MRSA (methicillin-resistant *Staphylococcus aureus*) is caused by the bacterium *Staphylococcus aureus* that is resistant to beta-lactams class of antibiotics (3, 4). MRSA can be classified in one of two ways, healthcare-acquired (HA-MRSA) or community-acquired (CA-MRSA) (3, 5). HA-MRSA occurs in individuals who are currently receiving treatment in or have recently been treated in a healthcare facility or setting. CA-MRSA occurs in individuals in the community who work or live in an unclean environment, live in close quarters/crowded conditions or who have a high level of direct skin to skin contact with other individuals such as wrestlers (4, 5).

**History:**

In the 1880’s *Staphylococcus aureus* was first discovered by a Scottish surgeon named Sir Alexander Ogston (11, 8). During the 1940’s with the progression of the development and use of penicillin the standard treatment for *S. aureus* was penicillin (8). This started the evolution of *S. aureus* to become resistant to penicillin so treatment switched to a derivative of penicillin called Methicillin to cut down on bacteria resistant to penicillin (8). However, in 1961 the first methicillin resistant strain of *S. aureus* was discovered thus the official birth of MRSA (8). As time has progressed MRSA has become resistant to a class of penicillin antibiotics referred to as beta-lactums and its virulence is continuing to allow it to evolve and now become resistant to other antibiotics. Some rare strains of MRSA are resistant to antibiotics like vancomycin which in the past was used as a last resort to treat MRSA infections (8). In the 1990’s community acquired MRSA appeared and an endemic quickly ensued (11). Since its emergence, CA-MRSA has continued to spread and is projected to become the dominant type of MRSA even in healthcare settings (11).

**Reservoirs:**

Human or Zoonosis

*Staphylococcus aureus* can survive on the skin or inside the nose of individuals who do not show current active signs of an infection and it can thrive in individuals who have an active infection (4, 6). Wild and domestic animals may also carry this microorganism (6).

**Transmission:**

MRSA is transmitted through direct and indirect contact. Most often direct contact transmission occurs when an individual with an active infection comes into direct skin to skin contact with another individual who has a break in their skin such as a cut or abrasion (1). It can also occur if an individual is carrying the bacteria on their skin or in their nose without an active infection but touches another individual who has a break in their skin transferring the *S. aureus* bacteria to them. The leading cause for direct transmission of MRSA is not properly washing hands after touching the bacteria (whether wiping your nose, touching an open infected sore or scratching
your arm) then touching another individual (1, 4, 6, 7). Indirect contact transmission occurs when an individual who is a carrier (not infected but has \( S.\ aureus \) on their skin or in their nose) or has an active infection transfers the bacteria either by sneezing or touching an object and then another person then comes into contact with that object such as a shared razor, handkerchief, or any commonly shared surface such as a door knob (1, 4, 7).

**Signs and Symptoms:**
The first signs and symptoms of a MRSA infection resemble most types of skin infections with areas of redness, heat, swelling, raised bumps or puss filled spots such as pimples or spider bites (1, 2). As the infection progresses systemic signs and symptoms may emerge like fever, bacteremia (infection of the blood stream), pneumonia, sepsis or even death (2).

![Photos provided by CDC:](https://www.cdc.gov/mrsa/community/photos/index.html)

**General Characteristics:**
Methicillin-resistant Staphylococcus aureus is a pus producing, non-motile gram-positive bacteria that appear in grape like clusters of cocci about .5-1.5-\( \mu \)m in diameter (12). This bacterium can also grow in a wide range of pH levels (4.2-9.3) and salt concentrations (0-15%) (6). \( S.\ aureus \) is particularly resistant to moist heat and can withstand dry heat up to 160-170°C for about an hour (6). It can also survive on surfaces in sunlight for 17 hours and on other surfaces for up to 40 days (6).

**Tests/Identification:**
There are a few types of testing performed when assessing if a patient has MRSA. The most common is a MRSA screening test which can be performed on individuals who do not have an active infection or those who are showing signs of one. For a simple screening to see if an asymptomatic individual is a carrier, a sample is taken (swabbed) from the nasal passage and then sent to a lab where it is cultured onto a nutrient rich agar plate that is usually infused with methicillin or oxacillin (9, 13). The plate is then incubated for 24-48 hours and if growth is present or a color change in the agar is detected then the test is positive (9,13). This test can also be performed with a direct culture from a wound with suspected MRSA infection. Another type
of testing is called molecular testing, and it looks for genetic markers in the sample collected that identify *S. aureus* and the mecA gene which signifies resistance to beta-lactums (9).

