Spread of Antibiotic Resistance

Sanjay Dorairaj
April 2018

The rise in the use of antibiotics has led to a growing concern about the spread of antibiotic resistant bacteria. This paper takes a closer look at this issue, discusses the mechanisms by which antibiotic resistance spreads, its implications and mitigation strategies.

Background

Antibiotic resistance refers to the ability of bacteria to mutate into forms that are capable of resisting available antibiotics. These are sometimes referred to as **superbugs**, because they resist current treatment options such as antibiotics and grow and spread with relative impunity. According to statistics from the World Health Organization (WHO), in 2016, 490,000 people developed resistance to multiple strains of antimicrobial drugs [1].

Mechanism of spread

Bacteria develop resistance to antibiotics when there is an overall increase in their exposure to antibiotics. As bacteria mutate, those bacterial strains with mutations that are resistant to antibiotics tend to dominate and spread to other people. This results in further increases in antibiotic resistant bacteria.

At a molecular level, antibacterial resistance spreads both vertically and horizontally within the bacteria population. In **vertical gene transfer**, new generations of bacteria are created with genes that are resistant to antibiotic resistance. In **horizontal gene transfer,** bacteria that have become antibiotic resistant transfer their genes directly to other bacteria. Bacteria with antibiotic resistance can counter antibiotics in several ways. They can either (1) modify the chemical composition of the antibiotic, (2) eject it from the bacterial cell as soon as it enters the cell or (3) create mutations to ensure that antibiotics do not even bind to the cell. As the use of antibiotics continues the rise, bacteria that are resistant to one drug can develop resistance to multiple drugs, making them even more difficult to eradicate.

According to the FDA, the primary cause for the growth and spread of antibiotic resistant bacteria is the improper use of bacteria. These improper uses include

1. Excessive use of antibiotics

The growing use of antibiotics not only in humans, but also in livestock and plants is one of the key factors in the rise of antibiotic resistance. Animal breeders use antibiotics in order to allow the animals to grow faster and to remain healthy in unsanitary breeding conditions. The consumption of meat and animal products such as milk, and the contamination of the fields and water that these animals are exposed to result in the spread of these antibiotic resistant bacteria. The use of antibiotics for plants, although necessary at times, results in residual antibiotics in the food we consume. This results in further exposure to antibiotics and consequently a rise in the population of antibiotic resistant bacteria.

2. Use of antibiotics for non-bacterial illnesses such as viral infections

People routinely take antibiotics for reasons other than fending off genuine bacterial infections. For example, fungal and viral infections, cannot be treated with antibiotics; however, often antibiotics are prescribed for these conditions as well. When bacteria in the human body are unnecessarily exposed to antibiotics, they tend to develop resistance to these antibiotics.

3. The failure to complete a full course of antiobiotic treatments.

Another reason for the rise of antibiotic resistance is the failure to follow through on a complete course of antibiotic treatment. People start on a course of treatment with antibiotics, feel better halfway through, and discontinue the use of antibiotics. Since not all of the bacteria has been killed, the remaining bacteria tend to develop antibiotic resistance.

Implications

There are several serious implications to the rise of antibiotic resistant bacteria. A key concern is the risk of a worldwide bacterial epidemic with no known treatment, due to the lack of a functioning antibiotic.

The pharmaceutical industry does not pursue antibiotics as aggressively as it pursues treatments for other diseases such as cancer and diabetes. This is because antibiotics are cheap and they lose their potency in a relatively short period due to the growth of antibiotic resistance. There is therefore less financial incentive for pharmaceutical companies to pursue antibiotics. With few new products int the pipeline, it is likely that we reach a point where our existing antibiotics do not work and we do not have new antibiotics to help counter the spread and growth of antibiotic resistant bacteria.

The below table from [3] provides a timeline of the introduction of new antibiotics and the development of corresponding antibiotic resistant bacteria.

Antibiotic	**Introduction**	**First incidence of Antibiotic Resistance Identified**

Penicillin	Pre 1940	1943
Tetracycline	1950	1959
Methicillin	1960	1962
Erythromycin	1953	1968
Gentamicin	1967	1979
Vancomycin	1972	1988
Imipenem	1985	1998
Levoflaxacin	1996	1996
Linezolin	2000	2001
Ceftaroline	2010	2011

As the above table shows, antibacterial resistance is inevitable and the only way to limit or spread the growth of this bacteria is by reassessing how we use antibiotics and encourage pharmaceutical companies to have a richer pipeline of antibiotic treatments.

Conclusions

In this paper we examine the definition of antibiotic resistance, the mechanism of spread and the implications of the spread and growth of antibiotic resistant bacteria. The primary reasons for the growth of antibiotic resistance are the improper and excessive use of antibiotics. The implications of not limiting the spread of antibiotic resistant bacteria could be at worst catastropic resulting in worldwide epidemics with no known treatment. Limiting the improper and excessive use of antibiotics and providing incentives to pharmaceutical companies to develop both new and novel antibiotics are key ways of curbing the spread of antibiotic resistant bacteria.

References

1. Antimicrobial resistance factsheet, WHO, http://www.who.int/en/news-room/fact-sheets/detail/antimicrobial-resistance
2. Combating antibiotic resistance, https://www.fda.gov/ForConsumers/ConsumerUpdates/ucm092810.htm
3. The Antibiotic Crisis, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4378521/