

Tuberculosis

Tuberculosis (TB), a leading global health issue, is a contagious disease caused by *Mycobacterium tuberculosis*, primarily affecting the lungs. Here we will introduce the story of TB and discuss some facts like treatment and stages about it.

Tuberculosis Introduction & History

Tuberculosis otherwise abbreviated as “TB” is a contagious bacterial infection that compromises various parts of an individual’s body. It primarily affects the lungs of individuals that are infected with tuberculosis but it could eventually proliferate and affect the nervous organs and kidneys if TB is not properly treated. The agent that is responsible for TB is a bacterium called *Mycobacterium tuberculosis* (MTB). Tuberculosis is considered the second-deadliest infectious disease in the world if it is not properly administered. The mortality rate of untreated TB is dangerously high as approximately 50% of patients that have suffered from TB died because it was not properly treated.

The history of Tuberculosis dates all the way back to about 20,000–15,000 years ago, it was spread along the various trade routes whether it was by humans or livestock that were being exchanged. In the 1600-1800s, TB has escalated to an epidemic with a mortality rate as high as 900 deaths per 100,000 inhabitants a year. It was known as “the white plague” in the 1700s which derived from the paleness patients experienced when infected with TB. In former eras, they did not have the proper treatment for TB. Instead, doctors just advised their patients to eat and rest well. It was known as the sanatorium cure, which involved isolating patients in institutions where they could rest, eat well, and exercise but no actual medications were administered at that point. That's until 1943 when things took a dramatic turn, Selman

Waksman, Elizabeth Bugie, and Albert Schatz developed streptomycin which is an antibiotic that fights off moderate to severe TB. Later in 1952 an antibiotic was discovered that has proven to be inexpensive, safe, and more accessible to treat TB, it was called Isoniazid. Thankfully the cases of TB had declined since then, with the help of various treatments and medications that were discovered. But, in 2023, the case of TB has reemerged due to the COVID-19 pandemic which has disrupted the TB control effort.

Symptoms/Stages of Tuberculosis

TB symptoms vary depending on whether the infection is latent or active. Latent TB infection (LTBI) is asymptomatic and non-contagious, meaning that individuals do not have any symptoms and cannot spread the infection. However, they may still have *Mycobacterium tuberculosis* in their currently inactive bodies but may become active later, especially if their immune system is weakened (Canada.ca, Mayo Clinic). When TB is active, it presents a range of symptoms: A persistent cough for more than three weeks that may contain blood or sputum. Chest pain and difficulty breathing. Systemic symptoms include fever, night sweats, fatigue, weight loss, and loss of appetite. These symptoms can make active TB highly contagious and require immediate treatment (Canada.ca, Mayo Clinic).

TB progresses through several stages. Initially, an individual may be exposed to *Mycobacterium tuberculosis* without showing signs of infection, meaning they are not yet infected and cannot spread the disease (World Health Organization [WHO]). Following exposure, the bacteria may remain inactive in the body, leading to LTBI. Those with LTBI do not have symptoms and are not contagious, though if the immune system is weakened, it may progress to

active TB. In active TB, the bacteria multiply and cause symptoms, including persistent cough, chest pain, fever, and fatigue. This stage is highly contagious. Drug-resistant TB occurs when the bacteria resist treatment, necessitating more complex antibiotics (Canada.ca, Mayo Clinic, WHO).

Stages of Infection

There are four stages in a full cycle of infection of tuberculosis, including exposure, immunological equilibrium, reactivation and transmission. In stage one, which is primary or secondary infection, is when an individual gets exposed to tuberculosis bacteria (the thing that causes this disease). The protein called pattern-recognition receptor is responsible for sensing the infection, or presence of pathogens(things that cause infection and diseases). During this time, the human body will respond to the infection with an increasing number of phagocytic cells, which are basically a type of white blood cell that fight against diseases. Progressing into the second phase, which is immunological equilibrium, also commonly known as latency, tuberculosis bacteria remain silent and inactive in the host, and may not show severe symptoms. However, this does not mean the infection is cured, tuberculosis bacteria keeps reproducing during this stage at a slow pace. During the third stage, tuberculosis bacteria become active and overcome the immune system. At this time, infected individuals show symptoms and are able to spread tuberculosis to other people. At the final stage, which is transmission, tuberculosis is able to be transmitted to new hosts.

