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Prevalence and Risk Factors of Tuberculosis in the West Bank (2016-2024)

Rawan Moraweh Hussein Abdelhaq

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Prepared by

Rawan Moraweh Hussien Abdelhaq

Supervisor: Dr. Asaad Ramlawi, PhD

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Prepared By: Rawan Moraweh Hussien Abdelhaq

Registration number: 22312559

Supervisor: Dr. Asad Ramlawi

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The names and signatures of the examining committee members are as follows:

1- Head of committee: Dr.Asad Ramlawi : signature:…….

2- Internal Examiner: Dr.Hatem Eideh signature:…….

3- External Examiner: Dr.Diaa Hajijah signature:…….

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Dedication

To my angel in heaven—my dear son Taym.

Though your time in this world was brief, your memory has become the strength behind every step I take and the light that continues to guide my path.

I dedicate this thesis to you with all the love a mother's heart can hold, hoping that somewhere, somehow, you know I carry you with me always.

I love you, my Taym.

Rawan Abdelhaq

Declaration

Unless otherwise stated, I certify that the thesis I submitted for the master's degree in Prevention and Control of Infectious Disease at Al-Quds University is the product of my research and that this work has not previously been submitted to another university for a higher degree.

Signature: 

Name**:** Rawan Moraweh Hussien Abdelhaq

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Rawan Moraweh Hussien Abdelhaq

Abstract:

Background: Tuberculosis (TB) remains a significant global public health concern, including in low-incidence but high-risk settings such as Palestine, where political constraints, limited diagnostic capacity, and socioeconomic hardship may mask the true burden of disease. Although the West Bank reports fewer than one case per 100,000 population, the actual burden may be underestimated due to diagnostic limitations, underreporting, and operational constraints within the health system. Understanding the epidemiological trends, risk factors, clinical characteristics, and household transmission patterns is essential to strengthening surveillance and improving TB control strategies.

Methodology: A retrospective descriptive study was conducted using national TB surveillance data obtained from the Palestinian Ministry of Health for the years 2016–2024. Data were extracted from standardized investigation forms and DHIS2 databases. Descriptive statistics and bivariate analyses were performed to assess sociodemographic, socioeconomic, clinical, diagnostic, and household contact variables, and to determine factors associated with TB forms and diagnostic outcomes.

Results: From 2016 to 2024, a total of 67 confirmed TB cases (49 PTB and 18 EPTB) aged ≥10 years were reported in the West Bank, corresponding to a very low but fluctuating incidence of 0.09-0.36 per 100,000 population and an overall prevalence of 2.01 per 100,000. Cases were predominantly male (65.7%) with a median age of 47 years; PTB was more common among older adults, whereas EPTB was relatively more frequent in younger adults. Bivariate analysis showed that occupation (notably doctors and digger-truck drivers) was significantly associated with TB classification ($p = 0.026$). At the same time, sex, housing conditions, and diagnostic delays were statistically associated with higher bacteriological positivity in selected tests, reflecting increased infectiousness in specific subgroups. Diagnostic pathways relied mainly on acid fast stain, culture, imaging, and Mantoux testing, with minimal use of GeneXpert and substantial underreporting of several diagnostic results and comorbidities. Among 139 household contacts, 23.1% had a positive Mantoux test. However, tuberculosis preventive therapy was documented for only about two-thirds of eligible contacts, and overall treatment outcomes for index cases were poorly recorded.

Conclusion: Although TB incidence in the West Bank remains low, the study highlights key epidemiological and clinical patterns that warrant attention, including occupational-related risks, diagnostic delays, and potential household transmission. Strengthening diagnostic capacity, enhancing early detection, improving documentation quality, and implementing targeted prevention strategies may help reduce future TB burden and support national progress toward the WHO End TB goals.

Keywords: Tuberculosis; Pulmonary TB; Extrapulmonary TB; Epidemiology; Risk Factors; West Bank; Surveillance; Household Contacts; Diagnostic Delay; Prevalence; LTBI.

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List of abbreviations

Abbreviation	Full Term / Meaning
TB	Tuberculosis
PTB	Pulmonary Tuberculosis
EPTB	Extrapulmonary Tuberculosis
TBI	Tuberculosis Infection
MoH	Ministry of Health
WHO	World Health Organization
EMR	Eastern Mediterranean Region
PCBS	Palestinian Central Bureau of Statistics
DHIS2	District Health Information Software – Version 2
HIV	Human Immunodeficiency Virus
BCG	Bacillus Calmette–Guérin (vaccine)
NTP	National Tuberculosis Program
NTEP	National Tuberculosis Elimination Program
DOT	Directly Observed Treatment
MDR-TB	Multidrug-Resistant Tuberculosis
DR-TB	Drug-Resistant Tuberculosis
PHC	Primary Health Care
MTB	Mycobacterium tuberculosis
IGRA	Interferon-Gamma Release Assay
TST	Tuberculin Skin Test
LTFU	Loss to Follow-Up
LMICs	Low- and Middle-Income Countries

Chapter One

1. Introduction

Tuberculosis (TB) remains one of the leading infectious diseases worldwide despite recent advances in diagnostic and treatment methods (Yayan et al., 2024). The causative organism, *Mycobacterium tuberculosis* (MTB), is an acid-fast bacillus that most often attacks the lungs but can also affect multiple organs, leading to extrapulmonary forms of the disease (Kanabalan et al., 2021; Khan et al., 2019).

Transmission usually occurs when droplet nuclei containing the bacillus are inhaled after being expelled by individuals with active pulmonary TB while coughing, sneezing, or even speaking. The risk of infection is even higher in crowded living spaces or poorly ventilated areas (CDC, 2024).

The active TB clinical presentation is most often characterized by prolonged cough, fever, night sweats, unintentional weight loss, and fatigue. The disease course is determined by the combination of host immune capacity and pathogen virulence (Losev et al., 2023). By contrast, latent tuberculosis infection (LTBI) is asymptomatic and not contagious, but it is a major reservoir for future active cases. It is estimated that between 5% and 15% of people with LTBI eventually develop active TB, most often within the first two to five years after initial infection (Kiazyk & Ball, 2017).

Globally, TB is still one of the deadliest infectious diseases, although it was temporarily overshadowed by coronavirus disease (COVID-19) during the pandemic. WHO reports indicate that around 10.8 million people contracted TB in 2023, with approximately 1.25 million deaths, including 161,000 among HIV-positive individuals (WHO, 2024). The burden falls disproportionately on low- and middle-income countries, where structural challenges such as poverty, undernutrition, overcrowding, and limited access to healthcare increase vulnerability (Losev et al., 2023; Dheda et al., 2024). Control efforts are further undermined by the emergence of multidrug-resistant TB (MDR-TB), which requires prolonged treatment with more toxic regimens and has considerably lower cure rates (Dheda et al., 2024).

Within the Eastern Mediterranean Region (EMR), TB accounts for about 8.1% of the global caseload, though rates vary substantially between countries (World Health Organization, 2023). Encouragingly, half of the EMR states have reported incidence levels below 20 per 100,000 population, indicating progress toward elimination targets (Van den Boom et al., 2024).

In Palestine, the reported incidence of TB is among the lowest worldwide—fewer than one case per 100,000 people in 2022 (World Bank, 2024). Nevertheless, this figure may not accurately represent the real burden due to diagnostic gaps and underreporting (Ereqat et al., 2012). Additional obstacles arise from political instability, socioeconomic stressors, and health system limitations that hinder timely detection and management (WHO, 2023). Importantly, molecular investigations have identified MDR-TB strains within the region, underscoring the need to strengthen surveillance and implement targeted interventions (Ereqat et al., 2011). To date, no published study in Palestine has utilized national surveillance datasets to examine TB epidemiology or associated risk factors in the West Bank.

1.1 Problem Statement

Palestine has one of the world's lowest incidence rates of tuberculosis (TB)—less than one case per 100,000 people—but this is probably an incomplete estimate of the burden of the disease. Surveillance data is challenged with underreporting, diagnostic limitations, misclassification, and documented cases of multidrug-resistant TB (MDR-TB) underscore the risk of unobserved and silent dissemination. The Palestinian medical system has unique structural and contextual problems, such as political instability, constrained resources, and socioeconomic hardship, which hinder timely diagnosis, effective treatment, and prevention. Such issues can lead to delayed case identification, incomplete contact tracing, and poor surveillance of treatment response. Although the world has made major progress in TB control and elimination, the West Bank has not participated in a population-based systematic study to establish TB prevalence, risk-factor associations, or clinical patterns across demographic groups. A lack of convincing, context-specific evidence constrains policymakers' capacity to build effective, resource-efficient interventions and to reinforce national TB surveillance and control systems. It is essential to fill these knowledge gaps to avert a future increase in TB morbidity, mortality, and drug-resistant types in Palestine. Thus, there is an urgent need for a context-specific epidemiological study to generate reliable data on TB in the West Bank.

