

Antibiotic Resistance: The Next World Crisis?

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ABSTRACT

The discovery and production of penicillin led to the global use of antibiotics to treat bacterial illnesses and infections. While initially it was highly successful, the past few decades have seen a decline in the effectiveness of antibiotics due to a resistance building up amongst disease-causing bacteria.

Bacteria which are resistant have genes which allow them to not be affected by antibiotics. This means they are able to grow and multiply in the presence of an antibiotic. Bacteria can acquire these genes through random mutation of the genes during DNA copying or through DNA transfer from other resistant bacteria in their surroundings.

One of the main causes of antibiotic resistance is the incorrect use of the drugs. When antibiotics are taken in the incorrect dosage or the course is not completed, selective pressure is put on the bacteria and it allows them to develop a tolerance to the antibiotic. Many people, especially in South Africa, are uneducated about the correct use of antibiotics and this has resulted in a widespread development of resistance. Tuberculosis is one of the diseases which South Africa is facing that has acquired an extreme resistance to the treatment. Economic factors and financial strain on the government has also contributed to the spread.

In order to combat the antibiotic resistance problem, doctors and other medical professionals need to take care to prescribe the proper antibiotics and usage thereof. Patients need to be carefully monitored so that they adhere to the correct use and do not cause a resistance to develop. Public health also needs to be improved. Experts are currently trying to find alternative methods of treatment, but for now, the public and medical workers must be educated about the consequences of improper antibiotic usage and the risks involved with resistant bacteria.

INTRODUCTION

“Within the next two decades we may not have any effective antibiotics for simple surgical operations.” [a]. The breakthrough discovery of penicillin [1] was a huge leap in the development of modern medicine and it led to the widespread production of antibiotics during the Second World War. For decades after, antibiotics became known as a wonder drug [2] and were used to treat

numerous amounts of bacterial illnesses, infections and diseases, including Tuberculosis (TB) and pneumonia. The more recent years, however, have seen a huge decline in the effectiveness of these antibiotics. This is mainly due to the increasing resistance that has developed amongst many pathogenic [3] bacteria, making them much more difficult to treat. If this continues to happen, all antibiotics that were once used to cure fatal illnesses will soon be rendered useless.

BODY

Drug resistant bacteria are able to survive and multiply in the presence of an antibiotic and continue to cause harm to that individual. Diseases that could have been easily treated are now much more complicated to control and more threatening to the lives of people. Some of the resistant bacteria that have been causing major health issues are methicillin-resistant *Staphylococcus aureus*(MRSA), vancomycin-resistant *Enterococcus* (VRE) and multi-drug resistant *Myobacterium tuberculosis* (MDR-TB). [b]

Naturally, some bacteria are resistant to some types of antibiotic. For example, bacteria found in the intestine are not really affected by benzyl penicillin [4]. However, in the past few decades different strains of infectious bacteria have developed resistance to antibiotics that could previously be used to treat them. In some cases, the bacteria have become completely resistant to all antibiotics and that strain of the disease has become untreatable. Antibiotic resistance is caused by various reasons.

Bacteria can develop resistance by acquiring 'resistant genes' [5]. Bacteria with this resistance to antibiotics such as vancomycin [6] and penicillin have genes that make proteins which counteract the antibiotic in some way. The existence of this gene can happen spontaneously through accidental gene mutations [7] in DNA copying. This mutation can cause a different protein to be made by the bacterium and if those different proteins are located at the site at which an antibiotic works, the antibiotic may not have an effect on the bacteria anymore. This is when they become resistant. After this, when an antibiotic is used, it eradicates the bacteria that are susceptible [8] to the antibiotic, leaving the resistant bacteria to thrive in conditions where its competition has just been eliminated. From the first use of antibiotics, selective pressure [9] has been put on bacteria resulting in the survival of resistant strains. Joe Cranston, Ph.D., director at the American Medical Association in Chicago said, "Whenever antibiotics are used, there is selective pressure for resistance to occur. It builds upon itself. More and more organisms develop resistance to more and more drugs."

