

Understanding Methicillin-Resistant *Staphylococcus aureus*

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Image Reference:

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What is Methicillin-Resistant *Staphylococcus aureus* (MRSA)?

- *Staphylococcus* is a genus of bacteria that includes more than 30 species.
 - Many are harmless.
 - They are found on the skin and mucous membranes of humans and animals.
- Methicillin-Resistant *Staphylococcus aureus* (MRSA) is a disease causing bacteria that has developed resistance to an entire class of antibiotics, including penicillin, methicillin, amoxicillin, and oxacillin.
 - MRSA is responsible for skin infections, pneumonia, food poisoning, toxic shock syndrome, and blood poisoning (bacteremia).



Courtesy of the CDC
Scanning electron micrograph (SEM) of two *Staphylococcus epidermidis* bacteria.



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What is Methicillin-Resistant *Staphylococcus aureus*?

Staphylococcus is a genus of gram positive bacteria (approximately 0.5–1.0 μm in diameter), of more than 30 species. Members of this genus are sphere-shaped and grow in clusters, pairs, and occasionally short chains. MRSA (Methicillin-Resistant *Staphylococcus aureus*) is a strain of *Staphylococcus aureus* bacteria that has developed resistance to an entire class of antibiotics (called beta lactams), including methicillin, penicillin, amoxicillin, and oxacillin. In addition, *S. aureus* is often found to be resistant to antiseptics and disinfectants. Over the past four decades in the US, it has evolved from an easily controlled microbe to a major public health problem.

Reference:

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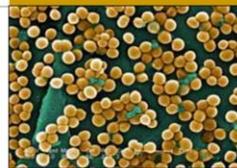
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Emergence of Methicillin-Resistant *Staphylococcus aureus* (MSRA)

- 1880s: *S. aureus* was identified as a cause of minor skin disorders, such as boils and impetigo.
- 1940s: The introduction of penicillin gave doctors a successful way to treat *S. aureus*, but resistant strains evolved quickly.
- 1959: Methicillin became available to combat the growing problem, but the first methicillin-resistant strain appeared within two years.



This scanning electron micrograph depicts numerous clumps of methicillin-resistant *Staphylococcus aureus* bacteria, commonly referred to by the acronym, MRSA; Magnified 4780x.



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Emergence of Methicillin-Resistant *Staphylococcus aureus* (MSRA)

S. aureus was first identified in the 1880s as a cause of boils, impetigo, and other skin disorders. It is among the populations of bacteria normally found on the skin's surface in humans. The introduction of penicillin in the 1940s gave doctors a successful way to treat these infections, but by the end of that decade, some strains of *S. aureus* had evolved ways to avoid being destroyed by antibiotics. In other words, these microbes had begun to develop resistance to this antibiotic. Methicillin was introduced in 1959 to combat the growing problem of penicillin-resistance, but British scientists identified the first methicillin-resistant strain (MRSA) only two years later. The first case of MRSA was reported in the United States in 1968.

Staphylococcus aureus gains resistance to antibiotics by a variety of strategies that include acquisition of new plasmids (mobile, circular pieces of DNA); addition of genetic information that is inserted into or rearranged within the chromosome; and spontaneous mutations. In addition bacteria employ several survival strategies to resist the effects of antibiotics. Pumps within the cell membranes of some bacteria can expel an antibiotic before it reaches its intracellular target. A number of bacteria have acquired a genetic change that allows an overproduction of "pumps," that allow the cell to expel the drug faster than it can enter. Another means of resistance by bacteria is to alter the molecules inside the cell that the drug is designed to target. These changes interfere with a drug's ability to bind and disrupt cell function. A third method of survival by bacteria is to produce enzymes that inactivate the drug before it can enter or obstruct the cell function.

Reference:

Baron, S. (ED.). (1996). *Medical microbiology* (4th ed.). Galveston, TX: The University of Texas Medical Branch at Galveston.

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National Institute of Allergy and Infectious Diseases. (2007). *Antimicrobial (Drug) Resistance. Methicillin-Resistant Staphylococcus aureus*. Retrieved 11/1/2007, from <http://www3.niaid.nih.gov/topics/AntimicrobialResistance/>

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Carr, J. H. and Hageman, J. (2005). Methicillin-resistant *Staphylococcus aureus*. Centers for Disease Control and Prevention. Retrieved 12-26-2007 from <http://phil.cdc.gov/phil/quicksearch.asp>.

Sources of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

- Until recently, most MRSA infections started in hospitals, especially among surgery patients and people with weak immune systems.
- In the 1990s, new strains of MRSA began to strike healthy people in community settings.
- These two types of MRSA are now known as hospital-associated MRSA (HA-MRSA) and community-associated MRSA (CA-MRSA).



