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Risk Factors of Tuberculosis and Strategies for Prevention and Control

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ABSTRACT
Tuberculosis stands out as a priority due to its high mortality rate, drug-resistant strains, and impact on vulnerable populations. Therefore, addressing these diseases requires a multifaceted strategy encompassing prevention, early diagnosis, enhanced healthcare access, and ongoing research to develop effective treatments and vaccines. This study focused on the risk factors of tuberculosis. The study found that a range of risk factors can predispose individuals to tuberculosis (TB, primarily pulmonary TB). These factors encompass a weakened immune system resulting from conditions like HIV infection, malnutrition, or certain medications, as well as specific demographics like the very young and the elderly, who are more susceptible. Other risk factors may include substance abuse, tobacco smoking, and pre-existing medical conditions such as diabetes or chronic kidney disease. Furthermore, close contact with an active TB case is a common risk factor. These factors collectively heighten the likelihood of TB infection and can influence the severity of the disease. For instance, a compromised immune system can hinder the patient's ability to combat TB bacteria, leading to a more extensive and severe form of the disease. Moreover, smoking can damage the lungs, rendering them more vulnerable to TB infection and diminishing the effectiveness of treatment. Therefore, taking proactive measures to address and mitigate these risk factors is paramount in preventing and controlling tuberculosis.
Keywords: Tuberculosis, Life-Threatening diseases, Public Health,

1. INTRODUCTION

Life-threatening diseases are medical conditions with the capacity to inflict severe harm on human health, often resulting in mortality (Rylander et al., 2013). Life-threatening diseases includes a range of ailments (Figure 1). Tuberculosis, caused by *Mycobacterium tuberculosis*, affects both humans and animals. *Mycobacterium tuberculosis*, the bacterium responsible for tuberculosis (TB), primarily targets the respiratory system, with the lungs being its primary site of infection (Moule & Cirillo, 2020). TB can also manifest as extrapulmonary TB, affecting various other body parts. These include lymph nodes, bones, joints, the spine (Pott's Disease), the abdomen, the genitourinary system, meninges (causing tuberculous meningitis), the skin (cutaneous TB), the heart (cardiac TB), eyes (ocular TB), ears (otic TB), the gastrointestinal tract, and the adrenal glands (Hakim & Grossman, 1995; Anaghashree, 2019; Kumar et al., 2010). The pulmonary TB, affecting the lungs, is the most common form. Each form of TB results in unique symptoms and requires specialized treatment, making early diagnosis crucial for effective management.