Spread/Precaution of Tuberculosis

Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, is spread primarily through the air when an infected person coughs, sneezes, or talks. Tiny droplets containing the bacteria are released as they spread. According to the Centers for Disease Control and Prevention (CDC), not all people exposed to TB develop the disease; many carry the bacteria in a latent form that is not contagious but can become active when the immune system is weakened. TB germs are more likely to spread indoors or in other places with poor air circulation (such as a close vehicle) than outdoors. TB germs aren't spread by shaking hands, sharing food or drink, touching bedding or toilet seats, sharing toothbrushes, or kissing.

Prevention strategies focus heavily on early detection and treatment, as untreated active TB is highly contagious and causes death. According to the Wisconsin Department of Health Services (WDHS), common TB precautions include providing tissues, surgical masks, hand hygiene products, and waste receptacles in common areas such as waiting rooms so that people with respiratory symptoms then can be isolated. In addition, infection control measures such as proper ventilation and the use of personal protective equipment (PPE) in healthcare settings are essential in high-risk environments. Vaccination with the Bacillus Calmette-Guerin (BCG) vaccine also provides protection, especially in children, although its effectiveness varies depending on where you are (WHO, 2023).

Tuberculosis Vaccines

Vaccines are representative of one of immunology's greatest achievements, at the same time the invention of highly effective vaccines that can offer lifelong protection against tuberculosis (TB) continues to challenge scientists. Immunization treatment against illness typically aims to prevent infections or diseases, but development of therapeutic vaccination

offers a novel approach by targeting already-established diseases to shorten treatment durations, or in the case of tuberculosis (TB), prevent relapse.

Currently, therapeutic TB vaccine candidates in medical development fall into several categories: killed whole-cell/fragmented vaccines, live attenuated vaccines, adjuvanted protein subunit vaccines, and viral vectored vaccines. Under the category of live attenuated vaccines, The Mycobacterium Bovis Bacille Calmette-Guérin (BCG) vaccine, which was developed in 1921, is the only licensed vaccine against TB. After injection, the BCG vaccine stimulates the immune system to recognize and respond to Mycobacterium tuberculosis. When the BCG vaccine is administered, the body's immune system recognizes the antigens (proteins) from the weakened bacteria as foreign, therefore fighting against it. While it provides reliable protection against severe and extrapulmonary forms of pediatric TB, its efficacy is inconsistent and inadequate against pulmonary TB across all age groups. It only provides the most effective protection against severe forms of TB in children.

The development of a safer and more effective tuberculosis (TB) vaccine in the future remains a critical priority on the global research agenda as tuberculosis (TB) is present as the top killer among all infectious diseases worldwide. The World Health Organization (WHO) recommends therapeutic vaccines for all TB patients, irrespective of age, drug sensitivity, or comorbidities, emphasizing the potential for this approach to enhance TB management globally.

Treatment for Tuberculosis

Tuberculosis (TB) treatment varies depending on whether a person has inactive TB or active TB disease. The treatment for inactive TB focuses on preventing progression to active

