In the last lesson we learned that pathogens cause illness by damaging host cells. We also learned that pathogens can damage host cells directly or indirectly. We focused on the impact bacterial replication has on host cell damage. Although many symptoms, like fever and swelling, result from immune responses, disease itself results from host cell damage.

This lesson continues to explore how bacteria cause damage to host cells, with a focus on how bacterial toxins damage the host. Although some toxins damage the host directly, others stimulate immune responses that lead to indirect damage.

What is a toxin?

A toxin is a poisonous substance that is produced by living cells or organisms. It is usually a protein or lipid, and is capable of causing disease when introduced into the body tissues. It is important to note that despite its potential involvement in disease, a toxin is not a pathogen, in large part because a toxin cannot replicate.

Toxins can be produced by all classes of microbes except viruses, and they can also be produced by larger organisms. For example, bee venom is a toxin, as is urushiol, which is the irritating substance in poison ivy. Despite causing irritation or illness, these toxins are not pathogens.

However, when pathogenic microbes produce toxins, it can dramatically increase their virulence. Being able to produce a toxin is a powerful adaptation because toxins can cause cell damage both directly, by actually destroying cells, and indirectly by triggering an immune response that destroy host cells. This host cell damage provides bacteria access to new areas of the body to inhabit and new nutrients. In this lesson, we will outline some examples of toxin-producing bacteria, and discuss how their toxins help impact the bacteria's life cycle.
MRSA: What is Methicillin-resistant Staphylococcus aureus (MRSA)?

Staphylococcus aureus causes a variety of suppurative (pus-forming) infections in humans. It can cause superficial skin lesions such as boils, more serious infections such as pneumonia, mastitis (inflammation of the breast), phlebitis (inflammation of veins), meningitis (inflammation of the brain), urinary tract infections, and deep-seated infections, such as osteomyelitis (inflammation of the bone) and endocarditis (inflammation of the heart). S. aureus is a major cause of hospital acquired infection of surgical wounds and infections associated with indwelling medical devices like IVs and urinary catheters. S. aureus causes disease by releasing exotoxins. Staphylococci produce a variety of exotoxins that can lyse red blood cells and white blood cells. It also produces an exotoxin that can cause blood clots.

Staph bacteria, like other kinds of bacteria, normally live on your skin and in your nose, usually without causing problems. Staph bacteria only become a problem when they cause infection. For some people, especially those who are weak or ill, these infections can become serious. Methicillin-resistant Staphylococcus aureus (MRSA) are a type of staphylococcus aureus bacteria that are resistant to many antibiotics. MRSA is different from other types of staph because it cannot be treated with certain antibiotics such as methicillin. When methicillin and other common antibiotics do not kill the bacteria causing an infection, it becomes harder to get rid of the infection.

MRSA bacteria are more likely to develop when antibiotics are used too often or are not used correctly. Given enough time, bacteria can outsmart antibiotics so that they no longer work well. This is why MRSA and other antibiotic-resistant bacteria are sometimes called “super bugs.”

What causes an infection?

MRSA, like all staph bacteria, can be spread from one person to another through casual contact or through contaminated objects. It is commonly spread from the hands of someone else who has MRSA. MRSA is usually not spread through the air like the common cold or flu virus, unless a person has MRSA pneumonia and is coughing. In fact about 10 - 30% of all people are infected with MRSA but do not display symptoms. MRSA used to mostly infect people who had chronic illnesses, but now MRSA is becoming more common in healthy people. These infections can occur among people who have cuts or wounds and then come into close contact with one another, such as members of sports teams. This type of MRSA is called community-associated methicillin-resistant Staphylococcus aureus (CA-MRSA).
MRSA that is acquired in a hospital or health care setting is called healthcare-associated methicillin-resistant Staphylococcus aureus (HA-MRSA). In most cases, a person who is already sick or who has a weakened immune system becomes infected with HA-MRSA. These infections can occur in wounds or skin, burns, and IV tubes or other sites where tubes enter the body, as well as in the eyes, bones, heart, or blood. HA-MRSA is usually resistant to more types of antibiotics than CA-MRSA, but is less widespread. The concern is that if CA-MRSA and HA-MRSA mingle they could share antibiotic resistant genes via plasmids, as we learned before.