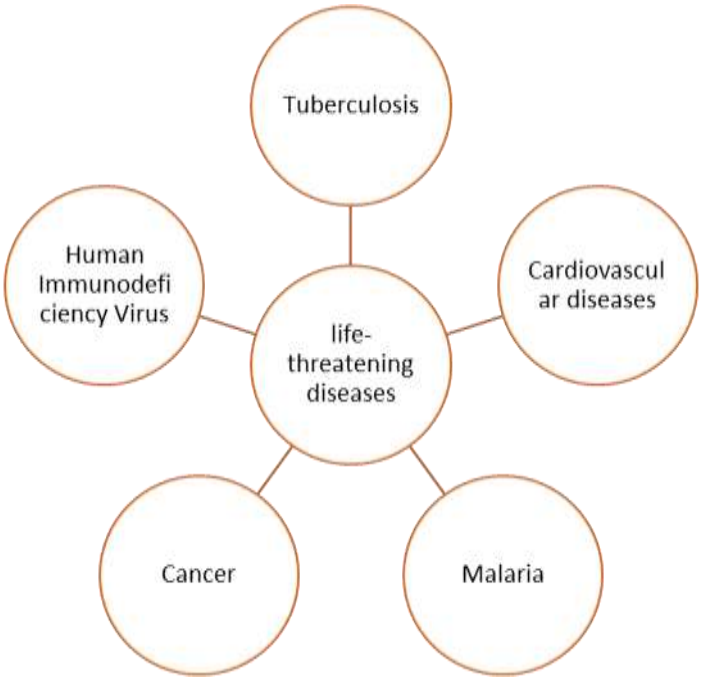

Figure 1: Some life-threatening diseases

Typically, Mycobacterium tuberculosis is a slow-growing, acid-fast bacterium with a unique cell wall structure that can make it challenging to culture and treat (Torrelles, 20212). The bacterium enters the body through inhaled respiratory droplets and is taken up by alveolar macrophages in the lungs (Bisen & Tiwari, 2007). These bacteria can evade the immune system and establish an infection within the macrophages. Over time, they can form granulomas, organized clusters of immune cells that help contain the infection. However, these granulomas can also a as reservoirs for the bacteria, allowing them to persist and potentially reactivate in the future, especially when the immune system is the host is already compromised (Monack et al., 2014).

In the case of inadequate treatment, TB can become a life-threatening condition, leading to fatality. Treatment typically involves a prolonged course of antibiotics to completely eradicate the bacteria and prevent the development of drug-resistant strains.

TB is a global disease that affects millions of people worldwide and stands as a leading cause of both illness and death (Chakaya et al., 2021). Despite significant efforts in its prevention and treatment, TB remains a significant health challenge, especially in regions with low to moderate income levels (Floyd et al., 2018).

Given the diverse range of risk factors that play a role in the transmission and progression of TB, it is essential to identify and address these factors to combat the disease effectively (Lönnroth et al., 2009). Therefore, this study focused on the risk factors that exacerbate the transmission of TB.

2. Tuberculosis: A Global Health Challenge with a Focus on Africa and Nigeria

Tuberculosis presents a formidable challenge to public health on a global scale. The World Health Organization (WHO) (2018) recognizes it as one of the top 10 leading causes of death worldwide. Moreover, tuberculosis stands as the foremost cause of death stemming from a single infectious agent, surpassing even HIV/AIDS in terms of its global impact (Price-Smith, 2001). In 2020, an estimated 1.5 million lives were claimed directly by tuberculosis, with 10 million individuals falling ill due to the disease (Chakaya et al., 2020; Tiberi et al., 2020). Countries with low to moderate incomes shoulder a substantial burden of the disease. The COVID-19 pandemic introduced an additional layer of complexity to tuberculosis management, leading to disruptions in healthcare services, diagnostic delays, and treatment suspensions (Coleman et al., 2022).

Africa bears a disproportionately significant share of the global burden of tuberculosis due to its high prevalence in the region (Coker et al., 2021). Numerous factors, such as a high prevalence of HIV, widespread poverty, inadequate nutrition, and overcrowded living conditions, contribute to the challenges in tuberculosis control in the region (Millet et al., 2013). In 2020, the WHO's African region reported approximately one-quarter of all diagnosed tuberculosis cases globally (Zumla et al., 2021). Furthermore, several African countries face a substantial threat resulting from drug-resistant tuberculosis strains.

Nigeria, as the most populous country in Africa, shoulders a significant portion of the tuberculosis burden in the region. Nigeria is ranked among the top 30 countries globally in terms of tuberculosis prevalence (Erah & Ojieabu, 2009). In 2020, over 200,000 new tuberculosis cases were reported in Nigeria, placing it among the countries in Africa with one of the highest TB incidence rates (Vukugah et al., 2022; Nachega et al., 2021; Williams et al., 2022).

On the overall, efforts to combat tuberculosis globally, across Africa, and particularly in Nigeria, involve strengthening healthcare systems, increasing funding for tuberculosis control, promoting early detection and treatment, and addressing socio-economic factors that contribute to the persistence of the disease. Collaboration among individuals, groups, and international entities at the local, national, and global levels is essential in the collective fight against tuberculosis. It is only through such concerted efforts that the battle against tuberculosis can be won.