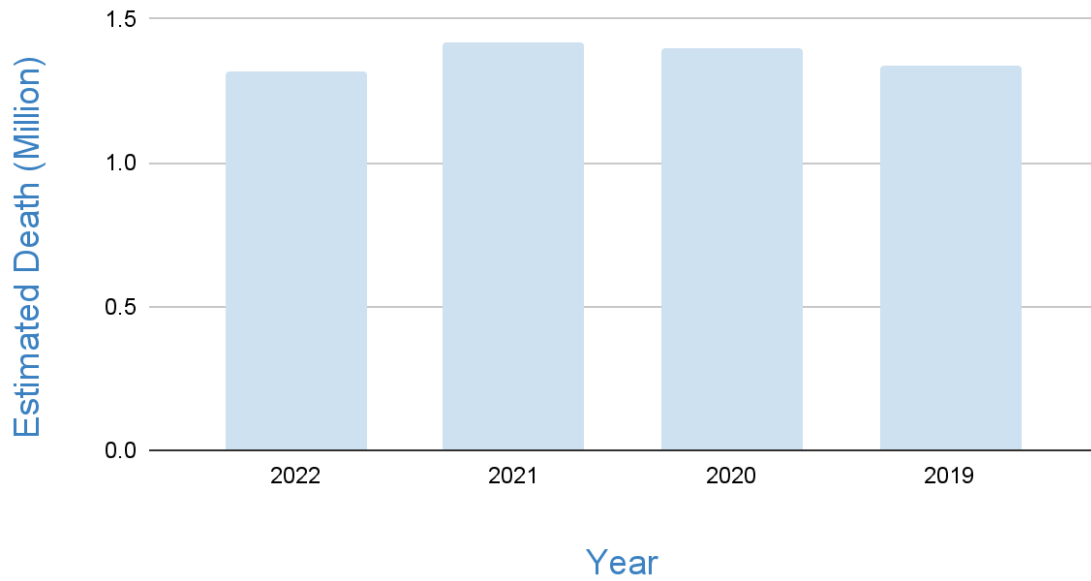
disease. Treatment typically lasts between three and nine months and involves a combination of medicines like isoniazid, rifampin, and rifapentine. For active TB disease, which is contagious and symptomatic, treatment is more intensive and can last four to nine months. It commonly includes a combination of medicines such as ethambutol, isoniazid, rifampin, rifapentine, pyrazinamide, and sometimes newer antibiotics like moxifloxacin. It's important to follow the prescribed treatment plan fully, as stopping early can lead to drug-resistant strains. Drug-resistant TB develops when bacteria that cause tuberculosis (TB) become resistant to the most potent TB medications. Multidrug-resistant TB (MDR TB), which doesn't respond to standard medications, requires a prolonged and more challenging treatment course, lasting 20 to 30 months, with higher risks of side effects. Some side effects that occur with the treatment include nausea, orange-colored body fluids, and in rare cases, liver damage or lightheadedness. Proper adherence to treatment is essential to ensure recovery, prevent relapse, and reduce the spread of TB to others.

Statistical Graph

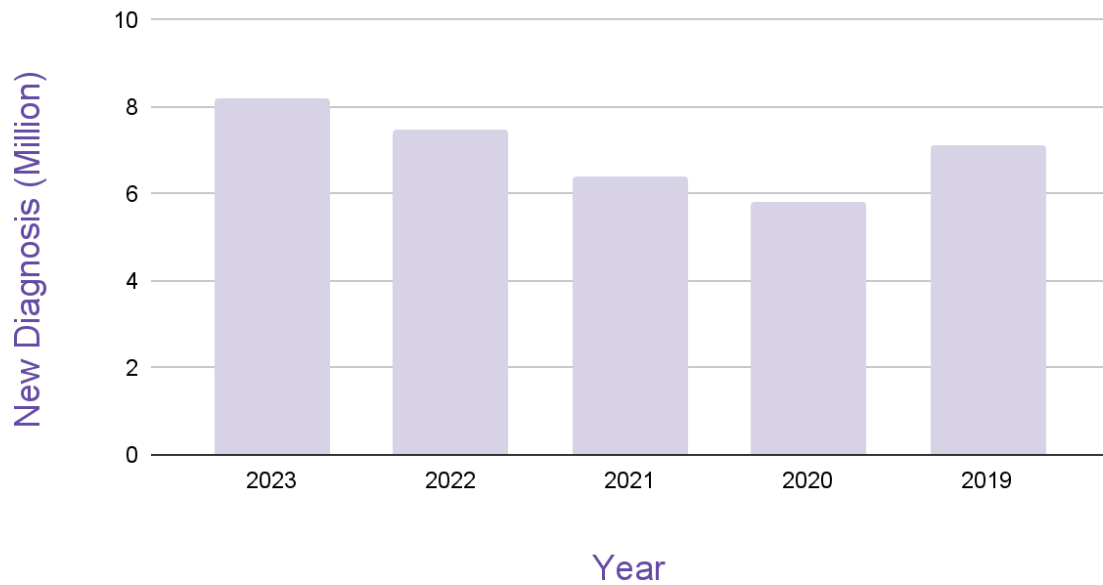
Tuberculosis Development (Gender)	New Tuberculosis Diagnose (Million)
Men 55%	8.2 million (2023)
Women 33%	7.5 million (2022)
Young/ Children 12%	6.4 million (2021)

