Antibiotic resistance

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Antibiotics are drugs principally derived from naturally occurring fungi and microorganisms that kill bacteria and can cure patients with bacterial diseases. Before the advent of antibiotics in the 1940s, many common diseases were lethal or incurable. Tuberculosis, pneumonia, scarlet fever, staph and strep infections, typhoid fever, gonorrhea, and syphilis were all dreaded diseases until the development of penicillin and other antibiotics in the middle of the twentieth century. Yet almost as soon as antibiotics came into common use, scientists noticed that some strains of disease-causing bacteria developed resistance to the antibiotic used most often against it.

People infected with an antibiotic-resistant bacteria must be treated with different antibiotics, often more potent and toxic than the commonly-used drug. In some cases, bacteria may be resistant to several antibiotics. Tuberculosis, once the leading killer in the United States at the beginning of the nineteenth century, seemed defeated with the introduction of streptomycin (derived from the actinobacterium *Streptomyces griseus*) and PAS (scientifically known as 4-aminosalicylic acid) in the 1940s and early 1950s. However, tuberculosis resurged in the United States and worldwide in the 1990s as people came down with antibiotic-resistant strains of the disease. Bacteria that cause salmonella, a foodborne illness, had become increasingly resistant to antibiotics by the early twenty-first century--as had the bacteria that commonly cause early childhood ear infections. Misuse and overuse of antibiotics contribute to the rise of resistant strains.

Bacteria can become resistant to antibiotics relatively quickly. Bacteria multiply rapidly, producing a new generation in as little as one-half hour. Hence, evolutionary pressures can produce bacteria with new characteristics in very little time. When a person takes an antibiotic, the drug will typically kill almost all the bacteria it is designed to destroy, plus other beneficial bacteria. Some small percentage of the disease bacteria, possibly as little as 1 percent, may have a natural ability to resist the antibiotic. Therefore, a small number of resistant bacteria may survive drug treatment. When these resistant bacteria are all that are left, they are free to multiply, passing the resistance to their offspring. Physicians warn people to take the fully prescribed course of antibiotics even if symptoms of the disease disappear in a day or two. This is to limit the danger of resistant bacteria flourishing. Bacteria can also develop resistance by contact with other species of bacteria that are resistant. Neighboring bacteria can pass genetic material back and forth by swapping bits of deoxyribonucleic acid (DNA) called plasmids. If bacteria that normally live on the skin and bacteria that live in the intestine should come into contact with each other, they may make a plasmid exchange, and spread antibiotic resistant qualities. Antibiotic-resistant bacteria are often resistant to a whole class of antibiotics, that is, a group of antibiotics that function in a similar way. People afflicted with a resistant strain of bacteria must be treated with a different class of antibiotics.

Antibiotic resistance was evident in the 1940s, though penicillin had only become available in 1941. By 1946, one London hospital reported that 14 percent of patients with staph infections had penicillin-resistant strains, and that number rose precipitously over the next decade. In 1943, scientists brought out streptomycin, a new antibiotic that fought tuberculosis (penicillin was found not to work against that disease). However, streptomycin-resistant strains of tuberculosis developed rapidly, and other drugs had to be found. In 1959, physicians in Japan found a virulent strain of dysentery that was resistant to four different classes of antibiotic. Some troubling cases of antibiotic resistance have been isolated incidents. Nevertheless, by the 1990s it was clear that antibiotic resistance was a widespread and growing problem. A few cases around the world in 1999 found deadly bacteria resistant to vancomycin, a powerful antibiotic described as a drug of last resort because it is only used when all other antibiotics fail. By this time, scientists in many countries were deeply alarmed about the growing public health threat of antibiotic resistance. In the mid-2000s, the Global Health Council estimated that 9.5 million people die each year from infectious diseases, most that are preventable with the use of antibiotics and other such medicines. In the United States, the Institute of Medicine stated that antimicrobial (antibiotic) resistance was likely to add $50 billion annually to the health care system in the late 2000s in the form of longer hospital stays and more expensive medicines to treat such problems. The U.S. Centers for Disease Control and Prevention (CDC) claimed in 2001 that antibiotic resistance had spread to "virtually all important human pathogens treatable with antibiotics." In 2010, the CDC further stated that these antibiotic resistance organisms make it more likely that humans will die as a result of an infection.

Antibiotic resistance makes treatment of infected patients difficult. The sexually transmitted disease gonorrhea was easily cured with a single dose of penicillin in the middle of the twentieth century. By the 1970s, penicillin-resistant strains of the disease had become prevalent in Asia, and migrated from there to the rest of the world. Penicillin was no longer used to treat gonorrhea in the United States after 1987. Standard treatment was then a dose of either of two classes of antibiotics, fluoroquinolones or cephalosporins. By the late 1990s, strains of gonorrhea resistant to fluoroquinolones had been detected in Asia. The resistant strains showed up in California in 2001. The California CDC soon recommended not using fluoroquinolones to treat gonorrhea, fearing that use of these drugs would actually strengthen the antibiotic resistance. If patients were only partially cured by fluoroquinolones, yet some infection lingered, they could pass the resistant strain to others. In addition, the resistance could become stronger as only the most resistant bacteria survived exposure to the drug. So public health officials and doctors were left with

cephalosporins to treat gonorrhea, more costly drugs with more risk of side effects.

