

\*\*\*Answers to Questions due within 2 weeks (9/27/06)\*\*\*

Source: <http://www.niaid.nih.gov/factsheets/antimicro.htm>



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## The Problem of Antimicrobial Resistance

### Overview

Since antibiotics and other antimicrobial drugs first became widely used in the World War II era, they have saved countless lives and blunted serious complications of many feared diseases and infections. The success of antimicrobials against disease-causing microbes is among modern medicine's great achievements. After more than 50 years of widespread use, however, many antimicrobials are not as effective as they used to be.

Over time, some bacteria have developed ways to circumvent the effects of antibiotics. Widespread use of antibiotics is thought to have spurred evolutionary adaptations that enable bacteria to survive these powerful drugs. Other microbes such as viruses, fungi, and parasites have developed resistance as well. Antimicrobial resistance provides a survival benefit to microbes and makes it harder to eliminate infections from the body. Ultimately, the increasing difficulty in fighting off microbes leads to an increased risk of acquiring infections in a hospital or other setting.

Diseases such as tuberculosis, gonorrhea, malaria, and childhood ear infections are now more difficult to treat than they were just a few decades ago. Drug resistance is an especially difficult problem for hospitals harboring critically ill patients who are less able to fight off infections without the help of antibiotics. Heavy use of antibiotics in these patients selects for changes in bacteria that bring about drug resistance. Unfortunately, this worsens the problem by producing bacteria with greater ability to survive even in the presence of our strongest antibiotics. These even stronger drug-resistant bacteria continue to prey on vulnerable hospital patients.

To help curb this problem, the Centers for Disease Control and Prevention (CDC) provides hospitals with prevention strategies and educational materials to reduce antibiotic resistance in health care settings. According to CDC statistics

- Nearly 2 million patients in the United States get an infection in the hospital each year
- About 90,000 of those patients die each year as a result of their infection, up from 13,300 patient deaths in 1992
- More than 70 percent of the bacteria that cause hospital-acquired infections are resistant to at least one of the antibiotics most commonly used to treat them
- People infected with antibiotic-resistant organisms are more likely to have longer hospital stays and require treatment with second- or third-choice medicines that may be less effective, more toxic, and more expensive

In short, antimicrobial resistance is driving up health care costs, increasing the severity of disease, and increasing the death rates from certain infections.

## **ENVIRONMENT FORCES EVOLUTIONARY CHANGE**

A key factor in the development of antibiotic resistance is the ability of infectious organisms to adapt quickly to new environmental conditions. Bacteria are single-celled organisms that, compared with higher life forms, have small numbers of genes. Therefore, even a single random genetic mutation can greatly affect their ability to cause disease. And because most microbes reproduce by dividing every few hours, bacteria can evolve rapidly. A mutation that helps a microbe survive exposure to an antibiotic will quickly become dominant throughout the microbial population. Microbes also often acquire genes from each other, including genes that confer resistance.

The advantage microbes gain from their innate adaptability is augmented by the widespread and sometimes inappropriate use of antibiotics. A physician, wishing to placate an insistent patient who has a virus or an as-yet undiagnosed condition, sometimes inappropriately prescribes antibiotics. Also, when a patient does not finish taking a prescription for antibiotics, some bacteria may remain. These bacterial survivors are more likely to develop resistance and spread. Hospitals also provide a fertile environment for antibiotic-resistant germs as close contact among sick patients and extensive use of antibiotics select for resistant bacteria. Scientists also believe that the practice of adding antibiotics to agricultural feed promotes drug resistance.

## **A GROWING PROBLEM**

For all these reasons, antibiotic resistance has been a problem for nearly as long as we've been using antibiotics. Natural selection of penicillin-resistant strains in a bacterium known as *Staphylococcus aureus* began soon after penicillin was introduced in the 1940s. Today, antibiotic-resistant strains of *S. aureus* bacteria as well as various enterococci (bacteria that colonize the intestines) are common and pose a global health problem in hospitals. More and more hospital-acquired infections are resistant to the most powerful antibiotics available, such as vancomycin. These drugs are reserved to treat only the most stubborn infections to slow development of resistance to them.

There are multiple signs that the resistance problem is increasing.

- In 2003, epidemiologists reported in *The New England Journal of Medicine* that 5 to 10 percent of patients admitted to hospitals acquire an infection during their stay and that the risk for a hospital-acquired infection has risen steadily in recent decades.
- Increasing reliance on vancomycin has led to the emergence of vancomycin-resistant enterococci infections. According to CDC, prior to 1989, no U.S. hospital had reported any vancomycin-resistant enterococci but subsequently, such microbes have become common in U.S. hospitals.
- The first *S. aureus* infections resistant to vancomycin emerged in the United States in 2002, presenting physicians and patients with a serious problem. In July of that year, CDC reported that a Michigan patient with diabetes, vascular disease, and chronic kidney failure had developed the first *S. aureus* infection completely resistant to vancomycin. A similar case was reported in Pennsylvania in September 2002.

- In 2004, the third reported case of vancomycin-resistant *S. aureus* (VRSA) in the United States was reported in New York. This case highlighted the failure of several standard automated susceptibility tests to identify vancomycin resistance in that isolate and suggests that additional VRSA cases may have occurred nationwide but escaped detection. Since then, three additional cases of VRSA, all occurring in Michigan, have been reported to CDC.
  - Strains of *S. aureus* resistant to methicillin are endemic in hospitals and are increasing in non-hospital settings such as locker rooms and day care centers. Since September 2000, outbreaks of methicillin-resistant *S. aureus* (MRSA) infections have been reported among high school football players and wrestlers in California, Indiana, and Pennsylvania, according to CDC. During the 2003 football season, an outbreak of MRSA occurred among members of a professional football team.
  - A number of cases of community-associated MRSA have also been reported, including cases in patients without established risk factors.
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## Questions

1. Are bacteria the only type of microbes that develop drug resistance?
2. What can happen if a patient does not finish taking the entire prescription of an antibiotic?
3. What does VRSA stand for? (completely spell out all words)