What are the symptoms of MRSA?
Symptoms of a MRSA infection depend on where the infection is. If MRSA is causing an infection in a skin wound, that area of your skin may be red or tender. If you have pneumonia, you may develop a cough. Community-associated MRSA commonly causes skin infections, such as boils, abscesses, or cellulitis. Often, people think they have been bitten by a spider or insect. Because MRSA infections can become serious in a short amount of time, it is important to see your doctor right away if you notice a boil or other skin problem that does not get better quickly.

How is an infection diagnosed?
If your doctor thinks that you are infected with MRSA, he or she will send a sample of your infected wound, blood, or urine to a lab. The lab will grow the bacteria and then test to see which kinds of antibiotics kill the bacteria, as we did in the lab experiment in Unit 2. The test may take several days. You may also be tested if your doctor suspects that you are a MRSA carrier. A MRSA carrier is a person who has the bacteria on the skin or in the nose but who is not displaying symptoms. This is done by taking a swab from the inside of the nose, just as we did in the lab experiment.

Treating MRSA
Most cases of CA-MRSA begin as mild skin infections such as pimples or boils. Your doctor may be able to treat these infections without antibiotics by using a minor surgical procedure that opens and drains the sores. Depending on how serious your infection is, the doctor may drain your wound, prescribe antibiotic medicine, give you an IV (intravenous) antibiotic, or hospitalize you. You might also be given an ointment to put on your skin or inside your nose and be asked to wash your skin daily with an antibiotic soap such as chlorhexidine (Hibiclens) to reduce the numbers of MRSA bacteria on your skin.
If you have a MRSA infection and need to be in a hospital, you may be isolated in a private room to reduce the chances of spreading the bacteria to others. When your doctors and nurses are caring for you, they may use extra precautions such as wearing gloves and gowns. If you have MRSA pneumonia, they may also wear masks.

If your doctor prescribes antibiotics, be sure to take all the medicine even if you begin to feel better right away. If you do not take all the medicine, you may not kill all the bacteria. No matter what your treatment, it is important to call your doctor if your infection does not get better as expected.

How can I prevent getting or spreading MRSA?

As more antibiotic-resistant bacteria develop, hospitals are taking extra care to practice “infection control,” which includes frequent hand-washing and isolation of patients who are infected with MRSA.

You can also take steps to protect yourself from MRSA by practicing good hygiene.

**Keep your hands clean** by washing them frequently and thoroughly with soap and warm water or using an alcohol-based hand sanitizer. Hand-washing is the best way to avoid spreading germs. Avoid spreading the infection by telling your family, and other people with whom you are in close contact to wash their hands often with soap and warm water or use an alcohol-based hand sanitizer, especially after changing the bandage or touching the wound. If you’re in the hospital, remind doctors and nurses to wash their hands before they touch you.

**Keep cuts and scrapes clean and covered** with a bandage and avoid contact with other peoples’ wounds or bandages. Follow your doctor’s instructions on caring for your wound.

**Do not share personal items** such as towels, washcloths, razors or clothing.

**Wash your sheets, towels, and clothes with warm water and detergent** and dry them in as a hot dryer as much as possible.

**Keep your environment clean** by wiping all frequently touched surfaces (such as countertops, doorknobs, and light switches) with disinfectant.

**Be smart about using antibiotics.** Know that antibiotics can help treat bacterial infections but they can’t cure viral infections. Always ask your doctor if antibiotics are the best treatment. And avoid pressuring your doctor to prescribe antibiotics when they won’t help you get better.

**Always take all your antibiotics** as prescribed by your doctor. Using only part of the medicine may cause antibiotic-resistant bacteria to develop.

**Don’t save any antibiotics,** and don’t use antibiotics that were prescribed for someone else.
What is E. coli?

Escherichia coli (E. coli) is a bacterium that commonly lives in the intestines of people and animals. There are many strains (types) of E. coli. Most of the E. coli are normal inhabitants of the small intestine and colon and are non-pathogenic, meaning they do not cause disease in the intestines. Nevertheless, these non-pathogenic E. coli can cause disease if they spread outside of the intestines, for example, into the urinary tract (where they cause bladder or kidney infections) or into the blood stream (sepsis). Some strains of E. coli are pathogenic, meaning they can cause disease in the small intestine and colon. These pathogenic strains of E. coli may cause diarrhea by producing and releasing toxins (called enterotoxigenic E. coli or ETEC) that cause the intestine to secrete fluid or by invading and inflaming the lining of the small intestine and the colon (called enteropathogenic E. coli or EPEC). A third strain of E. coli has a tendency to cause inflammation of the colon and bloody diarrhea (called enterohemorrhagic E. coli or EHEC).

