The Future of Superbug Outbreaks

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Humanity has faced numerous problems in 2020: from the threat of war between two nations and the raging fires that have devastated the environment of a whole continent, to the rise of a fatal viral outbreak that has gripped the world with fears and panics similar to those of the Influenza pandemic nearly a century ago. With so many problems and worries pressing on everyone’s minds, especially the issues given much attention by news networks, radios, and social media outlets, it can be hard for people to bring their attention to the looming threat of superbugs, as the shadows they will soon possess has not yet hovered over us. The problems we have and will face in this year should not be left alone if the dangers they present are serious, but at the same time people around the world, as well as their respective governments and healthcare workers, must have enough knowledge about superbugs in order to prepare for the eventual outbreaks that may occur in the near future.

Basic Overview: Explanation of Superbugs

In order to be prepared for the future in which superbugs will be a more noticeable threat, one must understand what a superbug is. A superbug, also known as a multidrug-resistant bacterium, is a bacterium that is able to display resistance to multiple types of antibiotics -- drugs or compounds meant to either destroy or inhibit the growth of a bacterial cell. Superbugs usually arise when bacteria that are genetically immune to a certain antibiotic are able to reproduce clones that also contain the multidrug-resistant character of their parents. Along with asexual reproduction, superbugs can also pass on their multidrug-resistant genes, through the form of plasmids, to neighboring bacteria via the process of transformation -- which in turn leads to the creation of new superbugs in the near future. Nutritious minerals, such as phosphate, in either soil, sewage, or feces can also provide
superbugs with enough energy to support these superbugs and encourage their growth (3**).**

Superbugs’ main tool in resisting the mechanisms of antibiotics is of course of their genes, which are usually the results of mutations, but another important factor for their success is the excessive or unnecessary usage of antibiotics done by humans.

There are various reasons for why individuals may take abundant amounts of antibiotics when the situation does not call for it: a person could have an infection that is viral instead of bacterial, but without consulting a physician first, the person takes antibiotics that only kill some of the unharmful or beneficial bacteria in the microbiome and do nothing against the infection -- leaving room for superbugs to thrive; doctors in less developed countries may have only limited medical supplies and training, and thus rely on prescribing antibiotics to patients in order to deal with illnesses (6); and even in a situation where a person does have a bacterial infection, antibiotics may not be necessary in achieving recovery, especially if the infection is not so severe, and thus the only drugs only achieve in creating an environment of immune and resistive bacteria (6).

Antibiotics given to agricultural animals, who are eventually killed to be turned into food for humans, can also give rise to superbugs that will harm people. Since the 1950s, farms and agricultural companies have been placing antibiotics in the food supplies of livestock in order to ensure that the animals live long enough to grow into healthy, robust adults for future consumption. Because many of the diseases that humanity has faced are zoonotic in nature, meaning that they jumped from infecting one animal species to infecting humans, bacteria inside of livestock that are able to resistant the antibiotics eaten can soon become infectious to people who eat the remains of those animals (6).

Like with most outbreaks of disease, epidemics, or even pandemics, caused by superbugs can occur through the use of travel by either humans or animals. People from one country where the superbug originated who end up traveling to another country can end up bringing the bacteria with them, unintentionally starting another outbreak in a new location (6); for example, a superbug strain found near a Norwegian research site that has an antibiotic-gene that originates from New Dehli, India could have received that gene from superbugs that traveled with scientists who once visited the city in India before working at the site (3). Colonies of birds, acting as vectors for superbugs, can also bring in zoonotic, multidrug-resistant diseases that are able to jump from one species to another; this scenario is especially likely to occur if the infected birds drink from a watering hole that is also used by small animals that are likely to interact with humans after obtaining the bacteria (3).

