruits, vegetables, and meat can be contaminated with bacteria (NFID). Next I will be discussing how bacteria develop sensitivity to another after getting stronger from another trait.

Bacteria develop sensitivity from other bacteria; they are "switching between these antibiotics may be one way of responding to growing antibiotic resistance" (Huzar). They can develop sensitivity from another with the antibiotic resistance trait (the traits that make bacteria not really affected by antibiotics) because they pump out the toxins (usually every bad toxin), which makes them not die as easily. They also have a chemical efflux pump to develop their sensitivity (Sharma). Next, we will discuss the new medications that scientists created to combat antibiotic resistance.

Scientists have been researching new drugs/medications to combat antibiotic resistance. One of the new exciting drugs/medications is cresomycin, a type of lincosamide antibiotic. Lincosamide antibiotics were found in nature but were altered in a laboratory and these are called semi-synthetic drugs. The structure of these antibiotics, combined with knowledge of how they bind to bacterial ribosomes, has enabled the synthesis of a fully synthetic compound called cresomycin. The scientists choose their building blocks, so as a result, they can make an antibiotic that forms into the exact shape that is needed to latch tightly onto ribosomes. Ribosomes form proteins which are necessary to survive, but since the cresomycin latches tightly onto the ribosomes they lose their ability to function (NIH). I concluded that cresomycin works against both gram-positive and gram-negative bacteria, as well as against strains that are

resistant to other lincosamide antibiotics (U.S. Department of Health and Human Services). Here are some of the ways we can combat resistance.

#### Discussion:

In conclusion, antibiotic resistance occurs when a bacterium develops a mutation that renders it stronger against antibiotics. Bacteria can also get this resistance trait from a gene from another bacterium that survived the antibiotics and reproduced. Natural selection is another example of antibiotic resistance and is the process by which better-adapted organisms in an environment will have a better likelihood of surviving. Adaptation is when a specific behavior, body feature, or part of a group of organisms survives and functions better in the environment. Some ways we can combat antibiotic resistance are never sharing or using leftover antibiotics, getting vaccinations, and washing our hands. If infections are prevented from using vaccines it can reduce the misuse and overuse of antibiotics, which is the main reason why antibiotic resistance is such a big issue. Antibiotic resistance is a serious problem that needs to be more recognized by more people; it can cause people to get sicker more easily and will make it harder to treat diseases.

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