Note: The data was obtained from World Health Organization Global Tuberculosis Report 2024

Tuberculosis Death Rate



Tuberculosis New Diagnosis



Global Impacts of Tuberculosis

Tuberculosis has been considered as a global leading infectious killer. Tuberculosis causes many deaths mainly within lower income communities and causes a decrease in antimicrobial resistance. As of 2023, there claimed to be 1.25 million cases of Tuberculosis that lead to death. Within these, there are 161,000 people with HIV which is mainly due to an decrease in antimicrobial resistance. In 2023, an estimated 10.8 million people fell ill with Tuberculosis worldwide, which includes 6.0 million men, 3.6 million women and 1.3 million children.

Reference

CDC.gov

[https://www.cdc.gov/tb/worldtbdays/history.htm#:~:text=TB%20in%20humans%20can%20be,China%20\(2%2C300%20years%20ago\).](https://www.cdc.gov/tb/worldtbdays/history.htm#:~:text=TB%20in%20humans%20can%20be,China%20(2%2C300%20years%20ago).)

News-medical.net

<https://www.news-medical.net/health/History-of-Tuberculosis.aspx>

National Institutes of Health (NIH)

<https://www.ncbi.nlm.nih.gov/books/NBK222466/>

Cleveland Clinic

<https://my.clevelandclinic.org/health/diseases/11301-tuberculosis>

Canada.ca. (n.d.). Tuberculosis. Government of Canada. Retrieved November 4. (2024)

<https://www.canada.ca/en/public-health/services/diseases/tuberculosis.html>

Mayo Clinic. (n.d.). Tuberculosis (TB). Retrieved November 4. (2024)

<https://www.mayoclinic.org/diseases-conditions/tuberculosis/symptoms-causes/syc-20351250>

Tuberculosis. Retrieved November 4. (2024)

https://www.who.int/health-topics/tuberculosis#tab=tab_2

Tuberculosis: causes and how it spreads. (2024, March 6). Tuberculosis (TB).

<https://www.cdc.gov/tb/causes/index.html>

Tuberculosis. (2024, May 1). Cleveland Clinic.

<https://my.clevelandclinic.org/health/diseases/11301-tuberculosis>

Wadsworth Mycobacteriology Laboratory. (2018). Tuberculosis (TB).

https://www.health.ny.gov/diseases/communicable/tuberculosis/docs/fact_sheet.pdf

Tuberculosis precautions. (2024, August 29). Wisconsin Department of Health Services.

<https://www.dhs.wisconsin.gov/tb/precautions.htm#:~:text=General%20TB%20precautions&text=Provide%20tissue%2C%20surgical%20masks%2C%20hand,can%20contain%20coughing%20and%20sneezing.>

World Health Organization: WHO & World Health Organization: WHO. (2024, October 29).

Tuberculosis. <https://www.who.int/news-room/fact-sheets/detail/tuberculosis>

Joel D. Ernst (2012) Nature Reviews Immunology 12

<https://www.nature.com/articles/nri3259#Fig1>

Centers for Disease Control and Prevention. (n.d.). Treating tuberculosis. Centers for Disease

Control and Prevention. <https://www.cdc.gov/tb/treatment/index.html>

<https://www.cdc.gov/tb/treatment/index.html>

Association, A. L. (n.d.). Diagnosing and treating tuberculosis. American Lung Association.

<https://www.lung.org/lung-health-diseases/lung-disease-lookup/tuberculosis/treating-and-managing>

World Health Organization. (n.d.). New treatment for TB. World Health Organization.

<https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2023/featured-topics/new-treatment-tb>

<https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2023/featured-topics/new-treatment-tb>

https://journals.asm.org/doi/10.1128/cmr.00100-19?url_ver=Z39.88-2003&rft_id=ori%3Arid%3Acrossref.org&rft_dat=cr_pub++0pubmed

<https://europepmc.org/article/MED/35812462#s1>

World Health Organization Global Tuberculosis Report 2024

<https://iris.who.int/bitstream/handle/10665/379339/9789240101531-eng.pdf?sequence=1>

World Health Organization Tuberculosis October 29, 2024

<https://www.who.int/news-room/fact-sheets/detail/tuberculosis>