1.2 Significance and justification

In the West Bank, there is a noticeable shortage of research that examines tuberculosis (TB) using recent national surveillance data and looks not only at how many people are affected but also at *why* certain people are more at risk than others. Identifying local determinants—such as poverty, overcrowded housing, malnutrition, tobacco use, and chronic conditions like HIV and diabetes—is essential for understanding who is most vulnerable and for designing more effective control strategies. This study helps fill that gap by generating locally grounded evidence that reflects the real situation in Palestinian communities. Its findings can support more accurate surveillance, guide health planning, and assist policymakers in designing targeted interventions rather than relying on generalized global assumptions.

On a practical and clinical level, this study analyzes almost a decade of national surveillance data (2016–2024). It offers insights to improve early case detection, diagnostic decision-making, contact tracing, and treatment follow-up. Such information is especially valuable in settings like Palestine, where diagnostic limitations, inconsistent documentation, and occasional shortages of testing supplies may delay or complicate TB management. The results can help decision-makers better allocate resources, strengthen prevention programs, and reinforce strategies to reduce the spread of multidrug-resistant TB (MDR-TB).

On both personal and academic levels, this research contributes to skill development in epidemiology, data analysis, critical appraisal, and public health research, while also promoting scientific communication. By addressing gaps in current knowledge and linking local findings to regional and global evidence, the study supports a clearer understanding of TB dynamics in low-incidence yet high-risk settings such as Palestine. Ultimately, it contributes to national efforts to strengthen TB surveillance, improve program performance, and progress toward the WHO End TB Strategy goals.

1.3 Study aims

This study aims to determine the prevalence of tuberculosis (TB) and analyze the key risk factors contributing to its occurrence in the West Bank from 2016 to 2024.

1.4 Research Objectives

1. To determine the prevalence of tuberculosis (TB) in the West Bank between 2016 and 2024.
2. To identify the major risk factors associated with TB in the West Bank and analyze their relationship to disease occurrence.
3. To compare the epidemiological patterns of pulmonary and extrapulmonary TB in the West Bank with international data and standards.
4. To describe the implementation and documented outcomes of national public health interventions used in the management of confirmed TB cases.
5. To characterize TB clinical manifestations and analyze their association with contributing factors.
6. To assess the household contact infectivity status and control measurements taken to prevent transmission of TB.

1.5 Research questions

1. What is the prevalence and the incidence of tuberculosis (TB) in the West Bank between 2016 and 2024?
2. What are the major risk factors associated with TB in the West Bank, and how do these factors relate to the occurrence of the disease?
3. How do the epidemiological patterns of pulmonary and extrapulmonary TB in the West Bank compare with international standards?

4. What national public health interventions have been implemented for TB case management, and what outcomes have been documented?
5. What are the clinical presentations of TB cases, and how are they associated with contributing risk factors?
6. What is the infection status among household contacts of TB patients, and what control measures have been implemented to prevent further transmission?

1.6 Conceptual definition

The conceptual framework defines tuberculosis (TB) outcomes as the result of dynamic interactions among four major domains: healthcare system factors, biological factors, socio-economic and environmental conditions, and socio-demographic characteristics. These domains operate together to influence an individual's likelihood of exposure to MTB, susceptibility to infection, progression from latent to active disease, timeliness of diagnosis, and treatment adherence.

- **Healthcare system factors**—including the date of illness and investigation, availability of diagnostic tools, and treatment compliance—affect early case detection and treatment outcomes, shaping overall morbidity and mortality.
- **Biological factors** such as HIV co-infection, prior TB contact, and BCG vaccination status influence immune response and disease progression.
- **Socio-economic and environmental factors**, including poverty and overcrowded living conditions, increase exposure risk and contribute to delays in seeking medical care.
- **Socio-demographic characteristics**—age, sex, marital status, and occupation—affect exposure patterns, vulnerability, and health-seeking behavior. (Conceptual framework provided in the appendix)

Chapter Two
Literature Review

2.1 Introduction

Tuberculosis (TB) remains one of the most persistent global health challenges, and its impact varies greatly across regions and populations. To design effective public health strategies, it is essential to understand the epidemiology, risk factors, and control measures of the disease. The existing literature on TB spans multiple dimensions, ranging from the microbiological characteristics of Mycobacterium tuberculosis to the natural history of the disease. It then moves to the clinical spectrum of TB, including both pulmonary and extrapulmonary forms, and explains how transmission occurs—mainly through airborne particles expelled by individuals with infectious TB.

A major focus in the literature is on diagnostic approaches and the determinants that increase the risk of developing TB. These include poverty, malnutrition, overcrowding, smoking, HIV co-infection, diabetes, and delays within health systems. Beyond its biological and clinical aspects, research also addresses variations in incidence and prevalence across countries, mortality trends, and the global burden of disease.

Furthermore, extensive attention has been given to prevention strategies—such as vaccination, infection control practices, and chemoprophylaxis—as well as to treatment approaches for both drug-sensitive and drug-resistant TB. Within this broad global context, studies conducted in Palestine highlight local epidemiological patterns, risk factors, and challenges within the health system. Together, these studies provide a valuable framework for understanding TB prevalence and the factors influencing its occurrence, which is essential for guiding local and national control strategies.

2.2 Historical and Microbiological Background of Tuberculosis

Tuberculosis (TB) is a communicable disease primarily caused by *Mycobacterium tuberculosis* (MTB), a member of the *Mycobacterium tuberculosis* complex (MTBC), which also includes *M. bovis, M. africanum, M. microti, M. canetti, M. caprae, M. orygis,* and *M. pinnipedi* (Jokhdar et al., 2021). Known as Koch's bacillus, MTB is transmitted mainly through airborne droplet nuclei generated during coughing, sneezing, or speaking (Bai & Ameyaw, 2024). Case definitions vary internationally; some rely on bacteriological confirmation, others on radiological or immunological evidence, such as interferon-gamma (IFN-γ) responses ≥0.35 IU/mL in interferon-gamma release assays (Mzembe et al., 2021).

TB is among the oldest documented human diseases, with evidence in Egyptian mummies (3000–2400 BC), prehistoric remains (~7000 BC), and ancient records from India and the Americas (~2000 BC. Historically termed phthisis, consumption, lupus vulgaris, or King's Evil, it was once believed to be hereditary. Before modern therapy, patients were often isolated in sanatoriums, where rest and fresh air were considered therapeutic (Ahmed et al., 2025). A major milestone occurred in March 1882 when Robert Koch identified the TB bacillus—later named *Mycobacterium tuberculosis*—revolutionizing diagnosis and scientific understanding (Adam et al., 2024).

2.3 Classification of TB Disease

Tuberculosis disease is classified into variants based on several considerations, including the causative agent, anatomical site, clinical course, drug susceptibility, and disease status.

2.3.1 Based on Causative Agent

Tuberculosis may be caused by different members of MTBC. The most common cause of human tuberculosis is *Mycobacterium tuberculosis*, and zoonotic tuberculosis is mainly caused by *Mycobacterium bovis.*

Human tuberculosis (TB) is caused by *Mycobacterium tuberculosis* (MTB), for which humans are the primary reservoir. MTB lacks classical virulence factors and instead relies on genetic adaptations that enable prolonged survival within macrophages and granulomas, allowing immune evasion and chronic infection. Transmission occurs via airborne droplet nuclei generated during coughing, sneezing, speaking, or singing by individuals with active pulmonary or laryngeal TB, especially those with cavitary disease and high bacillary loads (~10,000 organisms/mL); low-viscosity secretions aerosolize more efficiently. TB mainly affects the lungs but can involve other organs. Following exposure, some individuals develop **active TB** with symptoms such as persistent cough, fever, night sweats, and weight loss, while others develop **latent TB**, which is asymptomatic but may later reactivate. Diagnosis is based on symptoms, risk factors, chest imaging, TST or IGRA, and confirmed through sputum smear microscopy, culture, or nucleic acid amplification tests. Standard treatment consists of a 2-month intensive phase (isoniazid, rifampicin,

pyrazinamide, ethambutol) followed by a 4-month continuation phase (isoniazid, rifampicin) (Khursheed et al., 2024).