What is E. coli 0157:H7?

E. coli 0157:H7 is a strain of EHEC. It produces a toxin called Shiga toxin that damages the intestines causing colitis and bloody diarrhea. E. coli 0157:H7 is a major health problem. It is estimated to cause infection in more than 70,000 patients a year in the United States. It has been reported to cause both large outbreaks as well as isolated sporadic infections in small numbers of individuals. This diarrheal illness was first recognized when the Centers for Disease Control (CDC) isolated E. coli 0157:H7 from patients in two separate outbreaks in Oregon and Michigan. The illness was associated with eating hamburgers at the restaurants of one national chain somewhat unfortunately called In-N-Out Burger. Since then, hemorrhagic colitis due to E. coli 0157:H7 has been commonly referred to as hamburger disease.

How does E. coli 0157:H7 make us sick?

The incubation period between exposure to EHEC bacteria and onset of symptoms is usually 3-4 days. Symptoms of EHEC infection include severe abdominal pain and tenderness, often associated with bloody diarrhea. Curiously, there often is little or no fever. The diarrhea typically lasts for 6-8 days. The most worrisome complication of EHEC infections is hemolytic-uremic syndrome (HUS) because it is a serious and potentially fatal illness. “Hemolytic” refers to the breakup of red blood cells which leads to anemia. Platelets are also destroyed which, in turn, promotes abnormal bleeding. “Uremic” refers to failure of the kidneys. In addition, seizures and coma may occur. Hemolytic-uremic syndrome most commonly affects children under the ages of 10 years and is the most common cause of acute renal failure in infants and young children. It occurs in 6%-9% of hemorrhagic colitis.
**How do people get E. coli 0157:H7?**

Infection is transmitted primarily by food and less commonly by direct contact or water (i.e., contaminated swimming water). Most commonly, E. coli 0157:H7 infection comes from eating raw or undercooked hamburger or from drinking raw (unpasteurized) milk. Products that have been found to be infected include ground beef, salami, raw milk, alfalfa sprouts and unpasteurized apple cider and apple juice. Cattle are an important reservoir, although contaminated pork, poultry and lamb also have been encountered.

**What are E. coli symptoms, and how is it diagnosed?**

Patients suspected of having E. coli 0157:H7 infection (for example, if they have bloody diarrhea, severe abdominal pain and tenderness but no fever), a stool specimen is tested for the presence of E. coli 0157:H7. Some hospitals test for E. coli 0157:H7 in all stool samples submitted to their laboratories while others only test for E. coli 0157:H7 in samples from patients with bloody diarrhea. Still others only test for E. coli 0157:H7 upon request by the doctors.

There are two methods of testing for E. coli 0157:H7 in stool samples; 1) growing the bacteria in culture dishes, or 2) testing for the Shiga toxin produced by the bacteria. Toxin detection methods are becoming more common, but it is important to confirm that presence of E. coli 0157:H7 in cultures of stool containing toxin. Blood tests such as complete blood count (CBC), and blood levels of electrolytes, blood urea nitrogen (BUN), and creatinine (blood tests that measure function of the kidney) are performed periodically to look for the development of hemolytic-uremic syndrome.

**What is the treatment for E. coli 0157:H7?**

Infection with E. coli 0157:H7 should be treated by a physician. Antibiotics are not useful for the acute diarrheal illness. In fact, some studies have shown that antibiotic use does not affect the duration of bloody diarrhea and may even increase the chances of developing hemolytic-uremic syndrome. Treatment includes replacing fluids and electrolytes to prevent dehydration. Hemolytic-uremic syndrome and thrombotic thrombocytopenic purpura (small blood clots found throughout the body) require complex supportive care in the hospital. Patients with kidney failure may need dialysis. Even after the acute phase the value of antimicrobial agents in treating Shiga toxin-producing E. coli infections is not clear. Using anti-diarrhea medicines like Immodium should also be avoided because they appear to prolong bloody diarrhea and increase the incidence of hemolytic uremic syndrome.
**Clostridium botulinum**

**What is clostridium botulinum?**

Clostridium botulinum is the name of a group of bacteria commonly found in soil. They are rod-shaped organisms that grow best in low oxygen conditions. The bacteria form spores which allow them to survive in a dormant state until exposed to conditions that can support their growth. There are seven types of botulinum toxin designated by the letters A through G; only types A, B, E and F cause illness in humans.