**Virulence Mechanisms:**
The reason MRSA has become and continues to be problematic is due to its several different virulence factors/mechanisms. Perhaps the most well-known or researched virulence factor is a protein called Paton Valentine Leukocidin or PVL (10, 11). PVL is a exotoxin that causes holes or pores in leukocytes which lead to cell lysis (10, 11). Currently PVL is more commonly associated with CA-MRSA and there is some discrepancy of what role PVL actually plays in the pathogenesis of the disease (10, 11).

Another factor is α-toxin which also causes pores in leukocytes. However it a causes lysis in other immune cells like lymphocytes and macrophages and it also effects platelets and their morphology (11). Some research is being done to look into the use of α-toxin-specific antibodies as a treatment for MRSA infections (10).

Phenol soluble modulins also called PSM’s are produced by most staphylococci infections including MRSA and is another protein that is studied for its contribution to MRSA virulence (10, 11). According to several different studies high levels of PSM’s are associated with CA-MRSA and they are able to lyse human neutrophils (10, 11).

Another thought virulence factor is biofilms that MRSA can live in/on such as the biofilms found on medical implants like catheters. Overall bacteria in a biofilm is much more resistant to treatments because the cells act together as a unit as opposed to one individual cell on its own. This unit like mechanism helps to evade host immune systems allowing the survival of the bacteria (10).

The last virulence factor has to do with the production of superantigens which most *S. aureus* strains produce. The reason these superantigens are harmful is they cause a cytokine storm which can lead to sepsis and potentially death (11).

**Control/Treatment/Prevention/Vaccines:**
The best way to control MRSA is though prevention with proper cleaning and sanitizing techniques. Wash your hands with soap and warm water making sure to scrub your hands for at least 15 seconds, rinse and then dry with a paper towel (7). If you can use a paper towel to turn off the faucet and to grab a public bathroom door handle so you do not spread germs that may be on commonly used surfaces (7). Also follow some of the preventative guidelines below as provided by the CDC and the MayoClinic:

- **Keep wounds covered.** Keep cuts and abrasions clean and covered with sterile, dry bandages until they heal. The pus from infected sores may contain MRSA, and keeping wounds covered will help prevent the bacteria from spreading (7). Follow your doctor’s instructions about proper care of the wound. Bandages and tape can be thrown away with the regular trash. Do not try to treat the infection yourself by picking or popping the sore (1).
• **Keep personal items personal.** Avoid sharing personal items such as towels, sheets, razors, clothing and athletic equipment. MRSA spreads on contaminated objects as well as through direct contact (7).

• **Shower after athletic games or practices.** Shower immediately after each game or practice. Use soap and water. Don’t share towels (7).

• **Sanitize linens.** If you have a cut or sore, wash towels and bed linens in a washing machine set to the hottest water setting using soap (with added bleach, if possible) and dry them in a hot dryer. Wash gym and athletic clothes after each wearing (7).

Treatment of a MRSA infection will vary depending on the infection location, severity, and strain of the *S. aureus*. Due to the rise in the resistance to antibiotics not every infection will be treated with an antibiotic in which case the abscess would be lanced open, drained, cleaned thoroughly and sometimes packed with sterile gauze then closely monitored (14). If the use of antibiotics is warranted, antibiotics such as trimethoprim-sulfamethoxazole, doxycycline, minocycline and clindamycin are suggested if the strain of CA-MRSA permits (14). It is suggested to use antibiotics on any individuals that may have risk factors such as a compromised immune system, recurrent infections, rapid disease progression or are very old or young (14).

Currently there are no vaccines to prevent MRSA but research is being conducted to try to create something that would attack or counter act the toxins produced by the infection.

**Current Information:**

Local Cases: According to the Texas Department of State Health Services, individual cases of MRSA are not required to be reported so accurate numbers of incidence are difficult to obtain. However, an outbreak or unusual cases or strains of MRSA should be reported. Below are some statistics of cases reported in previous years provided by TxHSN (4).