Zoonotic TB (zTB) is primarily caused by *Mycobacterium bovis*, transmitted through unpasteurized dairy products or close livestock contact, posing a public health challenge at the human–animal interface. Although *M. tuberculosis* causes most human TB cases, zTB reflects the interconnectedness of human, animal, and environmental health and is most common in LMICs with high livestock density and unpasteurized milk consumption (Ahmed et al., 2025). zTB accounts for ~1.4% of global TB cases, with West Africa reporting cattle prevalence of 1.3–15%, particularly in Nigeria, Ghana, and Mali; human cases are frequently underreported due to diagnostic limitations and evolving strains (Acquah et al., 2022). Clinically, zTB closely resembles MTB infection, with pulmonary and extrapulmonary forms (e.g., lymphadenitis), complicating differential diagnosis (de la Rua-Domenech, 2006; Müller et al., 2013). *M. bovis* is intrinsically resistant to pyrazinamide, requiring treatment modification. Control strategies in affected regions include improved livestock surveillance, standardized diagnostics, and environmental measures such as safe carcass disposal (CDC, 2024).

2.3.2 Based on Anatomical Site

Pulmonary tuberculosis (PTB) remains the most common and contagious form of TB, primarily affecting the lung parenchyma, trachea, or bronchial tree, leading to persistent cough, chest pain, hemoptysis, fever, night sweats, weight loss, and fatigue. PTB is confirmed microbiologically and non-microbiologically confirmed (histologically or clinically diagnosed. Clinically, PTB patients more frequently presented with fever, night sweats, and weight loss compared to EPTB patients, whereas comorbidities and nutritional deficiencies may compromise immunity, increasing susceptibility to PTB and amplifying systemic symptoms. PTB is also associated with higher levels of white blood cells, neutrophils, C-reactive protein, and sedimentation rates, alongside lower albumin levels, indicating a stronger acute phase response and greater systemic inflammation. Pulmonary tuberculosis is treated with a standardized first-line regimen to eradicate bacteria and prevent resistance (Swinkels et al., 2025).

Extrapulmonary TB (EPTB) occurs when *M. tuberculosis* spreads beyond the lungs—typically via blood or lymphatics—to sites such as lymph nodes, pleura, bones, meninges, or the genitourinary tract (Golden & Vikram, 2005). Bacilli survive within macrophages and induce granulomatous inflammation, causing tissue necrosis and organ damage (Sharma & Mohan, 2021). Although caused by the same pathogen as PTB, EPTB differs in pathophysiology, clinical presentation, and prognosis (Sharma & Mohan, 2017). Diagnosis requires clinical suspicion supported by imaging and laboratory tests, with confirmation via acid-fast staining, culture, Xpert MTB/RIF, or histopathology showing granulomatous inflammation (WHO, 2020). Symptoms are site-specific—e.g., lymphadenopathy, pleuritic chest pain, spinal pain, genitourinary symptoms, or neurological deficits—while systemic symptoms (fever, fatigue, weight loss) may be mild or absent, making EPTB difficult to recognize and often requiring targeted evaluation (Golden & Vikram, 2005; Sharma &

Mohan, 2021). Treatment generally follows standard 6-month regimens (isoniazid, rifampicin, pyrazinamide, ethambutol for 2 months; then isoniazid and rifampicin for 4 months) (WHO, 2020). Severe forms such as TB meningitis, spinal TB, or disseminated TB may require 9–12 months of therapy, surgical intervention in selected cases, and adjunct corticosteroids for meningitis or pericardial TB to reduce complications (Sharma & Mohan, 2021; Unver Ulusoy et al., 2024).

2.3.3 Based on Clinical Course

In accordance with the clinical course, it is composed of primary, secondary, and relapse. Mycobacterium tuberculosis infection can result in both primary and post-primary or secondary tuberculosis, leading to reactivation TB.

Primary TB infection usually occurs among immunocompromised individuals suffering from insufficient immunity to control and confine *M. tuberculosis* in granulomas, resulting in a broad clinical spectrum such as meningitis, disseminated TB in humans with AIDS, miliary tuberculosis, and extrapulmonary granulomas. Notably, those very young and very old are the typical affected group, immunologically naïve and immunodepression populations. The primary TB confers protection in hosts in immunocompetent cases by eliciting systemic immunity efficiently, enabling it to contain and stop the disseminated infection. Accordingly, the infection will be controlled within weeks, and the lesions will recover.

Post-primary or secondary tuberculosis (reactivation TB) usually starts only after the establishment of systemic immunity in primary TB, evading and disrupting the immune response system. As a consequence, hypersensitivity to *M. tuberculosis* antigens, rather than bacillary loads, induces cavity formation that enables the replication and escape of mycobacteria to the environment. Overall, most of the post-primary TB infection in humans is paucibacillary.

Concerning reactive TB occurs when latent infection progresses to active disease years after initial exposure, making LTBI individuals a reservoir for transmission. HIV is the strongest risk factor for reactivation due to depletion and functional impairment of CD4+ and CD8+ T cells, which are essential for TB control. Other factors promoting reactivation include aging, malnutrition, inadequate or incomplete treatment, drug resistance, and comorbidities such as diabetes, renal failure, cancer, or immunosuppressive therapy. Relapse TB refers to the return of active disease after successful treatment and cure, due to reactivation of dormant bacilli, and differs from reinfection, which results from exposure to a new strain in high-incidence settings. Experimental murine models show that relapse TB has lower bacterial loads and reduced levels of inflammatory cytokines (TNF-α, IFN-γ, IL-6, CXCL9, CXCL10, IL-17), with expansion of memory Th1 cells, indicating enhanced bacterial control. Although relapse often responds similarly to primary TB, the elevated risk of drug resistance requires extended retreatment regimens (8–9 months or more), tailored to drug susceptibility and clinical status (Kanabalan et al., 2021).

2.3.4 Based on Disease Status

Latent tuberculosis infection (LTBI) occurs when the immune system contains MTB without clinical disease, allowing bacilli to persist in a dormant state within granulomas (Hashim et al., 2024). Global LTBI burden is substantial: nearly one-quarter of the world population is infected (Houben & Dodd, 2016), and 5–15% will develop active TB during their lifetime, with highest risk within the first 12–24 months (Kiazyk & Ball, 2017; Mhimbira et al., 2017). Prevalence varies widely: 31–55% across African countries and much higher in high-risk groups, including miners (89%) and healthcare workers (62–84%) (Javaid et al., 2018). In India, adult LTBI prevalence was 21.7%, rising to 70% among household contacts (WHO, 2024b). Children, the immunocompromised, and individuals living with HIV are at highest risk of progression to active TB (Hashim et al., 2024).

Diagnosis of LTBI remains challenging due to the absence of a gold standard. TST and IGRA detect immune sensitization but cannot distinguish recent from remote infection or predict progression, and are affected by BCG vaccination and immunosuppression (Hashim et al., 2024). New WHO-endorsed skin tests (C-TB, C-TST, Dia-skin test) offer improved specificity in children and people with HIV. LTBI treatment relies on isoniazid- or rifamycin-based preventive therapy, with adherence strongly influenced by regimen duration (Sterling et al., 2020; Alyaquobi et al., 2025).

Population studies highlight variability in LTBI burden and preventive therapy uptake. A Korean study of 4,692 schoolteachers found **20%** LTBI, higher in men and older adults; **31%** initiated therapy, with highest completion using rifampacin monotherapy (**87.5%**) (Kim et al., 2025). In Egypt, TB burden has declined by **1.3% annually** since 2005, but LTBI remains high in risk groups, including healthcare workers (**59.1%** in Zagazig; **13.5%** in Fayoum) and patients with erectile dysfunction (**29.9%**) (Nour & Nour, 2024). These findings underscore the need for targeted surveillance and preventive strategies despite declining TB incidence.

