**Bacterial Diseases and Their Impact on Public Health**

**Introduction**

There are some pretty big things in this world. The largest animal to have ever lived on earth was the blue whale, whose length expanded 100 feet long and weighed between 200,000 to 300,000 pounds. It’s hard to imagine something so big living anywhere on earth. It’s just as hard to imagine the smallest living creature on Earth. The smallest living organisms are so small, they can’t be seen with the naked eye! A microscope would be needed in order to see it. They are called microorganisms and they include bacteria, viruses, algae, protozoa, and fungi. Although these microorganisms are tiny, they play a huge role in life for other organisms, like humans. This chapter will discuss the impact bacteria has on the human body and the various diseases it can cause.

In order to understand pathogenic (disease causing) bacteria, it is important to understand what bacteria are first. Bacteria are single celled microorganisms that have no nucleus (which means they’re prokaryotic) and are considered living organisms because they undergo metabolism, grow, reproduce, maintain homeostasis, and respond to environmental changes! As mentioned before, bacteria are tiny, usually between .2 micrometers to 10 micrometers. To put it into perspective, the average width of a spider web strand is between 4 to 5 micrometers. Bacteria are found nearly everywhere on Earth, you just can’t see them! They’re found in soil, water, plants, hot springs, animals, even in and on the human body!

Some of the world’s most deadly diseases and viruses come from microorganisms. The world’s smallest living creatures are able to produce the world’s most deadly diseases. Of these, we will examine in this chapter: Tuberculosis, Anthrax, the Plague, Cholera, and Pertussis.

**Tuberculosis**

Tuberculosis is a widely infectious respiratory disease caused by the bacteria *Mycobacterium tuberculosis.* This bacteria was discovered by Dr. Robert Koch in 1882, but has been found in the spines of thousands year old Egyptian mummies, meaning the tuberculosis disease has been around for thousands of years. *Mycobacterium tuberculosis* is known to be found only in humans and not in any other species or environment. Tuberculosis is highly infectious, and every year there are nearly 9 million new cases in the world, and of those are 2 million recorded deaths. For example, in 2014 there were 9.6 million sick with Tuberculosis, causing 1.5 million deaths. This means that every second, someone new is infected with Tuberculosis somewhere in the world.

A huge reason of why it’s so infectious is that the bacteria spread through air droplets, which means it can be caught by breathing the same air as someone who is infected with the disease. When someone spits, coughs, talks, or somehow projects saliva into the air, the bacteria can infect anyone near an infected person. When you breathe in air containing droplets (aerosols) of the bacteria, the bacteria is able to travel to your lungs, where it can colonize. Once colonization occurs, the disease develops after the body’s immune system cannot stop *Mycobacterium tuberculosis* from growing and spreading.

Tuberculosis is epidemic in poverty stricken areas and with poor medical care. It is also the number one killer of patients suffering from HIV/AIDS (Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome). This is due to the fact that Tuberculosis causes infection more commonly in people with lowered immune systems who cannot fight off infections.

Treatment for Tuberculosis is long, as patients would have to take antibiotics for 6 to 12 months to fight off the infection. This long antibiotic regiment is to prevent the bacteria from producing drug resistant strains, as antibiotic resistance is already becoming a problem for *Mycobacterium tuberculosis.* This is because the tuberculosis bacteria is able to evolve when antibiotics are not taken thoroughly and regularly, and the person is still infectious with a now new resistant strain of bacteria. Drug resistance is a growing problem with Tuberculosis. When the bacteria mutates to become resistant to multiple drugs, it becomes difficult and sometimes impossible to treat, showing a growing threat to populations at risk for being infected with Tuberculosis. The disease is carefully monitored with cases reported and promptly treated to ensure that epidemics don’t happen on a wide scale in developed countries.

**Anthrax**

Shortly after the September 11, 2001 attacks, multiple letters were found in the mail laced with anthrax, killing 5 people and injuring 17 others. This has been one of the largest bioterrorism (the using of biotic elements like chemicals, viruses, and bacteria with the intention to infect and kill) attacks in America. Since then, anthrax has been regarded as a threat to the public and Western governments, pressuring them to think about the possibility of a bioterrorism attack and how to prevent it.