3 Risk factors associated with TB.

Risk factor involves any specific characteristic, behavior, condition, or element that increases an individual's chances of contracting a particular illness or experiencing an adverse health outcome (Kaplan, 2002). These risk factors can be categorized into various groups, including genetics, lifestyle, environment, and pre-existing medical conditions, all of which can contribute to the development of a specific disease (Budreviciute et al., 2020; Zhou et al., 2021). In the fields of healthcare and public health, the identification and comprehension of risk factors are of paramount importance as they enable healthcare professionals to assess and mitigate the likelihood of disease onset, and to create tailored prevention and treatment plans. The common risk factors associated with TB are summarized in Figure 2.

Figure 2: Risk factors associated with TB

3.1 Socioeconomic Factors:

With regard to TB, socioeconomic factors refers to the relationship between the social and economic characteristics an individual or a community and their susceptibility to TB, as well as the repercussions of TB on their overall well-being (Hudelson et al., 1996). It involves how social and economic factors influence factors such as treatment adherence, access to healthcare, and the risk of contracting tuberculosis.

Poverty act as a significant risk factor for TB for various interconnected reasons. The relationship between poverty and TB is multifaceted, contributing to an elevated risk of TB infection and adverse outcomes among impoverished individuals (Tola et al., 2019). Some of the key mechanisms through which poverty amplifies the risk of tuberculosis are summarized n Figure 3:

Limited healthcare access is a critical link between tuberculosis TB and poverty. Poor persons often encounter obstacles in obtaining quality healthcare services, diagnostic tools, and treatment (De Cuevas, 2013). This results in delays in TB diagnosis and treatment, exacerbating the severity of the disease and its potential transmission to others.

Malnutrition is a common issue in impoverished regions. Poor dieting could have adverse effects on the immune system. This is because insufficient essential nutrients that contribute to the ability of the body to fight against TB infection, thereby increasing the risk of infection and the development of severe TB among vulnerable populations (Papathakis & Piwoz, 2008; Calder & Jackson, 2000).

Overcrowded and unsanitary living conditions, which are prevalent in impoverished areas like hamlets, villages etc, facilitate the transmission of TB. Factors such as shared living spaces (room), inadequate sanitation, and poor ventilation could facilitate the spread of TB from an infected person to those nearby (von Seidlein et al., 2021).

Limited education and awareness about TB are also associated with poverty. Many poor individuals may lack access to health education and information about TB symptoms and proper care-seeking practices (Bam et al., 2014). This lack of knowledge could lead to delayed diagnosis and treatment, thereby allowing TB to worsen and spread.

Inadequate healthcare infrastructure in low-income countries, driven by poverty, may hampers the ability to accurately diagnose, treat, and prevent TB (Lönnroth et al., 2014). Under-resourced and underfunded healthcare institutions, which are often understaffed and ill-equipped, further increase the risk to the disadvantaged population.

Social marginalization and stigmatization are everyday experiences for those living in poverty who receive a TB diagnosis (Khan, 2012). This discrimination and exclusion can deter individuals from following treatment plans and seeking proper medical care, resulting in worse outcomes and increased transmission rates.

Limited access to infection control measures is another consequence of poverty. Poor individuals may lack the resources to implement recommended preventive measures like mask-wearing and isolation, contributing to the spread of tuberculosis in impoverished areas (Zar et al., 2020).

Figure 3: Poverty related risk factors of TB

3.2 Health-Related Factors:

Several health-related risk factors significantly impact an individual's susceptibility to and severity of tuberculosis (TB), necessitating a thorough understanding for effective TB prevention and control. The health-related risk factors associated with TB are summarized in Figure 4