Active tuberculosis (TB) occurs when *Mycobacterium tuberculosis* (MTB) replicates within the body, causing symptomatic illness and enabling transmission (CDC, 2024). It primarily presents as pulmonary TB, affecting the lungs and leading to persistent cough, chest pain, hemoptysis, fever, night sweats, weight loss, and fatigue, but may also involve other organs—including lymph nodes, kidneys, spine, or brain—resulting in manifestations such as lymphadenitis, hematuria, headache, seizures, or confusion, collectively termed extrapulmonary TB (Swinkels et al., 2025). Diagnosis is confirmed through positive culture or PCR, or clinically based on symptoms, radiological findings, and epidemiological risk factors (Van't Hoog et al., 2022). In 2023, an estimated 10.8 million people developed active TB globally, of whom approximately 8.2 million were diagnosed and treated, with 1.25 million deaths, making TB the leading cause of death from a single infectious agent (WHO, 2025b; Estaji, 2025). Approximately 2.7 million cases remained undiagnosed or unreported, indicating significant gaps in detection and surveillance (WHO, 2024b; WHO, 2025a). Outbreaks reported in 2024 in regions such as the UK and

the US reinforced the importance of active case finding, timely treatment, and cross-border public health coordination. Individuals with active TB can transmit the infection to 10–15 close contacts per year (Bai & Ameyaw, 2024). The global burden remains concentrated in low- and middle-income countries, with thirty nations accounting for 87% of cases, and India, Indonesia, China, the Philippines, and Pakistan alone representing 56% (Dall, 2024). In Europe, childhood TB increased by 10% in 2023, with over 7,500 cases among children under 15 years, illustrating the fragility of TB control and the need for urgent public health interventions (Reuters, 2025).

2.3.5 Based on Drug Susceptibility

Drug-sensitive tuberculosis (DS-TB) describes TB infections caused by Mycobacterium tuberculosis strains that are responsive to the standard first-line anti-TB medications. In such cases, the bacteria can be efficiently treated with the conventional regimen, which involves isoniazid, rifampicin, pyrazinamide, and ethambutol during the two-month intensive phase, followed by isoniazid and rifampicin in the four-month continuation phase. Drug-sensitive TB may affect the lungs (pulmonary TB) or other parts of the body (extrapulmonary TB). However, the standard treatment is generally highly effective when properly followed. Recognizing TB as drug-sensitive is important for selecting the appropriate therapy, achieving successful treatment outcomes, and reducing the risk of developing drug-resistant TB (Mansoori et al.,2024).

Drug-Resistant Tuberculosis (DR-TB) occurs when Mycobacterium tuberculosis becomes resistant to one or more first-line anti-TB medications. Multidrug-resistant TB (MDR-TB) is resistant to both isoniazid and rifampin, while pre-extensively drug-resistant (pre-XDR) and extensively drug-resistant TB (XDR-TB) show additional resistance to fluoroquinolones or second-line drugs such as bedaquiline and linezolid (Tiberi et al., 2022). DR-TB can be categorized into five types: isoniazid-resistant, rifampicin-resistant (RR-TB), MDR-TB, pre-XDR-TB, and XDR-TB (Tiberi et al., 2022).

Symptoms are similar to drug-sensitive TB, including prolonged cough, fever, night sweats, weight loss, and fatigue (Salari et al., 2023). Rapid molecular diagnostics like GeneXpert and whole-genome sequencing have improved detection of resistance (Tiberi et al., 2022; &WHO,2024c). High-risk groups include previously treated TB patients, close contacts of TB or MDR-TB cases, individuals with pulmonary TB, comorbidities like HIV or diabetes, young adults, and males (Meresa et al., 2025). Treatment now includes shorter multidrug regimens such as the six-month BPaLM regimen or nine-month all-oral regimens, yet global treatment success remains suboptimal, with XDR-TB success often below 50% and MDR-TB frequently failing to meet the WHO target of 75% (Pedersen et al., 2023).

In 2023, an estimated 10.8 million people developed TB, of whom 8.2 million were reported to WHO; around 1 million had Hr-TB, and 410,000 had MDR-TB or RR-TB. Only 40% of MDR/RR-TB patients were identified and started on treatment, and just over half of RR-TB patients received follow-up testing for fluoroquinolone resistance (WHO, 2025b). Multidrug-resistant and rifampicin-resistant TB (MDR/RR-TB) remain critical

challenges. Of the estimated 400,000 MDR/RR-TB cases in 2023, only 44% received diagnosis and treatment, with a treatment success rate of 68% due to newer, shorter regimens (Dall, 2024). WHO treatment guidelines prioritize two 6-month all-oral regimens for MDR/RR-TB, followed by 9-month regimens for fluoroquinolone-sensitive cases, and reserve 18–20-month regimens with injectable drugs as a last resort (WHO, 2022b; &WHO, 2024c). A systematic review across 94 studies found treatment success for XDR-TB was 44.2%, and 63.3% for pre-XDR-TB (Pedersen et al., 2023). Additionally, a cohort study of 535 MDR-TB patients in Peshawar, Pakistan, 24.1% experienced unsuccessful outcomes, with key predictors including being married, resistance to second-line drugs, and having XDR-TB (Javaid et al., 2018).

2.4 Transmission and Infection of TB

The risk of transmitting *Mycobacterium tuberculosis* depends on three main factors, including the quantity of bacteria released into the air, the concentration of these organisms in a given space, which is influenced by room size and ventilation, and the duration of time a person spends inhaling the contaminated air (Khursheed et al., 2024). Numerous studies have investigated the transmission of TB through the mucosa of the oropharynx or the gastrointestinal tract. Transmission mainly occurs through inhalation of aerosolized droplets released when individuals with pulmonary TB cough, sneeze, or spit, with only a few bacilli required to establish infection. The hallmark symptoms of active tuberculosis include a persistent cough that may produce blood-streaked sputum, along with fever, night sweats, and unintended weight loss (Mzembe et al., 2021). Recent arguments have shown that unpasteurized milk and undercooked meat from infected cattle can transmit *M.bovis* to humans when bovine tuberculosis is not well controlled. The infection may stay dormant for years and later reactivate, with *M. bovis* responsible for up to 10% of human TB cases (Khursheed et al., 2024). Individuals who carry TB bacteria but do not show symptoms cannot spread the disease. However, they face a lifetime risk of 5–10% of eventually developing active TB within the first 2 years after the infection. In some cases, individuals may naturally eliminate the infection (Mokhtar et al,2025). PTB, especially cavitary and laryngeal forms, are the most contagious, while extrapulmonary manifestations such as those affecting lymph nodes, pleura, or the osteoarticular system are generally noninfectious. Transmission risk depends on the degree and duration of exposure, physical proximity, bacterial load in respiratory secretions, and the immune status of the exposed individual, with immunocompromised persons, young children, and those with comorbidities being most vulnerable. Once inhaled, *MTB* typically establishes a latent infection in about 90% of individuals due to immune defenses, but in roughly 10% of cases, the bacteria progress to active disease, and in some instances disseminate via the bloodstream to sites such as the brain, lymph nodes, pleura, and osteoarticular system (Jokhdar et al., 2021; &Fuchs et al., 2024). TB predominantly affects the lungs, which are the primary site of infection, accounting for more than 80% of cases, but can involve virtually any organ, reflecting the pathogen's ability to survive in harsh environments due to its lipid-rich cell wall (Nour & Nour,2024).

2.5 Diagnostic Testing of TB

TB diagnosis has advanced from traditional sputum smear microscopy to molecular and point-of-care technologies. Primary diagnostic test in low-middle income countries depends on Rapid Diagnostic Test (RDT) like Xpert MTB/RIF for both Pulmonary TB (PTB) and Extrapulmonary TB (EPTB) in adults and children, whereas Tuberculin Skin Test (TST) is used as an adjuvant when there is uncertainty in diagnosis or when screening for latent infection. Accurate diagnosis relies on bacteriological confirmation through rapid molecular tests, LF-LAM assays, smear microscopy, or culture, while unconfirmed cases are classified as clinically diagnosed. In its latest Global Tuberculosis Report, WHO (2025c) reported that over 8.2 million people with TB were diagnosed and treated in 2023, marking an increase from previous years, compared to only 48% of the 8.2 million newly diagnosed TB cases were initially tested with WHO-recommended rapid diagnostics (WHO, 2024a). TST and IGRA remain common for TB infection detection, though TST is contraindicated in individuals with severe allergic reactions (<1%) and IGRA is not recommended for children under two, with both tests having limitations such as false positives from BCG vaccination and false negatives in immunocompromised patients (WHO, 2021a, 2022a, 2025b). Point-of-care tests like LF-LAM and sequencing technologies enhance detection and drug-resistance profiling (Coleman et al., 2022; WHO, 2021a). Current WHO guidance recommends low-complexity nucleic acid amplification tests (NAATs) as the initial diagnostic option for pulmonary, extrapulmonary, and TB meningitis cases, with the capacity to simultaneously detect rifampicin resistance. For pediatric patients with HIV-negative or unknown status, combined stool-based NAAT and LF-LAM testing may be used (WHO, 2025b). HIV testing among TB patients reached 80% globally in 2023, with the highest coverage in the WHO African Region (90%) and European Region (94%), and at least 90% awareness of HIV status in 99 countries, including 31 African nations. Detection of drug resistance requires bacteriological confirmation through molecular tests, culture, or sequencing (Adam et al., 2024).