- **2012:** Of the 609 *S. aureus* isolates, 335 isolates (55%) tested susceptible to oxacillin/methicillin
- **2013:** Of the 790 *S. aureus* isolates, 352 (44.55%) tested susceptible to oxacillin/methicillin
- **2014:** Of the 710 *S. aureus* isolates, 315 (44.33%) tested susceptible to oxacillin/methicillin

On a national level, it is estimated that approximately 90,000 Americans suffer from invasive MRSA infection and about 20,000 of those die (18). According to the CDC, in the US there has been a 13% decrease in MRSA bacteremia between 2011 and 2014 (15).
### National Estimates and Adjusted Incidence Rates of Invasive MRSA Infections

<table>
<thead>
<tr>
<th>Epidemiologic Category</th>
<th>Estimated Cases of Infection</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-Dialysis Patients</td>
<td>Dialysis Patients</td>
</tr>
<tr>
<td></td>
<td>Estimated No.</td>
<td>Incidence Rate (Confidence Interval)</td>
</tr>
<tr>
<td>CA</td>
<td>16,522</td>
<td>5.18 (4.03-6.79)</td>
</tr>
<tr>
<td>HCA</td>
<td>44,627</td>
<td>14.01 (12.17-16.29)</td>
</tr>
<tr>
<td>HCA-HO&lt;sup&gt;d&lt;/sup&gt;</td>
<td>10,130</td>
<td>3.18 (2.33-4.40)</td>
</tr>
<tr>
<td>HCA-HACO</td>
<td>34,497</td>
<td>10.83 (9.26-12.81)</td>
</tr>
<tr>
<td>Overall&lt;sup&gt;e&lt;/sup&gt;</td>
<td>61,927</td>
<td>19.45 (17.16-22.18)</td>
</tr>
</tbody>
</table>

CA: community-associated (not linked to inpatient medical care, e.g. in a hospital, nursing home, dialysis facility, etc.)
HCA: healthcare-associated (linked to receiving inpatient medical care, e.g. in a hospital, nursing home or dialysis facility, etc.)
HCA-CO: healthcare-associated, community onset (these infections are linked to recent inpatient medical care (e.g. in a hospital or nursing home), but the infection was identified when the patient was back in the general community (e.g. at home))
HCA–HACO: healthcare-associated, hospital onset (these infections were linked to and identified during recent inpatient medical care, e.g. in a hospital or nursing home, receiving dialysis)

<sup>a</sup>National Estimates and Incidence (no. per 100,000 population per year) are adjusted for age, race, gender and receipt of chronic dialysis using 2014 US Census Data.
<sup>b</sup>National Estimates and Incidence (no. per 100,000 dialysis patients per year) for dialysis patients are adjusted for age, race and gender using 2013 USRDS point prevalence data.
<sup>c</sup>Starting in 2011, confidence intervals on national estimates were calculated based on 72 age/race/gender/dialysis specific strata and summarized for an overall national estimate, accounting for variance across all strata producing a more conservative estimate (with wider confidence intervals) compared to estimates prior to 2011.
<sup>d</sup>Non-dialysis and dialysis estimated number and incidence based on data from a sample of HO cases.
<sup>e</sup>47 cases could not be classified into an epidemiological category or category is unknown and therefore are counted in the overall estimate only.

The above chart and information provided by the CDC: [https://www.cdc.gov/mrsa/tracking/index.html](https://www.cdc.gov/mrsa/tracking/index.html)
Global Cases: The evolution of MRSA has affected many countries other than the US making it a pandemic. Antibiotic resistant bacteria are not limited by country but is more prevalent in countries that have antibiotics more readily available. According to some sources HA-MRSA has declined in some European countries over the last few years, however some countries such as Sri Lanka (86.5%), South Korea (77.6%), Vietnam (74.1%), Taiwan (65%), Thailand (57%) and Hong Kong (56.8%) have remained high (19).

![Worldwide prevalence of hospital-acquired meticillin-resistant Staphylococcus aureus](http://www.handinscan.com/global-epidemiology-of-mrsa/)

Although it is hard to track individual cases of MRSA the UK has implemented a reporting system that has allowed for different ways of reporting. By no means is any reporting system perfect but the results seem to show that there is also a higher prevalence of CA-MRSA cases than HA-MRSA cases just like those reported here in the US. The chart below shows the results for the UK from 2015 to 2016 (20).
**Image provided by MRSA Action UK: [http://mrsaactionuk.net/monthlystatistics.html](http://mrsaactionuk.net/monthlystatistics.html)**

**Bibliography**