Examples: Current and Potential Superbugs

There are various types of superbugs that exist in this world, such as Methicillin-resistant *Staphylococcus aureus* (MRSA), a bacterium that is able to withstand the effects of methicillin (a penicillin-based antibiotic) and other similar drugs, but one that will be given much attention to in this article are the superbugs that make up a group of bacteria called Carbapenem-resistant Enterobacteriaceae (CRE). CRE are bacteria belonging to the Enterobacteriaceae family, such as *Escherichia coli* (*E. coli*) and *Klebsiella pneumoniae* (*K. pneumoniae*), residing in the human gut microbiome that are able to resist an antibiotic class known as carbapenem (a compound containing the molecular ring beta-lactam) which consists of "last-resort" drugs that are used in cases where a patient experiences a severe bacterial infection. There are several ways in which CRE are able to resistant carbapenem-based antibiotics. Many CRE have a gene that, when expressed, produces an enzyme called a carbapenemase that renders the carbapenem useless, as well as other drugs that contain beta-lactam such as penicillin and cephalosporin. However, only 30% of CRE have a gene encoding carbapenem; the remaining 70% are able to resist carbapenem due to chromosomal mutations and other defense mechanisms. Many victims of CRE infections are those in healthcare settings like nursing homes and hospitals who either rely on medical equipment (e.g., catheters and ventilators) -- where infections can originate -- or have weakened immune systems. Symptoms caused by CRE include various bodily infections, pneumonia, and intra-abdominal abscesses -- which is when the abdominal tissue contains swollen areas that excrete pus.

One bacterial species that has been chosen as a potential superbug candidate by the CDC is *Mycoplasma genitalium* (*M. genitalium*), a bacterium that introduces a sexually transmitted disease when displaying pathogenic characteristics (5). As of recently, it has been discovered that the bacterium is highly resistant to azithromycin, an antibiotic that treats various bacterial infections. The symptoms can vary depending on the sex of the individual. For those of male anatomy, *M. genitalium*, upon colonizing the urethra, induces urethritis, painful urination, discharge, arthritis, and pain and swelling in testicles. For those of female anatomy, the symptoms, upon colonization of the cervix, include cervicitis, inflammation of the uterus' inner linings, inflammation of the fallopian tubes, infertility, and premature birth of infants. Though it is being watched by healthcare professionals in the case that a superbug outbreak occurs, *M. genitalium* does not seem to present that much of a threat in comparison to more prevalent superbugs like MRSA or CRE, as most people housing the bacterium do not display any signs of illness, showing that for the most part that *M. genitalium* is not pathogenic (7).

The Dangers Ahead: Impacts of superbugs on people and the economy in the future

If an immediate and sufficient response is not given to the growing rise of superbug outbreaks, then society in the next few decades will suffer greatly in terms of population numbers and economic difficulties. In fact, it could be argued that the world has already suffered blows from these multidrug-resistant bacteria. According to the CDC in 2014, more than 2 million people in the United States are infected by some form of a superbug every year, with nearly 23,000 of those infected (~1.15%) dying as a result (1). As well, the CDC reports that nearly 700,000 people die annually as a result of superbug infections, with many of those bacteria belonging to the Enterobacteriaceae family, such as *K. pneumoniae* and *E. coli* (6). In this current moment, the people most susceptible to superbug infections are those who reside in healthcare settings, such as hospitals and nursing homes. Those health care patients include those who have a weakened immune system, such as the elderly, and are thus vulnerable to secondary infections, and those who rely heavily on antibiotics for medical procedures (e.g., chemotherapy, organs transplants, surgeries, and childbirth) (2). Despite the annual deaths being low, and the pool of potential victims being restricted to a certain demographic in a unique setting, researchers state that thing may only get worse as time moves on; according to a 2014 study, it is estimated that by 2050, more than 10 million people would have died from diseases caused by multidrug-resistant bacteria each year (6).