On one hand, HIV among people diagnosed with TB is typically detected using rapid diagnostic tests (RDTs), which identify HIV antibodies in a blood sample and provide results within minutes; positive results are confirmed with a second rapid test or laboratory-based assay. For adults and adolescents living with HIV, tuberculosis screening can include the use of C-reactive protein (CRP) with a threshold of >5 mg/L, as well as assessing for a cough that persists for two weeks or more (WHO, 2025b). Testing should be integrated into TB care, accompanied by pre- and post-test counseling, to ensure early diagnosis and initiation of antiretroviral therapy. In 2023, global HIV testing among people diagnosed with TB reached 80%, with the highest coverage in the WHO African Region (90%) and European Region (94%), and at least 90% awareness of HIV status in 99 countries, including 31 African countries. On the other hand, detection of drug resistance requires bacteriological confirmation and rapid molecular tests, culture, or sequencing methods (Adam et al., 2024).

Among some studies regarding diagnostic tests to confirm TB infection, a cross-sectional study in overcrowded university hostels in Kenya examined TB prevalence among 156

student contacts. Overall, 8.3% tested positive for TB, with 3.2% confirmed by GeneXpert alone; most cases (92%) were pulmonary, and only 1.9% were co-infected with HIV. GeneXpert diagnosis was used in 43% of index cases. Nationally, Kenya reported a pulmonary TB prevalence of 558 per 100,000 in 2016, with 16.7% co-infected with HIV. In 2017, HIV prevalence in Kilifi County was 3.8%, and 86% of children had received BCG vaccination (Maina et al.,2021).

2.6 Risk Factors of TB

The occurrence of TB is shaped by a multifaceted combination of biological, behavioral, environmental, and social determinants. Factors such as being male, older age, poverty, limited education, malnutrition, existing health conditions, smoking, substance use, inadequate housing, exposure within households, and certain occupational risks all increase the likelihood of infection. These influences frequently intersect, producing compounded vulnerabilities that help maintain TB transmission in regions with high disease burden.

2.6.1 Sociodemographic Factor

2.6.1.1 Age Factor

Globally, adults account for most TB cases (88%), though children under 15 still represent a notable proportion (Chakaya et al., 2021). TB incidence declined across all age groups between 2015 and 2020, with the sharpest reductions observed in children (<5 years: 16.5%; 5–14 years: 16.2%), whereas declines were more modest among adults (15–49 years: 6.3%; 50–69 years: 5.7%; ≥70 years: 8.5%) (Kyu et al., 2024). Age patterns follow a U-shaped distribution, with higher incidence in infancy, adolescence, young adulthood, and older age (Chiang et al., 2025). Older adults, particularly those >65 years, experience worse outcomes due to immunosenescence, comorbidities, and treatment-related complications, with evidence from Iran and Germany showing substantially higher mortality and treatment failure in this age group (Kévelaitiene et al., 2025). Although prevalence data indicate declining TB transmission in several Asian and African countries, some African regions (e.g., Ghana, Lesotho, Malawi, Mozambique, Rwanda, Tanzania) continue to report high transmission, particularly among adults aged 35–54, partly driven by HIV co-infection (WHO, 2024b). In South Africa, a cross-sectional analysis of 9,180,047 adults ≥50 years showed an HIV prevalence of 5.3% and TB prevalence of 2.9%, with TB most common among those aged 50–54 (27.19%), 55–59 (27.86%), 60–64 (19.45%), and 65–69 (14.29%), and declining in older age groups (70–74: 7.30%; ≥75: 3.91%) (Akokuwebe et al., 2024). Similarly, a five-year study (2013–2018) in northern Iran found markedly higher mortality among smear-positive TB patients aged >65 years, demonstrating that advanced age is a major predictor of active disease and poor treatment outcomes, underscoring the importance of screening, early diagnosis, and tailored care for elderly populations (Golsha et al., 2024).

2.6.1.2 Sex Factor

Globally, TB shows a pronounced sex gap, with adult men experiencing substantially higher incidence, morbidity, and mortality than women (Stop TB Partnership, 2022). In 2023, TB affected 646,000 adult men and 410,000 adult women, indicating a 1.7-fold higher incidence in men (Ohnishi et al., 2021). From 2007–2021, 66–75% of bacteriologically confirmed pulmonary TB cases occurred in men, attributed to behavioral and biological factors, including smoking and delayed diagnosis (Ranasinghe et al., 2022). Women show increased vulnerability during adolescence, while older adults of both sexes face higher risk due to comorbidities and immunosuppression (Laycock et al., 2021).Meta-analyses show that men have a 30–50% higher TB-related mortality risk, with a pooled male-to-female fatality ratio of 1.4:1 in Europe (Zhu et al., 2024), a pattern consistent in South Africa, Ethiopia, Afghanistan, and Saudi Arabia (Osman et al., 2021; Dememew et al., 2025). A systematic review by Pape et al. (2024) similarly reported 1.4-times higher case fatality among men, linked to social determinants such as homelessness and delayed care, underscoring the need for gender-responsive TB strategies.

2.6.1.3 Marital status Factor

Marital status is an important social determinant of TB risk and treatment outcomes, with unmarried, divorced, or widowed individuals demonstrating poorer outcomes than married patients due to reduced social and economic support and higher psychosocial stress. In Southwest Ethiopia, 19.1% of TB patients experienced unsuccessful treatment outcomes, with male sex, divorced or widowed status, HIV co-infection, poor adherence, and previous TB treatment identified as key predictors (Berhe Hiluf et al., 2024). In Iran, analysis of 1,083 TB cases showed that 2.5% had MDR/RR-TB and 6.7% had any drug resistance, with marital status significantly associated with MDR/RR-TB ($p = 0.003$); single, divorced, and widowed individuals had higher risk than married patients due to weaker social support, economic disadvantage, and poorer adherence (Mansoori et al., 2024).

2.6.1.4 Education Factor

Education strongly influences TB risk and treatment outcomes, as low literacy and lack of formal schooling are linked with higher infection risk and poorer adherence. Limited education reduces disease awareness and health-seeking behavior. TB also imposes substantial psychological and social burdens through stigma, discrimination, and isolation, particularly in low-income settings (Mokhtar et al., 2025; Bai & Ameyaw, 2024; Kévelaitiene et al., 2025). In Mexico's Chiapas Highlands, higher education levels were associated with better treatment success, while primary education and residency in indigenous communities predicted poorer outcomes, underscoring the need for education- and support-based interventions (Sanchez-Perez et al., 2024).

2.6.2 Socioeconomic and Environmental Factors

2.6.2.1 Poverty, Unemployment, and Low Income

Poverty, unemployment, and low income significantly increase TB risk and worsen outcomes by contributing to malnutrition, overcrowding, poor ventilation, inadequate sanitation, and limited healthcare access (International Society for Infectious Diseases, 2025; Petersen & Zumla, 2025). When household income falls below the Regional Minimum Wage, nutritional needs are often unmet, increasing vulnerability to infection. In Kazakhstan, a case–control study of 1,555 participants found strong associations between TB and poverty-related factors, including unemployment, low education, and social exclusion, with unemployment showing a highly significant association with adverse TB outcomes ($\chi^2 = 81.1$, $p < 0.001$). Structural barriers such as financial constraints and limited healthcare access further exacerbated risks (Yerezhepov et al., 2024).