**What causes an infection?**

The bacterium Clostridium botulinum produces a nerve toxin that causes a rare but serious paralytic illness called botulism. Although rarely seen in the United States, botulism is one of the most feared diseases because of the incredible potency of the botulinum toxin. The toxin has frequently been identified as a potential weapon of bioterrorism because of its potency and means of ingestion by contaminated food or water. Methods to detect the bacterium and the toxin in the food supply are becoming a high priority to prevent both the natural form of the disease and the use of the toxin as a biological weapon.

There are three main kinds of botulism. Food borne botulism is caused by eating foods that contain the botulism toxin. Wound botulism is caused by toxin produced from a wound infected with Clostridium botulinum. Infant botulism is caused by consuming the spores of the botulinum bacteria, which then grow in the intestines and release toxin.

C. botulinum spores are normally found in soil or marine sediment and contaminate meats, vegetables, and fish. Because the spores are relatively heat resistant, they survive food processing and canning when the temperatures are insufficiently high. Under anaerobic conditions (without oxygen), such as found in canned foods, the spores germinate and release the potent toxins. In many cases the food has a normal appearance and taste. Even an experimental nibble of such food can contain enough toxin to cause lethal disease. All forms of botulism can be fatal and are considered medical emergencies. Foodborne botulism can be especially dangerous because many people can be poisoned by eating contaminated food.

**How common is botulism?**

In the United States, an average of 145 cases are reported each year. Of these, approximately 15% are foodborne, 65% are infant botulism, and 20% are wound. Adult intestinal colonization and iatrogenic botulism also occur, but rarely. Outbreaks of foodborne botulism involving two or more persons occur most years and usually caused by eating contaminated home-canned foods. The number of cases of foodborne and infant botulism has changed little in recent years, but wound botulism has increased because of the use of black-tar heroin, especially in California.
**LESSON MATERIALS**

**What are the symptoms of clostridium botulinum infection?**

The symptoms of botulism include double vision, blurred vision, drooping eyelids, slurred speech, difficulty swallowing, dry mouth, and muscle weakness. Infants with botulism appear lethargic, feed poorly, are constipated, and have a weak cry and poor muscle tone. These are all symptoms of the muscle paralysis caused by the bacterial toxin. If untreated, these symptoms may progress to cause paralysis of the arms, legs, trunk and respiratory muscles. In food-borne botulism, symptoms generally begin 18 to 36 hours after eating a contaminated food, but they can occur as early as 6 hours or as late as 10 days.

The botulinum toxin causes these effects because it is a neurotoxin that prevents the release of the neurotransmitter acetylcholine, thereby interfering with neurotransmission at the muscles.

**How can botulism be treated?**

The respiratory failure and paralysis that occur with severe botulism may require a patient to be on a breathing machine (ventilator) for weeks, plus intensive medical and nursing care. After several weeks, the paralysis slowly improves. If diagnosed early, food borne and wound botulism can be treated with an antitoxin which blocks the action of toxin circulating in the blood. This can prevent patients from worsening, but recovery still takes many weeks. Physicians may try to remove contaminated food still in the gut by inducing vomiting or by using enemas. Wounds are treated, usually surgically, to remove the source of the toxin-producing bacteria followed by administration of appropriate antibiotics. Good supportive care in a hospital is the mainstay of therapy for all forms of botulism. A human-derived antitoxin is used to treat cases of infant botulism and is available from the California Department of Public Health.

**Are there complications from botulism?**

Botulism can result in death due to respiratory failure. However, in the past 50 years the proportion of patients with botulism who die has fallen from about 50% to 3-5%. A patient with severe botulism may require a breathing machine as well as intensive medical and nursing care for several months. Patients who survive an episode of botulism poisoning may have fatigue and shortness of breath for years and long-term therapy may be needed to aid recovery.
Neisseria Meningitidis

What is neisseria meningitidis?