Overuse of antibiotics contributes to antibiotic resistance. The number of antibiotic prescriptions for children rose almost 50 percent in the United States between 1980 and 1992. Two decades later, in the early 2010s, children, the elderly, and those with compromised immune systems are the most likely to receive antibiotic prescriptions. That same decade, the medical community estimates that about 150 million prescriptions are issued each year in the United States. Of those, about 90 million are for antibiotics; and well over one-half of them are considered "absolutely unnecessary or inappropriate." Antibiotics work only against bacterial diseases, and are useless against viral infections. Yet physicians frequently prescribe antibiotics for coughs and colds.

An article on the problem in *American Family Physician* found that most doctors understood the inappropriateness of their prescriptions, yet feared that patients were unsatisfied with their care unless they received a drug. The CDC launched various state and national initiatives to educate both doctors and their patients about overuse of antibiotics. Other groups took on specific diseases, such as the over-prescribing of antibiotics for childhood ear infections. The common ailment was known to be treatable without antibiotics, but many doctors continue to give antibiotics anyway. In fact, many children in day care centers who had ear infections had an antibiotic-resistant form of the condition. Consequently, pediatricians and parents are advised to use antibiotics only when necessary. Most bacteria live in the body without causing harm, but can make people ill if they build up to certain levels, or if a person's immune system is weakened. People carrying Cipro-resistant bacteria could potentially come down with a resistant form of pneumonia or some other bacterial illness later in life.

People are also exposed to antibiotics through meat and other food. About one-half the antibiotics used in the United States go to farm animals, and some are also sprayed on fruits and vegetables. Some farm animals are given antibiotics to cure a specific disease. However, other antibiotics are given as preventives, and to promote growth. Animals living in crowded and dirty conditions are more susceptible to disease, and the preventive use of antibiotics keeps such animals healthier than they would otherwise be. The antibiotics prescribed by veterinarians are similar or the same as drugs used in humans. Farm animals in the United States are routinely given penicillin, amoxicillin, tetracycline, ampicillin, erythromycin, and neomycin, among others, and studies have shown that antibiotic resistance is common in contaminated meat and eggs. Salmonella bacteria are killed when meat is cooked properly, and most cases of salmonella disease get better without treatment. However, for the small percent of cases of more serious infection, multiple antibiotic resistance could make treatment very difficult. Twenty percent of the urinary tract infections studied were resistant to Bactrim (a branded name for trimethoprim-sulfamethoxazole), meaning that in most cases physicians would be advised to treat with a stronger antibiotic with more side effects.

Antibiotics in preventive doses or for growth promotion of farm animals were banned by the European Union in 1998. Many groups in the United States concerned with antibiotic resistance recommend the United States follow suit. However, as of 2010, the United States has not done so. The plan released by the CDC, the Food and Drug Administration (FDA), and the National Institutes of Health (NIH) in 2001 to combat antibiotic resistance called for increased monitoring of antibiotic use in agriculture and in human health. The plan also called for public education on the risks of overuse and improper use of antibiotics, and for more research in combating drug-resistant diseases. As of 2010, the FDA, the NIH, and the CDC continue to investigate links between agricultural use of antibiotics and human health.

- Antibiotic overuse

Further Readings

Resources

Books

- *Germ Wars: Battling Killer Bacteria and Microbes*. New York: Rosen, 2008.
- Sachs, Jessica Snyder. *Good Germs, Bad Germs: Health and Survival in a Bacterial World*. New York: Hill and Wang, 2007.
- Spellberg, Brad. *Rising Plague: The Global Threat from Deadly Bacteria and Our Dwindling Arsenal to Fight Them*. Amherst, NY: Prometheus Books, 2009.
- Zimmerman, Barry E., and David J. Zimmerman. *Killer Germs: Microbes and Diseases that Threaten Humanity*. Chicago: Contemporary Book, 2003.

Other

- Centers for Disease Control and Prevention. "Antibiotic/Antimicrobial Resistance." http://www.cdc.gov/drugresistance/index.html (accessed November 8, 2010).
- Global Health Council. "The Impact of Infectious Diseases." http://www.globalhealth.org/infectious_diseases/ (accessed November 8, 2010).
- Infectious Diseases Society of America. "Facts about Antibiotic Resistance." http://www.idsociety.org/Content.aspx?id=5650 (accessed November 8, 2010).