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Sources of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

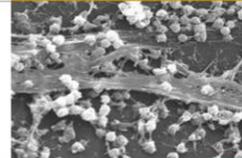
MRSA is a serious cause of infections in hospitals and long-term care facilities, primarily affecting patients with weakened immune systems and those who have had recent surgeries or other medical procedures. These infections are referred to as hospital-associated MRSA (HA-MRSA) to distinguish them from infections caused by newer strains of *S. aureus* that originate in community settings. Community-associated MRSA (CA-MRSA) developed in the 1990s, often striking healthy people with no history of surgery or hospitalization. CA-MRSA is often passed among people who have close skin-to-skin contact such as athletes.

Reference:

National Institute of Allergy and Infectious Diseases. (2007). *Antimicrobial (Drug) Resistance. Methicillin-Resistant Staphylococcus aureus*. Retrieved 11/1/2007, from <http://www3.niaid.nih.gov/topics/AntimicrobialResistance/>

Hospital-Associated Methicillin-Resistant *Staphylococcus aureus* (HA-MRSA)

- Hospital-associated strains of *S. aureus* still cause about 85% of all MRSA cases.
- Hospital patients with *S. aureus* infections are five times more likely to die in the hospital than are patients without the infection.
- Vancomycin is one of the few remaining treatments for hospital-associated strains of *S. aureus*, but it is no longer effective in every case.



Courtesy of the CDC
This electron micrograph depicts large numbers of *Staphylococcus aureus* bacteria, which were found on the inside surface of a catheter. The sticky-looking substance woven between the round cocci bacteria is known as a "biofilm". Biofilms help to protect the bacteria.



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Hospital-Associated Methicillin-Resistant *Staphylococcus aureus* (HA-MRSA)

A recent study by the Centers for Disease Control and Prevention (CDC) found that hospital-associated strains of *S. aureus* are still responsible for about 85% of MRSA infections. The CDC study estimated that in 2005, 94,360 people developed serious, invasive MRSA infections, and that approximately 18,650 patients died during a hospital stay related to these infections. In a review of hospital records from 2000 to 2001, researchers found that patients diagnosed with *S. aureus* infections were five times more likely to die in the hospital than were patients without the infection.

For severe hospital-associated MRSA infections, doctors typically administer vancomycin intravenously. This antibiotic is one of the few remaining treatments for HA-MRSA. In 2002, the first vancomycin-resistant bacteria were identified in the United States, but fortunately, these strains are rare at this time.

References:

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Community-Associated Methicillin-Resistant *Staphylococcus aureus* (CA-MRSA)

- CA-MRSA typically occurs in places where people have close contact, including childcare centers, nursing homes, prisons, and on athletic teams.
- Several antibiotics remain effective against CA-MRSA, but it is an aggressive and rapidly evolving form of *S. aureus*.
- CA-MRSA usually appears as a skin infection, but it can spread quickly to a bloodstream infection or a very serious form of pneumonia.



Courtesy of the CDC

Cutaneous abscess caused by methicillin-resistant *Staphylococcus aureus* bacteria.



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Community-Associated Methicillin-Resistant *Staphylococcus aureus* (CA-MRSA)

Unlike hospital-associated MRSA, which usually can be traced to a single source, community-associated strains can be more elusive and aggressive. CA-MRSA now accounts for most skin and soft tissue infections seen in emergency rooms. It often occurs in settings where people live in close quarters, have skin-to-skin contact (such as athletes) or unsanitary conditions.

CA-MRSA is sometimes mistaken for a spider bite or a minor skin problem, but it can progress rapidly to a bloodstream infection or a serious illness called necrotizing pneumonia. This form of pneumonia occurs in only 2% of MRSA infections, but it is fatal in 75% of cases. CA-MRSA can still be treated with several antibiotics, but it is evolving rapidly.

References:

- Ledform, H. (2007) Research Highlights Nastier Form of MRSA. *Nature News*, Published online 1/18/2007. Retrieved 11/1/2007, from <http://www.nature.com/news/2007/070115/full/news070115-10.html>.
- National Institute of Allergy and Infectious Diseases. (2007). *Antimicrobial (Drug) Resistance. Methicillin-Resistant Staphylococcus aureus*. Retrieved 11/1/2007, from <http://www3.niaid.nih.gov/topics/AntimicrobialResistance/>

Image Reference

Cutaneous abscess caused by methicillin-resistant Staphylococcus aureus, # 7826. Retrieved 12-26-2007 from <http://phil.cdc.gov/phil/quicksearch.asp>

Risk for Methicillin-Resistant *Staphylococcus aureus* (MRSA)

- MRSA can strike anyone, regardless of age or health, but certain population groups have a higher risk.
 - Children and young adults
 - People with chronic illnesses
 - Health care workers
 - People living in confined areas or unsanitary conditions
 - Athletes who play contact sports or share equipment or personal items



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Risk for Methicillin-Resistant *Staphylococcus aureus* (MRSA)

Serious MRSA disease can strike anyone, regardless of age and health. Older adults and people with chronic illnesses are at heightened risk of developing serious infections because their immune systems are no longer strong. Children and young adults also are at risk because their immune systems aren't fully developed. Health care workers and people who have close contact with health care workers have an increased risk of exposure to MRSA infections. Outbreaks also have occurred among soldiers, athletes, prison inmates, and residents of childcare or residential care facilities.