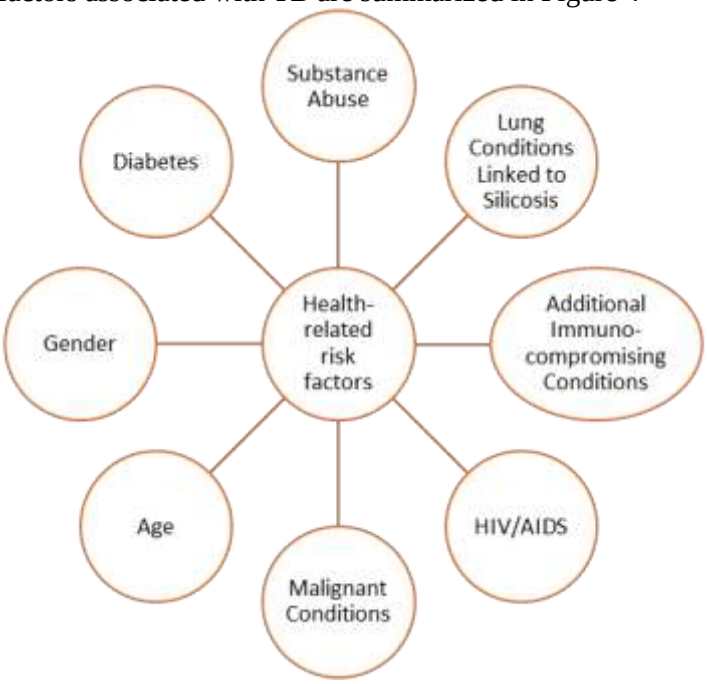

Figure 4: Health-related risk factors associated with TB

HIV infection has the ability to weaken the immune system, making individuals that have contacted the virus more vulnerable to TB. The co-occurrence of HIV and TB often accelerates the progression of both diseases, affecting the prognosis of active TB and increasing the risk of latent TB developing into an

active disease (Singer & Clair, 2003). Consequently, TB is more prevalent among people living with HIV/AIDS, particularly in areas with high prevalence of both diseases (Corbett et al., 2007).

Untreated diabetes mellitus could exacerbates the severity of TB and increases the risk of TB development (Wilkinson 2021). Elevated blood sugar levels may impede the ability of the immune system to combat TB bacteria, leading to a higher likelihood of developing active TB after exposure and potentially more severe forms of the disease.

Conditions like the use of immunosuppressive medications, organ transplants, and certain cancers further lower immunity, elevating the TB risk (Haanen et al., 2020). Immunosuppression can weaken the body defense mechanism against TB bacteria, thereby allowing the bacteria to multiply and cause active disease.

Smoking, excessive alcohol consumption, and illicit drug use can damage the lungs and decrease lung function, raising the risk of TB contraction. These behaviors do not only contribute to an unhealthy lifestyle with poor diet and limited healthcare seeking but also increase the susceptibility to TB.

Workplace hazards like exposure to silica dust can lead to lung diseases such as silicosis, which could increase the risk of TB development (Rees and Murrary, 2020; Hoy & Chambers, 2020; Rushton, 2007). Silicosis can damage the lungs and impairs the ability of the body to fight TB bacteria, heightening the risk of acquiring active TB (Rees and Murrary, 2020; Hoy & Chambers, 2020; Rushton, 2007).

Age is a significant health-related risk factor for TB. Although TB can affect persons of all ages, the elderly and young children are particularly vulnerable to it (Lalvani, 2007; Bates et al., 2004). Children have developing immune systems, making them more susceptible to TB, while older individuals may experience declining immunological function, thereby increasing their susceptibility to TB.

In most regions, men are more likely to contract TB than women (Dhatt & Pley, 2020; Lee et al., 2023). The reasons behind these gender-specific differences in TB risk may relate to exposure patterns and healthcare-seeking behavior, and understanding these distinctions is crucial for tailored interventions (Dhatt & Pley, 2020; Lee et al., 2023).

TB is more common among persons with specific cancers, particularly those affecting the head, neck, and lymphatic system. Cancer and its treatments, such as radiation therapy and chemotherapy, can compromise immune function, raising the risk of TB contraction (Boopathi, & Thangavel, 2021). Understanding these health-related risk factors is crucial for targeted TB prevention and control strategies.