The bacteria itself, *Bacillus anthracis*, is not contagious. Infections occur when the bacteria itself (or bacterial spores) are ingested, inhaled, entered through an open wound, or injected by a person. That person cannot spread their infection to other people unless bacterial spores itself reach other people. Each type of infection incurs its own set of symptoms, including: for cutaneous (skin infected) anthrax groups of blisters or sores can form; for gastrointestinal anthrax poisoning (ingestion) anthrax one might experience fever and chills, a swollen neck, pain in abdomen, headache, and diarrhea; for injection anthrax one might experience fever and chills, blisters at the injection site, swelling and redness around the injection site, and black sores; for inhalation anthrax poisoning one might experience fever, chest pain, sweating, lethargy, stomach pain and body aches. 95% of human cases are caused by cutaneous infection, but only have a 20% mortality rate if left untreated. Gastrointestinal anthrax poisoning and inhalation anthrax poisoning both have mortality rates of 100% if left untreated. Prompt medical care is required in order to save those infected. For those infected, antibiotics are used to kill the bacteria, and the use of antitoxins may be necessary to disable the toxin *Bacillus anthracis* releases in the body.

This disease is not only found in developed countries, but also in farming communities. The disease causing spores can also live in the soil for years, and can infect herbivores who graze. *Bacillus anthracis* is found in cows, sheep, and goats (among other animals). This poses a threat to communities that handle these animals directly and may contract the disease. Anthrax poisoning is more commonly found in areas where there is less vaccination for these animals and occur when someone ingests infected animals or infected animal products. Vaccination of animals helps lower the probability of getting the infection for farming communities. Anthrax poisoning is usually not a problem for developed countries, but still exists outside of being a bioterrorism agent.

**The Plague**

The Plague also has major foundations in history. The Plague, caused by bacteria *Yersinia pestis*, killed up to two-thirds of Europe’s population (around 50 million deaths) between 1346 and 1353. Since then, small cases arise every now and then in the United States, however currently there are antibiotics and treatments for the plague to keep it under control.

At the time when the Black Death occurred in the 14th century, civilization did not understand the disease or how to treat it. There were no antibiotics available, and the disease was highly infectious. *Yersinia pestis* is naturally found in animals like rodents, and are carried by fleas to infect human hosts. This is when infection occurs in humans and sickness develops. Once a human develops the disease, they can spread it to others through inhalation of aerosols, similar to how Tuberculosis is spread. There are two types of disease caused by *Yersinia pestis*, the bubonic plague and pneumonic plague. Both are highly infectious and have a high mortality rate. Bubonic plagues occurs after a flea bite with a high fever and a bubo (swollen lymph node) present. The bubos are often dark colored or black, therefore giving the disease the name “The Black Death”. In addition to the fever and bubos, the bacteria spreads rapidly throughout the body and eventually is able to enter the bloodstream. At this point, a person develops bacteremia (presence of bacteria in the blood), and can cause septic shock where the body experiences a full inflammatory response and vital organs shut down. Without proper medical treatment, bubonic plague has a 75% mortality rate.

When a person develops plague through inhalation of aerosols, the bacteria enters the respiratory system and the disease is called pneumonic plague. Those infected with pneumonic plague can experience symptoms of fever and respiratory issues within one day of contracting the disease. According to the Centers for Disease Control, infected persons with pneumonic plague may experience shortness of breath, chest pain, and ultimately suffer from respiratory failure and shock. This form of plague is highly contagious from person to person, with a mortality rate of nearly 90% in untreated cases of pneumonic plague. There hasn’t been a case on pneumonic plague occurring in the United States since 1924, but the disease poses as a risk still for developing countries without adequate medical care. It’s important to note that because animals like squirrels, mice, rabbits, and others carry *Yersinia pestis*, it’s important to take precautions when dealing with these animals. This includes keeping the rodent population in check and reduced, wearing gloves when working with these animals and skinning them and preparing them for consumption, using repellents against fleas or animals, keeping household pets flea free, and not coming into contact with wild animals.