2.6.2.2 Malnutrition Factor

Several studies have identified low BMI (<18.5 kg/m²) as a significant risk factor for TB development and poor treatment outcomes, while both underweight and obesity (>30 kg/m²) impair cell-mediated immunity and increase susceptibility to infection and relapse; normal BMI up to 28 kg/m² may be protective (Oyewusi et al., 2024; Cai et al., 2024). Nutritional support has been shown to enhance immune function and improve treatment adherence (Költringer et al., 2023). Evidence from Ethiopia demonstrated that underweight homeless individuals had a 5.3-fold higher likelihood of bacteriologically confirmed pulmonary TB compared with those of normal or higher BMI, with additional associated factors such as smoking, HIV infection, and chronic exposure to TB cases (Kenu et al., 2025). Globally, undernutrition contributes to an estimated 2.2 million TB cases (≈20%), and increases the risk of progression from latent to active disease by 2–3 times (Sinha et al., 2021). These findings collectively underscore the role of malnutrition as a major driver of TB incidence and highlight the importance of integrating nutritional support into TB prevention and treatment strategies.

2.6.2.3 Occupation Factor

Occupational conditions, particularly in construction, mining, manual labor, and agricultural activities, also contribute to TB risk due to poor work environments, low wages, overcrowded living conditions, and limited health education. Quarrying and mining are strongly linked to TB, primarily through chronic inhalation of silica dust, inadequate ventilation, and restricted healthcare access. Silica exposure damages pulmonary defenses, increasing the risk of infection and progression to active disease, while construction and manual labor frequently involve substandard housing and dormitory crowding, contributing to gender disparities in TB burden (Semilan et al., 2021; Maatoug et al., 2025).

A cross-sectional study of 935 sandstone miners in India found that 6.4% had X-ray-confirmed TB, with prevalence increasing with duration of silica exposure: 2% (<10 years), 6% (11–20 years), and 12.7% (>20 years). Silica-exposed workers had a 2.8–39-fold higher risk of pulmonary TB compared to unexposed individuals, and those with >10 years of exposure had over fourfold higher odds of TB. The authors recommended wet drilling and the use of mandatory personal protective equipment (PPE) to reduce risk.

Similarly, a study from war-affected North Wollo, Ethiopia, reported a 17.2% TB prevalence, higher among adults >60 years (29.4%), drivers (38.5%), and rural residents (19.5%). Among 47 MTB cases, 36.2% had rifampicin-resistant TB (RR-TB), with higher rates in females (40.9%), widows (75%), and farmers (55.5%), underscoring the need for mobile clinics, community-based treatment, nutritional support, and mental health services in conflict zones (Asmare et al., 2025).

Retrospective findings from Mexico further demonstrated occupational disparities, showing that agricultural workers and residents in municipalities with large indigenous populations experienced significantly lower TB treatment success, whereas non-agricultural workers achieved higher success rates (Sanchez-Perez et al., 2022).

Comparable results were observed in Saudi Arabia, where a cross-sectional study of 1,270 TB cases (including 300 workers) reported a TB incidence of 9 per 100,000 among workers, highest in supporting basic engineering (13 per 100,000), agriculture/animal husbandry/fishing (12 per 100,000), and service occupations (11 per 100,000). Risk was disproportionately elevated among male and non-Saudi workers, and a negative correlation was observed between monthly wage and TB incidence, indicating that lower-income occupations carry higher disease burden, while education level showed no correlation. The authors concluded that low socioeconomic status and specific occupational sectors are key risk determinants warranting targeted TB control measures (Semilan et al., 2021).

2.6.2.4 Residency Place and Housing Factor

In general, people in rural settings often face structural barriers to TB diagnosis and treatment, resulting in delayed care, prolonged infectiousness, and increased community transmission. In South Africa's high-burden Northern Cape Province, a quasi-experimental cohort study of 774 participants found that being male and living in a town were strongly associated with higher TB incidence. Additionally, individuals born in rural areas who later migrated to towns had elevated risk, whereas those born in towns but residing in rural areas had the lowest likelihood of active TB, suggesting that demographic shifts and socioeconomic transitions influence susceptibility (Oyageshio et al., 2024). Conversely, a case–control study of 1,555 participants in Kazakhstan reported that urban residency was linked to increased TB risk and poorer treatment outcomes, reflecting different contextual drivers (Yerezhepov et al., 2024). Similarly, a cross-sectional study in Mexico found that residents of largely indigenous municipalities experienced lower treatment success rates, highlighting spatial and social disparities in TB outcomes (Sanchez-Perez et al., 2024).

2.6.3 Behavioral and Lifestyle Factors (Smoking, Alcohol Use, Illicit Drugs, and Substance Abuse)

Tobacco use, alcohol consumption, and substance abuse weaken immune defenses and heighten susceptibility to tuberculosis (TB). Smoking disrupts mucociliary clearance and impairs alveolar macrophage function, increasing infection risk (Al-Salih et al., 2024). Evidence indicates that smoking—active or passive—increases TB infection risk by approximately 1.5–2 times, raises reactivation risk two- to threefold, and is associated with more severe forms such as cavitary TB and a 1.5–3-fold higher TB mortality. Substance use also contributes to delayed diagnosis and poor treatment adherence (Osei-Wusu et al., 2025). Data from Somalia suggest that over half of male TB patients engage in smoking or alcohol use (Ahmed et al., 2025).

A retrospective cohort study from Tel Aviv, Israel, compared TB patients with a history of smoking or substance use (n = 50) to matched controls (n = 100). Substance-using patients had significantly poorer outcomes, including prolonged hospitalization, higher rates of multidrug-resistant TB, treatment failure up to 68.8% among smokers, and increased mortality. The study highlighted the need for integrated interventions addressing substance use within TB care to improve adherence and treatment success (Kaliner et al., 2024).

Excessive alcohol use is an established TB risk factor and is associated with unfavorable outcomes. In 2022, alcohol use disorders contributed to an estimated 700,000 new TB cases globally, with drinkers having a 35% higher infection risk than non-drinkers (Kévelaitiene et al., 2025). Alcohol delays culture conversion, increases relapse, and elevates TB mortality, and modeling studies estimate that reducing alcohol consumption could prevent ~17% of new TB cases and ~15% of TB deaths worldwide. A Global Burden of Disease analysis across 204 countries reported that alcohol-related TB mortality declined from 5.35 to 2.54 per 100,000 between 1990 and 2019, with the greatest reductions in Andean Latin America, East Asia, and Central Latin America (>7% annually), although inequalities persisted, particularly in Central Asia (Jinyi et al., 2024). Older adults (60–80 years) were disproportionately affected, and projections suggest continued—but uneven—declines by 2035. Complementary findings by Kaliner et al. (2024) showed that alcohol-using TB patients had a fourfold higher risk of treatment failure, reduced survival, and younger age at death, underscoring the dual impact of alcohol on clinical outcomes and social marginalization.

The WHO identifies substance users as a high-risk group for TB due to biological vulnerability and risky behaviors. Global drug use has risen from 4.8% in 2009 to 5.3% in 2018, with more than 296 million users reported in 2021. Substance use facilitates TB transmission and undermines treatment adherence. In Brazil, a cohort of 111 TB outpatients who smoked at treatment initiation showed low smoking cessation success (26.8%) at treatment completion and high loss to follow-up (40.5%), driven by treatment discontinuation or death. Anxiety, depression, social smoking environments, and concurrent drug use were major barriers. The authors recommend integrating mental

health, addiction support, and targeted counseling within TB programs to improve adherence and cessation outcomes (Coutinho et al., 2024).

2.6.4 Biological Factors

2.6.4.1 TB Contact Factor

2.6.4.1.1 Household Contact Factor

Close household and social contact with TB patients have higher TB positivity rates. Untreated individuals with smear-positive pulmonary tuberculosis serve as the main source of TB transmission within the community. Actually, an index patient can transmit TB to two to three household members at least. Meanwhile, prolonged exposure significantly increases the infectivity risk. Reviews in Indonesia has shown that poor household ventilation and close contact with TB patients are key modifiable risk factors for infection (Nindrea et al., 2024).

2.6.4.1.2 Social Contact Factor

Populations such as migrant workers, urban slum residents, refugees, internally displaced persons, prisoners, and individuals living in congregate settings (e.g., dormitories, military barracks) face elevated TB risk due to overcrowding, poor ventilation, inadequate hygiene, limited healthcare access, and exposure to high-prevalence environments (Mzembe, 2024; Fuchs et al., 2024). Transmission is further amplified in crowded community spaces such as markets, public transportation, and places of worship, indicating that TB control strategies must extend beyond household-based interventions (Hella et al., 2017).