3.3 Behavioural Factors

Behaviour plays a significant role in the onset and dissemination of TB, making it crucial to understand these behavioural factors for effective TB care and prevention (WHO, 2001). Table 1 summarise some of the significant behavioural factors associated with TB. Behavioural factors are essential in TB prevention and control. Non-compliance with TB therapy, delayed healthcare-seeking behavior, substance abuse, smoking, high-risk sexual behaviours, unsanitary living conditions, stigmatization, lower educational levels, and travel-related behaviours all impact TB. Non-compliance risks TB relapse and drug-resistant strains, while delayed care-seeking worsens TB and its transmission (Shasha, 2013). Substance abuse and smoking weaken immunity, increasing TB risk. High-risk sexual behaviours raise vulnerability to TB via HIV. Unsuitable living conditions facilitate TB transmission, while stigmatization deters care-seeking and treatment adherence (Nyasulu et al., 2016). Lower education and health literacy may lead to misconceptions and treatment discontinuation. Travel and migration challenges can contribute to the global TB spread.

Table 1: Behavioral factors associated with TB and their impacts

Behavioral Factor	Impact on TB
Non-compliance with Therapy	Risk of TB relapse and drug-resistant TB due to incomplete treatment
Delayed Healthcare-Seeking Behavior	Worsening of TB, increased transmission risk, and potential spread of disease
Drug and Alcohol Abuse	Heightened TB risk, unstable living conditions, malnutrition, and treatment challenges
Smoking	Weakened lung function, increased risk of active TB, and heightened risk from secondhand smoke
High-Risk Sexual Behaviors	Elevates TB risk through HIV infection and weakened immunity
Unsafe and Congested Living Conditions	Facilitates TB transmission, preventive measures is necessary
Stigmatization	Hinders to prevention and control, reluctance to seek care, and ongoing disease transmission
Educational Level and Health Literacy	Misconceptions, lack of knowledge, and early treatment discontinuation
Travel and Migration	Global TB spread due to challenges in adherence and healthcare access

3.4 Occupational and Environmental Factors

Environmental and occupational factors significantly contribute to TB development and transmission risk. These factors can lead to increased exposure to Mycobacterium tuberculosis, the bacteria responsible for TB, and, in some cases, a higher likelihood of infection and more severe disease manifestations (Narasimhan et al., 2013). These factors can be categorized into two are summarized in Figure 5.

Figure 5: Environmental and occupational factors significantly contribute to TB development and transmission risk

Occupational settings and healthcare facilities pose significant risks for TB transmission. Healthcare workers, especially those closely interacting with patients, face TB exposure through handling samples and equipment, increasing their susceptibility. Miners in coal and gold mining industries are at heightened TB risk due to silica dust exposure, potentially leading to silicosis and respiratory damage (Cohen & Velho, 2002). Overcrowded conditions in prisons contribute to TB transmission risks for both staff and inmates due to limited space and ventilation. Specific occupational environments with high TB prevalence, such as textile mills and homeless shelters, can also raise vulnerability to TB. Healthcare

facilities may serve as TB transmission hubs when patients with the disease interact with medical staff and other patients, exacerbated by inadequate infection control and delayed diagnosis, emphasizing the need for improved safety measures in these settings.

Several environmental factors significantly contribute to TB transmission and infection risk. Densely populated areas, such as refugee camps, may create conditions of overcrowding that facilitate the transmission of TB due to close contact among persons. Inadequate ventilation in public spaces, workplaces, and homes can promote the spread of TB, highlighting the importance of proper natural or mechanical ventilation to reduce airborne TB bacteria (Du et al., 2020). Indoor air pollution from burning wood or coal for cooking and heating can damage the respiratory system and weaken the immune function, increasing TB risk (Rosário Filho et al., 2021). Homeless individuals, lacking access to suitable housing and healthcare, are more susceptible to TB, with delayed diagnosis and treatment. Migration, displacement, and temporary housing can heighten TB risk, and refugee camps face challenges due to overcrowding and limited healthcare access (Dhavan et al., 2017). Environmental mycobacteria can lead to TB-like infections, complicating TB diagnosis in certain regions with higher concentrations of these mycobacteria and thereby impacting local TB cases.