The plague can be treated with several antibiotics such as streptomycin, tetracyclines, chloramphenicol, or trimethoprim-sulfamethoxazole. These medicines are available now, but centuries ago when the Plague wiped out 50 million Europeans, they had no protection or defense for the disease.

**Cholera**

Cholera is a diarrheal disease that can kill within hours without proper medical treatment from fluid loss and has been known to cause millions of cases every year. This disease is caused by the bacteria *Vibrio cholerae* and is primarily found in water. When someone gets infected with *Vibrio cholerae*, watery diarrhea occurs rapidly along with vomiting, causing massive dehydration in those infected. Fluid replacement is vital in treatment to keep the body from becoming dehydrated as up to 1 liter of water can be depleted from the body in an hour due to the disease. If left untreated, an infected person can experience muscle cramps, electrolyte loss causing acidosis in the body, cardiac arrhythmia and kidney failure. Cholera has a 60% mortality rate for those untreated, but that is lowered to less than 1% of patients who receive prompt medical care. Patients who have Cholera receive oral rehydration salts to fight dehydration and antibiotics in order to kill *V. cholerae* in the body and to reduce diarrhea.

 It is estimated by the World Health Organization that there are between 1.4 million and 4.3 million cases of Cholera per year, causing between 28,000 to 142,000 deaths worldwide.

*Vibrio cholerae* can be found in water and typically found where water sanitation is very low. Epidemics occur in communities near these bodies of water in slums where infrastructure is highly poor. *Vibrio cholerae* is thought to have originated from the Ganges delta in India, where it spread across the world in the 19th century. Cholera is generally not a disease that affects developed countries with adequate water treatment and a high level of sanitation. In order to prevent infection and spread of this disease economic intervention is necessary, where water sources must be properly sanitized and cleaned before it is used by humans. This can be done by using water from treatment facilities or by using water filters in the home. Additionally, there are vaccinations available to prevent Cholera infections that have been widely administered.

**Pertussis**

Chances are if you’ve ever been to a pediatrician or the nurse’s office within the last couple of years, you’ve seen posters and pamphlets warning against Pertussis, or Whooping Cough. Whooping Cough is a respiratory disease that primarily affects small children and was a major cause of child mortality throughout the 20th century. This disease is caused by the bacteria *Bordatella pertussis* and is highly contagious and can be contracted by inhaling aerosols containing the bacteria. The upper respiratory system is lined with ciliated cells that allow the movement of mucous and dirt for removal to keep the airways clean, but when *Bordatella pertussis* enters the body through, it damages these ciliated cells. This causes the body to show symptoms of Whooping Cough in three stages after 7 to 10 days: the catarrhal stage, the paroxysmal stage, and the convalescent stage. During the catarrhal stage, one would have a fever, a general feeling of sickness, symptoms that could resemble the common cold. During this stage those infected are highly contagious and could spread the infection through aerosols. During the paroxysmal stage, the ciliated epithelial cells become damaged, allowing the buildup of mucous in the respiratory tract. This causes the typical whooping cough (called paroxysms) with those infected experiencing painful and annoying coughing. The third stage of Whooping Cough is the convalescent stage, where paroxysms are less frequent, but more serious illnesses arise like pneumonia, seizures, and brain damage can occur.

Pertussis can be treated with antibiotics when caught early. Early treatment may cause the coughing to be less serious, thus preventing the spread of the disease. Vaccinations for pertussis are widely available and it is highly recommended that children are vaccinated in order to prevent infection and the spread of the disease. The vaccination used for pertussis is called dTAP which also protects against diphtheria and tetanus. Even though this disease can be easily controlled through vaccinations and monitoring of the disease, cases have been increasing in the United States, which researchers cannot explain (according to the Centers for Disease Control). It is just highly suggested to stay on top of vaccinations in order to prevent disease.

**Summary**

In this chapter we explored various diseases that have had a huge impact on public health in history. We just covered five of several infectious diseases, but they all were caused by microorganisms called bacteria. Even though bacteria are tiny, they have a huge impact on human health, economics, and government issues. These bacteria come from a variety of environments around the world, and we’re still learning about them every day. From developing vaccines and antibiotics, studying infectious diseases and bacteria help us gain a better understanding of ourselves and the environments around us.

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