Prisons are recognized as global TB hotspots. Over 125,000 new TB cases occur annually in prisons—approximately 1% of global cases—and incidence often exceeds 1,100 per 100,000, far higher than in the general population (Nyasulu et al., 2025). Prevalence is particularly high in South America, Africa, South-East Asia, and the Eastern Mediterranean, with Africa exceeding 2,200 per 100,000. Detection is suboptimal, with only 53% of cases identified. Examples include extremely high incidence in Ukraine (>4,000 per 100,000), central China (1,156 per 100,000), India (1,076 per 100,000), the Philippines (6,357 per 100,000), and Thailand (5,249 per 100,000). In the U.S., prisons account for 4.2% of national TB cases, while in South Africa, prevalence is 3.13%, exceeding rates in high- and upper-middle-income countries (2.25%). Overcrowding showed strong correlation with incidence, and TB risk in incarcerated populations exceeds that associated with diabetes, alcohol use disorders, smoking, and undernutrition, highlighting the need for active case finding and targeted interventions (Nyasulu et al., 2025).

Migrant workers, refugees, and ethnic minority groups similarly experience disproportionately higher TB risk due to overcrowded housing, barriers to healthcare, and residence in high-prevalence settings. In Europe, migrants have up to 8.6-fold higher odds of TB compared to non-migrants (Maatoug et al., 2025), and displaced individuals or those with prior TB exposure show elevated positivity rates (Asmare et al., 2025).

Several regional studies underline the geographic dimension of TB risk. A retrospective study in Riyadh (2002–2017) confirmed TB endemicity in Saudi Arabia, with incidence decreasing from 18 to 10 per 100,000 but remaining higher in non-nationals (10.9 vs. 7.4 per 100,000) (Alateah et al., 2020). Most cases occurred in males (71.2%), adults <45 years (68.6%), and pulmonary TB accounted for ~86% of newly diagnosed cases. National Tuberculosis Program data (2014–2020) further reported 21,120 TB cases, with mean incidence of 6.92 per 100,000 for pulmonary and 2.33 per 100,000 for extrapulmonary TB. Incidence was highest in Jeddah (PTB 13.77; EPTB 4.33) and Jazan (PTB 11.18; EPTB 3.63), and non-Saudis comprised 53% of TB cases. The study recommended routine health screening for immigrants from high-risk countries.

A systematic review in Europe found that migrants experienced lower TB mortality than host populations but showed significantly higher treatment interruption and loss-to-follow-up—linked to unstable residency, limited healthcare access, and fragmented post-diagnosis care. The authors called for standardized migrant-initiated screening programs and improved continuity-of-care systems across Europe to reduce treatment discontinuation and strengthen TB control (Braga et al., 2024).

Community-based transmission has also been documented. In Tanzania, combining molecular epidemiology with social mixing data revealed that public spaces—especially markets and public transport—substantially contribute to TB transmission, complementing household spread. The study recommended expanding TB control measures to public venues through improved ventilation, crowd management, and community awareness (Hella et al., 2017).

In Eastern Ethiopia, a cross-sectional study of 454 household contacts of smear-positive PTB patients identified multiple TB risk factors, including <3 meals/day, drinking raw milk, multiple TB cases within households, and poor ventilation or small living spaces. Additional predictors included age, income, smoking, overcrowding, and proximity to the index case. Strengthening contact tracing, improving treatment adherence, and enhancing health education were recommended (Adane et al., 2020).

2.6.4.2 Comorbidities Factor (HIV, DM. Chronic kidney Disease, COVID-19) and Immunosuppressive Cases

Comorbid conditions and immunosuppressive cases significantly increase TB risk and confound treatment outcomes, being associated with higher rates of TB incidence, treatment failure, and survival rates (Osei-Wusu et al., 2025c).

2.6.4.2.1 HIV

HIV dramatically increased the risk of mortality during retreatment. Studies showed in Kenya, Uganda, Zambia, and Zimbabwe that 70% of patients completing TB treatment had at least one comorbidity, with HIV co-infection present in 44% of infected TB cases (Kévelaitiene et al.,2025). Nur et al (2025) conducted a study in Ethiopia, found that HIV-

positive individuals were about five times more likely to fail TB treatment than HIV-negative patients, underscoring HIV as a key factor in poor TB outcomes.

Matulyte et al (2023) conducted a longitudinal retrospective study in Lithuania in Baltic region among 345 TB-HIV cases, aimed to assess the clinical and socio-demographic characteristics of adults co-infected with tuberculosis (TB) and HIV, as well as their treatment outcomes. Treatment success was notably low (61.4%) for drug-susceptible TB and only 34.6% for drug-resistant TB. Drug resistance was prevalent, affecting 38% of new cases and 61% of retreatment cases. Overall, unsuccessful treatment occurred in 38.6% of drug-susceptible and 65.4% of drug-resistant cases, underscoring the difficulties of managing TB-HIV co-infection. The study highlights the urgent need for strengthened integrated TB-HIV services, emphasizing early diagnosis and specialized management of drug-resistant cases to improve outcomes.

2.6.4.2.2 Diabetes Mellitus (DM)

DM significantly increases the risk of tuberculosis (TB), contributing to worse treatment outcomes, higher mortality, and occasionally greater multidrug-resistant TB risk. DM impairs immune function, slows sputum conversion, and complicates TB management (Osei-Wusu et al., 2025). Out of unlimited studies, Huangfu and his colleagues conducted a systematic review and meta-analysis of 104 studies that included more than 56,000 TB patients with diabetes and over 243,000 without. The analysis showed that diabetes substantially worsens TB outcomes. Specifically, TB patients with diabetes had nearly double the risk of death (OR 1.88) and a 64% higher risk of relapse (OR 1.64) compared to non-diabetic patients. In addition, diabetes was linked to an almost two-fold increase in the risk of multidrug-resistant TB (OR 1.98). Based on these findings, the authors emphasized the importance of integrating diabetes screening and management into TB control programs to improve survival and treatment success (Huangfu et al.,2019). Similarly, Gautam et al. (2021) reviewed 74 studies from South Asia to examine the prevalence of diabetes among TB patients and its impact on treatment outcomes. They found that about 21% of TB patients had diabetes, with rates ranging from 11% in Bangladesh to 24% in Sri Lanka. Co-infected patients faced significantly worse outcomes, including a 70% higher risk of mortality (OR 1.7) and 70% higher risk of treatment failure (OR 1.7), though no association was seen with multidrug-resistant TB (OR 1.0). The authors concluded that routine diabetes screening and management should be incorporated into TB programs in South Asia to reduce deaths and improve treatment success.

2.6.4.2.3 Chronic Kidney Disease (CKD)

CKD is an increasing global health concern, and when it occurs alongside TB, it leads to worse clinical outcomes. Evidence indicates that people with CKD, especially those receiving hemodialysis, face a greater risk of developing TB and have less favorable treatment results compared to the general population. Xiao et al. (2022) examined TB in Chinese patients with chronic kidney disease (CKD), focusing on clinical patterns and outcomes. The study found that CKD patients, particularly those in advanced stages or on

hemodialysis, had a much higher risk of extrapulmonary TB and mortality compared to non-CKD patients (37.3%) in dialysis patients and (31.9%) in advanced CKD versus (6.1%) in non-CKD. Key predictors of death included older age, late-stage CKD, hemodialysis, and low albumin levels. The researcher stressed the importance of early detection and tailored management to improve survival and treatment outcomes in this vulnerable group. Similarly, Pradhan and Sigdel (2020) conducted a descriptive study in Nepal, aimed to determine the prevalence, clinical features, and treatment outcomes of tuberculosis (TB) among patients with chronic kidney disease (CKD) in a tertiary hospital. They found that 13.7% of CKD patients in Nepal developed TB, with nearly one-third dying within two months of treatment despite a 59.2% improvement rate. The study underscores the urgent need for early screening and timely management to reduce poor outcomes and mortality in this high-risk group.