3.5 Age and Gender

Age and gender significantly determine an individual's susceptibility to TB infection and disease conditions. Figure 6 highlights the role of gender and age in TB risk.

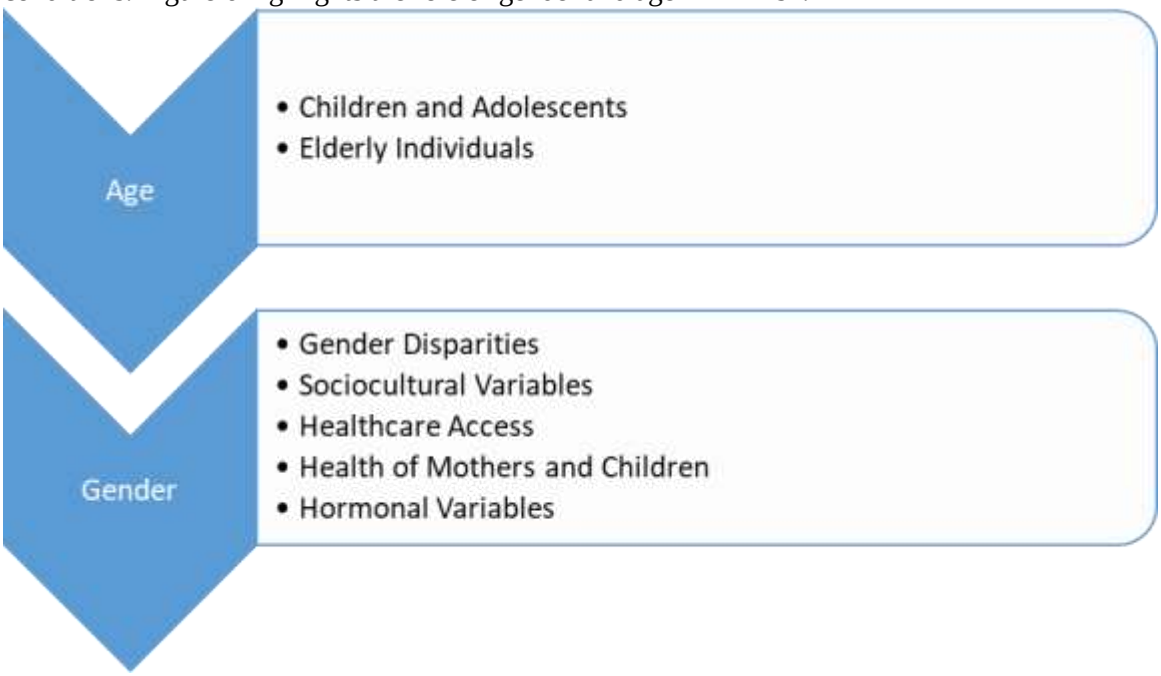

Figure 6: Gender and age as a risk factor for TB

TB presents significant risks to both children and adolescents, particularly in regions with high TB prevalence. Their developing immune systems render them more susceptible to TB infection, compounded by their lack of prior TB exposure, increasing vulnerability to primary infection and raising the likelihood of severe symptoms and post-infection consequences (Lalvani, 2007; Bates et al., 2004). Conversely, in elderly individuals, ageing weakens the immune system, heightening susceptibility to TB (Gavazzi et al., 2004). Age-related immune changes impair the ability of the body to combat TB, elevating the risk of developing active TB upon exposure. Additionally, older adults are at a higher risk of latent TB reactivation, further underscoring the importance of age as a TB risk factor.