As with all living organisms, evolution allows bacteria to change, develop and improve as time passes to ensure survival. Antibiotics use chemicals found naturally in the environment, for example penicillin is produced by the fungus *Penicillium*. Therefore, there are bacteria found naturally that are resistant to the different chemicals. Bacteria are able to share DNA with other bacteria, including those of different species, in its surroundings, passing the resistant genes to others by means of conjugative plasmids [10]. In this way, bacteria with natural resistance to an antibiotic can pass that gene to a non-resistant bacterium and similarly, bacteria which have mutated to acquire resistant genes can also pass those genes on to other bacteria. Once this has happened, any use of antibiotic will favour the resistant bacteria because the susceptible strains have been eliminated, allowing the resistant bacteria to flourish.

In some ways, the use of antibiotics is the cause of the resistance to it. By overusing or using unnecessarily, bacteria develop a tolerance to the antibiotics. Over the years, the incorrect use of antibiotics has increased the amount of resistance found amongst bacteria. Antibiotics are often mistakenly used to treat infections such as the cold or flu which is caused by a virus and will not be affected by antibiotics. This puts selective pressure on the bacteria in the body and resistant bacteria will become dominant and develop resistant strains of the disease. Many antibiotics are sold over the counter and taken without recommendations from a medical professional. This means the incorrect dosage is often taken and courses are left incomplete. If too little is taken over a long period, it allows for bacteria to mutate and resistance to develop against the antibiotic because not enough was taken to kill all the pathogenic [3] bacteria. When a course is not completed, a similar situation applies. Ensuring that all bacteria are destroyed is essential as none will be able to form a resistance.

In South Africa, drug resistance has become a major crisis with Tuberculosis. MDR-TB and XDR-TB [11] has spread widely threatening the lives of individuals and communities. As with other bacterial infections and in other countries, one of the main reasons for the resistance to occur is because of the lack of education in rural and poverty-stricken areas. Members of these communities do not know how to correctly use antibiotics or the importance of it. Because of this, the incorrect dosage is often taken and resistant strains are developed and spread. Specifically with TB, the treatment is a long and extensive course of antibiotics known as DOTS [12]. This is because the tuberculosis bacterium has a very slow division rate and a strong cell wall. However, this gives the bacteria more time to mutate and develop resistance. A huge problem with TB is that patients often stop the course once they feel better but before killing off all the bacteria, which can then progress into

MDR-TB and XDR-TB thereafter. This incorrect use of the treatment is one of the major contributors to resistant strains of TB. In informal settlements, housing is often developed packed together making the spread of any disease easier and more so a resistant one.

Economic factors have also contributed to the increase in resistance. In South Africa, health care is constant battle. Many underprivileged areas do not have access to proper health facilities and medical professionals. This leads to a prolonged period in which an individual has a bacteria-caused disease before they acquire treatment. An inability to afford proper treatment and the incorrect prescription of drugs also causes antibiotic resistance. Many contagious diseases put a huge financial strain on the government. Often, the government is not able to provide the proper medication or health care facilities for the population, again allowing the resistant bacteria to spread. There have been many cases where patients with XDR-TB have exhausted all methods of treatment and are sent home due to poor facilities. TB is a highly contagious [13] disease and they can very easily spread that resistant strain of TB to other members of the family and community. Resistant strains can become very difficult and expensive to treat.

Another problem South Africa and other countries is faced with is the increasing number of people living with HIV [14]. This makes them highly susceptible to bacterial infections such as TB and pneumonia. With high rates of unsuccessful treatment due to the slow immune system of these bacterial infections, the resistant strains develop even more.

The World Health Organisation has become highly concerned with the levels of resistance arising all over the world and recently released a document (World Health Organisation, 2001) encouraging governments to create policies which will contain antibiotic resistance. In South Africa, there is little control over the access to antibiotics and very often people take them without a prescription from a doctor. Poor sanitation, lack of education and overcrowding all add to the increase in resistant diseases and the spread of it. Preventative and control measures must be put into place to ensure the antibiotic resistance does not continue.