Reference

National Institute of Allergy and Infectious Diseases. (2007). *Antimicrobial (Drug) Resistance. Methicillin-Resistant Staphylococcus aureus*. Retrieved 11/1/2007, from <http://www3.niaid.nih.gov/topics/AntimicrobialResistance/>

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Transmission of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

- Most MRSA infections occur through direct contact with people or surfaces that carry the bacteria.
- Staph bacteria enter the body through skin cuts or abrasions and spread easily.
- Approximately 25-30% of people carry *S. aureus* on their bodies without becoming sick, but they can pass the germ to others, who may become ill.



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Transmission of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

Staph bacteria cause illness when they enter the body through skin wounds. Most MRSA infections occur through direct contact with people or surfaces that carry the germ. Approximately 25-30% of the human population is “colonized” with strains of *S. aureus*, meaning that the bacteria are present (usually on the skin or in the nose), but are not causing illness. Healthy people who carry *S. aureus* can pass the bacteria unintentionally to other people. Only about 1% of people who carry staph bacteria have methicillin-resistant strains.

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Centers for Disease Control and Prevention. (2005). *Community-Associated MRSA Information for the Public*. Retrieved 11-1-2007, from http://www.cdc.gov/ncidod/dhqp/ar_mrsa_ca_public.html

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Treatment of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

- Some *S. aureus* infections can be treated without antibiotics by surgically draining the wound.
 - This treatment should be done only by a health professional.
- Before prescribing an antibiotic, a doctor must determine if MRSA bacteria are present.
- Using the wrong drug delays treatment and encourages the development of more resistant bacteria.



CDC/Don Stalons
Cultured *Staphylococcus aureus* on agar plate.



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Treatment of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

Many *S. aureus* infections can be treated without antibiotics by draining the wound, which should be done only by a health care professional. Before prescribing an antibiotic, a doctor must determine if MRSA bacteria are present. Accurate diagnosis is critical, because prescribing the wrong medication will delay the start of effective treatment, and it also can encourage the development of more resistant bacteria. New tests that can diagnose MRSA in a matter of hours are becoming more widely available.

Reference:

National Institute of Allergy and Infectious Diseases. (2007). *Antimicrobial (Drug) Resistance. Methicillin-Resistant Staphylococcus aureus*. Retrieved 11/1/2007 from <http://www3.niaid.nih.gov/topics/AntimicrobialResistance/>

Image Reference:

Stalons, D. *Cultured agar plate with Staphylococcus aureus*. Centers for Disease Control and Prevention. Retrieved 12-26-2007 from <http://www.nlm.nih.gov/medlineplus/mrsa.html>

Transmission and Infection of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

- Wash hands frequently and thoroughly.
- Use a hand sanitizer when soap and water are not available.
- Keep skin cuts clean and covered with a dry bandage.
- Don't touch another person's skin wound or bandage.
- Avoid sharing personal items, such as towels, washcloths, and razors.
- See a doctor promptly if a skin problem becomes infected.



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Transmission and Infection of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

Good hygiene is the best defense against staph infections. In addition to the guidelines on this slide, it is important to pay attention to pimples, insect bites, cuts, and abrasions, especially in children and young adults. See a health professional if a skin problem looks like it has become infected. The site of a typical staph infection is red, swollen, and painful, often with pus or other drainage. If an antibiotic is prescribed, it is important to take all the doses, even if the infection appears to improve before the medication is gone. Antibiotics should not be shared or saved for future use.

Researchers are beginning to unravel the inner mechanisms of MRSA infections. For example, recent studies show that CA-MRSA secretes higher amounts of a peptide than other bacteria that causes neutrophils (immune cells) to burst, thereby debilitating the immune system. It also produces proteins that make the microbe stickier, so it can invade tissue more easily. With this type of information, scientists hope to develop new drugs that attack the biology of the bacteria, rather than focusing only on finding new antibiotics that kill it.

References:

- Centers for Disease Control and Prevention. (2005). *Community-Associated MRSA Information for the Public*. Retrieved 11-1-2007, from http://www.cdc.gov/ncidod/dhqp/ar_mrsa_ca_public.html
- Ledford, H. (2007) Research Highlights Nastier Form of MRSA. *Nature News*, Published online 1/18/2007. Retrieved 11/1/2007 from <http://www.nature.com/news/2007/070115/full/news070115-10.html>
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