Gender disparities play a significant role in TB incidence, healthcare access, and care-seeking behaviours, with men often experiencing higher TB rates in many regions, resulting in gender-based disparities in TB incidence. Sociocultural norms influence could these disparities, as limited mobility by women may reduce their exposure to TB cases outside the home. At the same time, social interactions and

employment may increase men risk to TB. Gender-related barriers can impact the ability of women to access healthcare, potentially leading to delays in TB diagnosis and treatment (Krishnan et al., 2014; Yang et al., 2014). Additionally, gender differences in maternal and pediatric care can affect TB transmission within families, heightening susceptibility among pregnant women and young children (McCloskey, 2017; Herba et al., 2016). Hormonal factors, such as estrogen, may also influence the immunological response to TB, explaining gender-based variations in TB incidence (Mabhula, 2015; Dabitao & Bishai, 2023).

4 CONCLUSION AND THE WAY FORWARD:

Even in the contemporary era, severe and fatal diseases such as tuberculosis, HIV/AIDS, cancer, malaria, and cardiovascular disorders persist as significant challenge to global health. Tuberculosis, in particular, demands immediate attention due to its high mortality rates, the emergence of drug-resistant strains, and its disproportionate impact on vulnerable demographic groups. Consequently, addressing chronic diseases necessitates a multifaceted approach that encompasses disease prevention, early diagnosis, improved access to healthcare, and ongoing research to develop effective treatments and vaccines. The findings of this study revealed a wide array of risk factors that heighten the likelihood of developing tuberculosis, especially pulmonary tuberculosis. These risk factors include weakened immune system due to conditions like HIV infection, malnutrition, or specific medications, as well as certain demographics, including the very young and the elderly, who are more susceptible to the disease. Moreover, tuberculosis is more likely to spread within communities marked by higher poverty rates. Substance abuse, cigarette smoking, or preexisting medical conditions such as diabetes or chronic renal illness are also considered risk factors. One of the most prevalent risk factors is close contact with a tuberculosis patient who is actively suffering from the disease. These combined risk factors not only increase the risk of tuberculosis infection but also impact the severity of the disease. For instance, individuals with their immune systems compromised may struggle to resist tuberculosis-causing bacteria, resulting in a more advanced and severe form of the disease. This can, in turn, elevate the risk of the infection spreading to other parts of the body. Furthermore, smoking can damage the lungs, making individuals more susceptible to tuberculosis and reducing the efficacy of treatment.

Therefore, to effectively preventing and managing tuberculosis necessitates proactive measures to address and mitigate these risk factors. This comprehensive approach is essential for the successful prevention and control of the disease, and they are as follows

1. Implementing poverty reduction initiatives and social safety nets to improve vulnerable populations' access to proper housing, nutrition, and healthcare.
2. Investing in healthcare infrastructure, particularly in low-income regions, to enhance TB diagnosis, treatment, and prevention.
3. Conducting public health campaigns and education programs to increase awareness about TB, its symptoms, and the importance of early diagnosis and treatment.
4. Implementing policies to reduce socioeconomic inequalities, addressing the root causes of TB risk factors.
5. Developing targeted interventions and TB screening programs for high-risk groups, including healthcare workers, miners, and prisoners.
6. Ensuring appropriate housing and ventilation in high-risk settings, such as prisons, refugee camps, and healthcare facilities.
7. Enforcing workplace safety measures, especially in industries associated with occupational TB risk.
8. Tailoring healthcare services to the specific needs of different genders, addressing barriers to care-seeking and diagnosis.
9. Implementing age-specific strategies considering the vulnerabilities of children, adolescents, and the elderly to TB.
10. Investigating the role of hormonal variables, like estrogen, in TB incidence to understand gender-specific disparities better.

11. Developing public health policies and campaigns to reduce TB stigma, encourage early diagnosis, and promote treatment compliance.
12. Improving living conditions and ventilation in overcrowded and high-risk environments to curb TB transmission.
13. Integrating healthcare interventions and poverty reduction measures to effectively combat TB in disadvantaged populations.
14. Encouraging international collaboration and funding to support TB prevention, diagnosis, and treatment efforts, particularly in regions with high prevalence.

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