N. meningitidis Is a Gram-negative diplococcus that can colonize mucous membranes, such as in the nose, without causing symptoms. (It is estimated that in endemic areas, 5 to 10% of the population are meningococcal carriers.) While isolated cases, case clusters, or large epidemics of meningococcal disease can occur, the more usual outcome of exposure to the meningococcus is colonization of the nose (nasopharynx) with no local symptoms or systemic consequences although it can cause purulent (pus-forming) infections. In contrast, Meningococcal infection of the bloodstream is a systemic and life-threatening disease and Neisseria meningitidis is one of the leading causes of bacterial meningitis. In the United States, bacterial meningitis is relatively rare and usually occurs in isolated cases. Clusters of more than a few cases are uncommon.

In parts of Africa, widespread epidemics of meningococcal meningitis occur regularly. In 1996, the biggest wave of meningococcal meningitis outbreaks ever recorded hit West Africa. An estimated 250,000 cases and 25,000 deaths in Niger, Nigeria, Burkina Faso, Chad, Mali, and other countries paralyzed medical care systems and exhausted vaccine supplies.

What causes an infection?

The bacteria are spread by direct close contact with the discharges from the nose or throat of an infected person. Fortunately, none of the bacteria that cause meningitis are very contagious, and they are not spread by casual contact or by simply breathing the air where a person with meningitis has been. The cascade of events leading to disease are attachment of the bacteria to the cells of the mucous membrane which results in death of the ciliated cells that normally sweep bacteria out of the nose. If meningococci enter into the bloodstream they can cause devastating systemic disease marked by many small blood clots in the skin, meningitis, shock, and death. These signs are the direct result of the ability of the meningococcus to survive and multiply in the bloodstream. Meningococci multiply rapidly, reaching levels in the blood that are among the highest known for any bacterium. Then when they die they produce an endotoxin, which causes the pathogenic effects. Meningococci also make a capsule, which allows it to evade recognition by the immune system and plays an important role in its pathogenicity. Patients susceptible to meningococcal meningitis often have immune systems that cannot recognize the capsule as being a foreign invader. If they are not killed by phagocyte cells of the immune system in the bloodstream, meningococci multiply rapidly.

What are the symptoms of neisseria meningitidis infection?

Anyone can get bacterial meningitis, but it is most common in infants and children. In persons over age 2, common symptoms are high fever, headache, and stiff neck.
These symptoms can develop over several hours, or they may take 1 to 2 days. Other symptoms can include nausea, vomiting, sensitivity to light, confusion, and sleepiness. In advanced disease, bruises develop under the skin and spread quickly. In newborns and infants, the typical symptoms of fever, headache, and neck stiffness may be hard to detect. Other signs in babies might be inactivity, irritability, vomiting, and poor feeding. People who have had close or prolonged contact with a patient with meningitis caused by Neisseria meningitidis can also be at increased risk. This includes people in the same household or day-care center, or anyone with direct contact with discharges from a meningitis patient’s mouth or nose. As the disease progresses, patients of any age can have seizures.

**What complications can result from bacterial meningitis?**

Advanced bacterial meningitis can lead to brain damage, coma, and death. Survivors can suffer long-term complications, including hearing loss, mental retardation and paralysis.

**How is bacterial meningitis diagnosed?**

The diagnosis is usually made by growing bacteria from a sample of spinal fluid. The spinal fluid is obtained by a spinal tap. A doctor inserts a needle into the lower back and removes some fluid from the spinal canal. Identification of the type of bacteria responsible for the meningitis is important for the selection of correct antibiotic treatment.

**How is an infection treated?**

There are vaccines against some strains of Neisseria meningitides. The vaccines are safe and highly effective in older children, but not in children under age 2 years. Routine vaccination of all persons 11-18 years of age with 1 dose of meningococcal conjugate vaccine is recommended at the earliest opportunity. Pre-teens who are 11-12 years old should be routinely vaccinated at the 11-12 year old check-up. Also, since the occurrence of meningococcal disease increases during adolescence, health-care providers should vaccinate previously unvaccinated pre-teens and teens 11-18 years of age with meningococcal conjugate vaccine at the earliest possible health-care visit.

College freshmen living in dormitories are at increased risk for meningococcal disease and should be vaccinated with meningococcal conjugate vaccine before college entry if they have not previously been vaccinated. The risk for meningococcal disease among nonfreshmen college students is similar to that for the general population of similar age (age 18-24 years). However, since the vaccines are safe and produce immunity, they can be provided to nonfreshmen college students who want to reduce their risk for meningococcal disease.
**Lesson Materials**

*Clostridium tetani*

What is *Clostridium tetani*?