Scientists say that the resistance to antibiotics is inevitable. However, there are measures that can be implemented in order to slow it down or minimise the spread. An important measure that South Africa's medical professionals can put in place is to enforce the correct use of antibiotics. Local doctors, nurses and pharmacies need to ensure that they prescribe the correct antibiotic with the correct dosage to patients who truly need them. This way the chance of a resistance forming will be

limited. Doctors sometimes succumb to the expectation from patients that they should prescribe antibiotics, even though it is not necessary. Common precautions doctors should keep in mind include: not treating viral infections with antibiotics, avoid giving mild doses over a short period, not prescribing a specific antibiotic to a strain that is already resistant.

South Africa as a whole needs to work on improving public health measures, especially within the poverty stricken areas. Better hygiene in communities and in the clinics and hospitals needs to be promoted, improvements of sewage systems and water purification must be implemented and overcrowding in rural areas should be developed. Screening people at risk of getting a resistant infection could also help prevent the spread. It needs to be ensured that the medical staff and professionals are well informed of the importance of antibiotic resistance and the causes of it. Especially with the dilemma resistant TB, health care workers need to be vigilant with their patients and the completion of their treatment.

Medical experts all around the world, including South Africa, are working to find alternative methods of treatment to bacterial illnesses. This is to prevent the continued use of antibiotics in the hope of slowing the spread of resistant bacteria and also to have alternate options in the case that no antibiotic will affect a specific disease-causing bacterium. One example of alternative treatment options that is currently being researched and investigated is the use of viruses called bacteriophages [15], which target specific bacteria cells and eventually destroy them. Organisations are also trying to produce a new range of antibiotics which will be able to combat bacterial infections when the current ones have lost all effect.

A large portion of South Africans is significantly uneducated. Therefore, medical professionals must make it their duty to educate and inform the public. Most of the population does not know about the possible consequences of not using antibiotics correctly or how to do so. Educating them about the importance of completing the course or how to prevent infection can have a huge effect on the development and spread of resistance amongst disease-causing bacteria.

CONCLUSION

Antibiotic resistance is becoming a major health issue and if it is not controlled properly, a main source of treatment for bacterial illnesses could become completely useless. Bacteria are able to develop a resistance relatively easily and the incorrect use of antibiotics is enabling it to do so even further. Members of the public need to be educated about the importance of proper antibiotic use and medical professionals need to ensure it is adhered to.

This research topic is one of great significance as it is affecting everyone all around South Africa and the world. People may be exposed to resistant strains of a disease without realising it. The most important elements found during this research was the causes of the antibiotic resistance and that it mainly stems from the very use of antibiotics in the first place. By understanding this, preventative and control measure can be put in place in order to combat the increasing levels or resistance amongst bacteria.

Additional research that could add to the current findings would be a further study of the exact process in which resistance occurs and also, the various types of resistance so as to fully understand the implications thereof. There are already many preventative and control measures which have been put in place by the World Health Organisation and individual countries. By investigating these measures, they can be understood and slowly implemented to help contain the spread of resistant bacteria and preserve the effectiveness of the antibiotics that is currently being used.

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GLOSSARY

- [1] **Penicillin** a group of antibiotics produced from the *Penicillium fungus*
- [2] **wonder drug** usually a newly produced drug that is known for its curative effect
- [3] **Pathogenic** disease-causing
- [4] **benzyl penicillin** a penicillin antibiotic commonly given intravenously for syphilis, meningitis, pneumonia and others
- [5] **Resistant genes** genes on the DNA that allow the bacteria to have a resistance against a specific antibiotic
- [6] **Vancomycin** an antibiotic that was initially used as a last resort drug ie. When others did not work
- [7] **Gene mutation** a permanent change in the DNA sequence of a specific gene
- [8] **Susceptible** not able to withstand the effects of the antibiotic
- [9] **Selective pressure** a phenomena that causes organisms to evolve in a certain way by the survival of a beneficial change
- [10] **Conjugative plasmids** a part of bacterial DNA
- [11] **MDR-TB** resistant to 1 or 2 first line drugs
- XDR-TB** resistant to 3 or more second line drugs
- [12] **DOTS** Directly Observed Therapy, Short-course. The 6 month treatment for TB.
- [13] **Contagious** is able to be spread from person to person
- [14] **HIV** Human Immuno-Deficiency Virus
- [15] **Bacteriophages** a virus that infects and replicates within a bacteria