Besides impending mortalities and infection rates, the rise of superbug outbreaks can also harm the economic sectors of many countries. A disturbing factor to take in from the fight against multidrug resistance is the fact that the last class of antibiotics to be discovered was in 1987 -- which was over thirty years ago by 2020 (6). As time moved on since the discovery of superbugs, it became more apparent to researchers in pharmaceutical companies that the task of creating a new drug that would be able to suppress a bacterium's multidrug resistance mechanisms is not an easy one; a drug that is seen as worthy enough to make it onto the pharmaceutical market is usually worth around millions of dollars, instead of the billions it is expected to put out (4). Because the market is often not willing to place much monetary value on an antibiotic that may not be so sufficient, many of these pharmaceutical companies suffer financially as a result, which often results in employees being laid off or the company as a whole closing down (6). A lack of an appropriate stream of revenue for many pharmaceutical companies can impede the efforts of many researchers from developing antibiotics that could combat superbugs.

Government-run healthcare departments can also suffer financially from the outbreak of superbugs. For example, in 2017, the U.S. government spent nearly 130 million dollars in the fight against CRE infections, and nearly 1 billion dollars went into combating Clostridioides difficile (C. diff.) infections (5). If the number of superbug cases is expected to increase over the upcoming decades, then every government experiencing their own outbreaks will have to spend much more money in terms of healthcare preparation. In fact, the cost of combating superbug will increase so much that by 2050 the global GDP will have been reduced by 3.5%, which could bring about the risk of an economic recession or depression (6).

Preparation: Efforts to slow down superbug growth

Though the threats posed by superbugs are severe enough to warrant panics from concerned observers, there should be some comfort present when knowing the reassuring fact there are researchers and other individuals at work to prevent the spread of these diseases and to inform the public of how they can aid in reducing the number of casualties. With the last known antibiotic having been obtained in 1987, many scientists are out on the hunt for new antibiotics from various organisms that have rarely or never been encountered, like microbes (on land and in water environments), plants, fungi, and insects (6). In situations where antibiotics can not be found to deal with the problem, scientists have other alternatives in mind to indirectly prevent the spread of these drug-resistant microorganisms. In severe cases where the infection overwhelms the victims, surgical removal of the site of infection might be performed, such as is the case for a *C. diff* patient who requires surgery to a portion of their intestines (2). To ensure that zoonotic diseases do not arise, scientists are attempting to find an alternative to the antibiotics that are usually fed to livestock, such as a chemical stored in a medicinal plant, so that superbugs do not replace the non-resistant bacteria in the microbiomes (6).

Besides scientists and research companies, governments, corporations, and those of the general public can also do their part in stopping the spread of superbugs. Governments at the local, state, and federal level could ensure that public water systems are managed properly and taken care of, as sewage and feces that enter the system can foster a perfect breeding ground for dangerous bacteria (3); to ensure that physicians and healthcare settings do not provide antibiotics in either unnecessary amounts or when they are not needed, countries should enforce restrictions on the prescription of antibiotics based on advice from medical professionals (6). Big Pharma can also be seen as a key player in the fight against superbugs. Since there is a low chance that there will be a sudden abundance of new antibiotics, the pharmaceutical industry must be willing to place whatever drug is available on the market in order to ensure that pharmaceutical companies can survive long enough to continue with their research and further development on antibiotics (6). Finally, the general public's role in this conflict consists of following a simple checklist: wash hands frequently with soap and water, especially in before entering and before leaving a healthcare setting; refrain from sharing personal hygiene products (toothbrush, razor, washcloth, etc.), and consult with a health professional before deciding to take an antibiotic if faced with an infection (1).

Conclusion: A summary to end off

It has been nearly a century since the first antibiotic, penicillin, was discovered by the physician Alexander Fleming in 1928. After that discovery was made, more antibiotics were uncovered by more scientists, leading to the revolutionary usage of these drugs in all aspects of life, from personal medicine for human use to agricultural management in ensuring the production of healthy livestock. But despite the progress in the medicine that has been achieved through antibiotics, we are now in a century where it will soon be the case that those drugs will no longer help us in fighting bacterial infections, but will instead give rise to the creation of more robust bacteria that will bring us harm and death. If we are to prevent the damage from becoming too impactful, we must encourage our governments and scientists to continue on with their efforts of preparing for the inevitable wave of outbreaks, and the rest of us must continue to remain knowledgeable of the dangers of superbugs and must ensure that we do not encourage their success.

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