*Clostridium tetani* is the name of a group of bacteria commonly found in the gastrointestinal tract of humans and animals and in soil. These rod-shaped organisms grow best in the absence of oxygen. It is gram positive and has a flagellum. As the bacteria mature they develop a spore, which allows them to survive in a dormant state until exposed to conditions that can support their growth. *C. tetani* spores are extremely hardy as they are resistant to heat and most antibiotics. The spores are found in manure-treated soils and can also be found on human skin and in contaminated heroin.

Tetanus, which is caused by *C. tetani*, is a tragic disease, not only because of its severity but also because it can be completely prevented by appropriate immunization. Experience with tetanus in the two world wars of the past century demonstrated beyond doubt the benefits of the tetanus vaccine. Universal immunization of the American forces in World War II virtually eliminated the disease as a complication of traumatic injuries in soldiers. In developing countries where immunization is not widely practiced, tetanus remains a serious public health problem.

What causes an infection?

Most cases of tetanus are associated with a traumatic wound. Neonatal tetanus results from contamination of the umbilical cord at the time of delivery, either through unsanitary procedures or local customs of wrapping the cord in dung or mud. The spores of *Clostridium tetani* enter the damaged tissue and then transform into the rod-shaped bacteria which produce an exotoxin (also known as tetanus toxin). This toxin is inactive inside the bacteria, but when the bacteria dies, it is released and taken up by nerves. The toxin blocks neurotransmission producing the symptoms of the disease.

What are the symptoms of *Clostridium tetani* infection?

Tetanus, also called lockjaw, is a medical condition characterized by a prolonged spasm of skeletal muscle fibers in the jaw (thus the name “lockjaw”) and elsewhere in the body. Mortality rates reported vary from 40% to 78%. In recent years, approximately 11% of reported tetanus cases have been fatal. The highest mortality rates are in unvaccinated people and people over 60 years of age.

The incubation period of tetanus may be up to several months but is usually about 8 days. In general, the further the injury site is from the central nervous system, the longer the incubation period. The shorter the incubation period, the more severe the symptoms. In neonatal tetanus, symptoms usually appear from 4 to 14 days after birth, averaging about 7 days.

*Fig 4.2.9: Typical arched back paralysis is a symptom of tetanus*
Generalized tetanus is the most common type of tetanus, representing about 80% of cases. The first sign is lockjaw, and the facial spasms followed by stiffness of the neck, difficulty in swallowing, and rigidity of chest and calf muscles. Other symptoms include elevated temperature, sweating, elevated blood pressure, and episodic rapid heart rate. Spasms may occur frequently and last for several minutes with the body shaped into a characteristic form called opisthotonos. Spasms continue for up to 4 weeks. Death usually results from respiratory failure caused by paralysis of chest muscles. Complete recovery may take months.

How can tetanus be treated?
The treatment of tetanus mainly tries to prevent complications. Although anti-toxin should be given at the earliest possible moment, but it is often futile because any toxin that has been produced is already fixed to the nerve cells. Antibiotic treatment is directed to kill the bacteria in the wound. In addition, the involved wound should be cleaned surgically.

Prevention of tetanus is achieved through immunization. Active immunization should be carried out in all infants and children and in pregnant women who have not been previously immunized. The vaccine consists of inactivated tetanus toxin that cannot cause tissue damage, but that still activates the immune system. It is the T of the DPT vaccine given to infants and children.
**Bacterial Infections Jigsaw**

*Directions:* Complete the chart below during small group discussions with your peers. Use the back of the sheet if you need additional space.

<table>
<thead>
<tr>
<th>Name of the bacteria</th>
<th>Disease the bacteria will cause</th>
<th>Symptoms of the disease</th>
<th>Does the bacteria produce an endotoxin or exotoxin or both?</th>
<th>What does the bacteria do to surrounding tissue?</th>
<th>Other important facts</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>MRSA</td>
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<tr>
<td><em>E- Coli 0157-H7</em></td>
<td>Gastroenteritis</td>
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<tr>
<td><em>Clostridium botulinum</em></td>
<td>Botulism</td>
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<tr>
<td><em>Neisseria meningitidis</em></td>
<td>Bacterial meningitis</td>
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<tr>
<td><em>Clostridium tetani</em></td>
<td>Tetanus</td>
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</tbody>
</table>