2.6.4.2.4 COVID-19

The COVID-19 pandemic has further complicated TB control, as both diseases primarily affect the lungs and share symptoms such as cough and fever, which can delay diagnosis and timely treatment. Evidence indicates that COVID-19 can disrupt TB management and, when co-infection occurs, increases the risk of severe disease, higher mortality, and long-term lung damage. A multi-country study was conducted by a team of researchers to evaluate the long-term outcomes of patients co-infected with tuberculosis (TB) and COVID-19. The study found that over 10% of co-infected patients died during follow-up, with the highest mortality observed when both TB and COVID-19 contributed to death. Co-infection was also linked to reduced survival and a greater risk of chronic lung complications. The authors emphasize the need for integrated care pathways that prioritize early diagnosis, patient-centered management, and long-term follow-up to reduce mortality and improve outcomes in this high-risk population (Casco et al., 2023). Another descriptive study was conducted, aimed to assess, examined the impact of the COVID-19 pandemic on tuberculosis (TB) diagnosis, multidrug-resistant TB (MDR-TB) detection, and TB-related mortality across 11 countries in Europe, North America, and Australia. Their study found a significant decline in TB case notifications and MDR-TB diagnoses in 2020 compared to 2019, while TB-related deaths increased in most countries. These results highlight how the pandemic disrupted TB control, delayed diagnosis, and contributed to poorer patient outcomes. The authors stress the importance of maintaining resilient health systems and uninterrupted TB services during global health crises to reduce mortality and improve treatment success (Nalunjogi et al.,2023).

2.6.4.2.5 Organ Transplant

People who receive organ transplants are especially vulnerable to tuberculosis. Among solid organ transplant recipients, the incidence of TB is markedly higher, particularly in older individuals and men, and developing TB in this group more than doubles the risk of death. Systematic reviews have shown that organ transplant recipients face a 20- to 74-fold higher incidence of tuberculosis (TB) than the general population, largely because

immunosuppressive therapy heightens the likelihood of latent TB reactivation or new infections (Vega et al.,2025). Chuang et al. (2025) investigated tuberculosis (TB) risk and outcomes among solid organ transplant recipients in Taiwan, focusing on how post-transplant immunosuppression affects disease development and survival. In a cohort of 7,685 recipients followed over 34,412 person-years, they identified 201 TB cases, with men and those over 65 at notably higher risk. TB infection doubled the mortality rate compared to non-infected recipients. The authors recommend strengthening TB screening and ongoing monitoring before and after transplantation, particularly for older male patients, to support earlier diagnosis and reduce TB-related deaths in this vulnerable group. Additional study carried out by Natori et al. (2019) aimed to examine the incidence, clinical outcomes, and long-term immune response to tuberculosis (TB) in solid organ transplant recipients, who face elevated infection risks due to immunosuppression. The study found that TB occurred more frequently in transplant recipients than in the general population, with many cases presenting as atypical or extrapulmonary disease, making diagnosis more challenging. Despite adequate treatment, transplant recipients often faced delayed recovery, graft complications, and impaired TB-specific immunity, increasing the risk of reactivation or reinfection. The authors recommend thorough screening, early treatment, and continuous immune monitoring to improve outcomes.

2.6.4.2 .6 Pregnancy

It remains unclear whether pregnancy increases the likelihood of progression from tuberculosis infection (TBI) to active TB. However, large epidemiological studies indicate that women face the greatest risk of developing TB within the first 90 days postpartum compared to any other period in their lives. According to the national registry study, TB incidence found to be elevated among pregnant and postpartum women, with rates 1.4 times and 1.9 times higher, respectively, compared to the general population In the meantime, pregnant individuals who test positive on an IGRA or TST should be evaluated for active TB through symptom screening and, if indicated, sputum analysis using molecular tests or M. tuberculosis culture (Mathad et al.,2022). The systematic review and meta-analysis titled Mycobacterium tuberculosis infection in pregnancy assessed the risk of progression from latent TB infection (TBI) to active tuberculosis (TB) during pregnancy and the postpartum period. The review included five studies that quantified perinatal progression from MTB infection to active TB disease. Two of these studies demonstrated an increased risk compared to non-pregnant populations, with incidence rate ratios (IRR) of 1.3–1.4 during pregnancy and 1.9–2 postpartum. These findings underscore the elevated risk of TB progression during the perinatal period, highlighting the importance of screening and preventive measures for pregnant and postpartum women (Morton, et al.,2024).

2.6.5 Healthcare System Factor

Healthcare system factors play a critical role in controlling the incidence of tuberculosis (TB), as weaknesses in health infrastructure, limited access to diagnostic and treatment

services, and shortages of trained healthcare personnel can delay diagnosis and interrupt effective care. Incompetent case early detection, improper or delayed follow-up, and limited integration of TB services within primary healthcare settings significantly contribute to prolonged periods of infectivity and circular transmission of the disease in the community. Additionally, under-funded health infrastructure settings hindered the implementation of the over control programs like directly observed therapy (DOT) or to provide timely treatment for drug-resistant TB, further increasing TB incidence and prevalence.

2.6.5.1 Limited Access to Diagnostic Tools

Limited access to accurate and timely diagnostic tools plays a significant role in nourishing the high incidence and prevalence of tuberculosis (TB) globally. Delayed and /or missed diagnostic tests delayed the early detection and treatment of active TB cases, sustaining the risk of ongoing community transmission. In many low- and middle-income countries, dependance on conventional methods such as sputum smear microscopy, blood and stool tests, reported low sensitivity particularly among HIV individuals or extrapulmonary TB, contributes to underdiagnosis and misclassification. Furthermore, gaps in the availability of advanced diagnostics like GeneXpert MTB/RIF, and line probe assays, hindered the detection of drug-resistant cases, leading to inappropriate treatment and further spread of resistant strains. Such missing in diagnostic kits undermine TB control efforts besides contributing to higher morbidity, mortality, and financial healthcare burden (WHO, 2025c). A study conducted in 2024 by Bai and colleagues investigated the global trends in tuberculosis (TB) incidence and identified diagnostic tests limitations as significant contributors to the disease infectivity. The researchers found that despite the downward trend of TB incidence from 2000 to 2021, limited available diagnostic tests for TB, in addition to imperfect access to most important health information hindered early detection and treatment, leading to increased transmission and prevalence of TB. The study highlighted the need for improved diagnostic tools and strategies to address regional disparities to reduce the global TB burden.

2.6.5.2 Loss to Follow-up during Tuberculosis Treatment (LTFU)

One of the major obstacles to TB elimination is poor treatment adherence, including delayed care-seeking, treatment discontinuation, and loss to follow-up (LTFU). In 2025, national reports from India indicated that LTFU rates ranged from 15% to 25%, highlighting ongoing challenges to treatment continuity. Qualitative work in rural India further illustrated the consequences of LTFU. In Haryana's Ballabgarh block, Khaitan et al. (2024) interviewed TB patients who defaulted on treatment and staff from the National TB Elimination Program (NTEP) to explore determinants of LTFU with a focus on alcohol use. Both patients and program staff identified alcohol consumption as a major contributor to treatment discontinuation via multiple pathways, including adverse interactions with medications, financial strain, reduced family support, and behavioral factors. Treatment interruption was associated with relapse, drug resistance, and continued transmission,

ultimately worsening patient outcomes and undermining TB control. The authors recommended routine assessment of alcohol use at treatment initiation and completion, alongside integrating brief cessation interventions into TB care (Khaitan et al., 2024).

Similar findings have been reported at the national scale. Barreto-Duarte et al. (2024) analyzed TB cases in Brazil (2015–2022) using the national surveillance registry to identify factors associated with unfavorable outcomes among retreatment cases. Of 743,823 reported cases, 555,632 met inclusion criteria, comprising 462,061 new cases and 93,571 retreatments (48,929 after LTFU and 44,642 recurrent). Individuals with prior LTFU had nearly fourfold higher odds of poor treatment outcomes (OR = 3.96) and almost fivefold higher odds of being lost to follow-up again (OR = 4.93). Treatment success among recurrent LTFU patients fell well below WHO End TB Strategy targets. The authors emphasized that patients returning to treatment after LTFU constitute a high-risk group and recommended targeted adherence support to improve treatment success and advance national progress toward WHO TB elimination goals (Barreto-Duarte et al., 2024).

2.6.5.3 Directly-observed Treatment (DOT)

DOT is an effective strategy in which healthcare workers or trained personnel directly watch patients take their tuberculosis (TB) medication to ensure proper adherence. This method is designed to prevent missed doses, incomplete treatment, and the emergence of drug-resistant TB. Implementation of DOS requires some basic resources, including trained staff, transportation, and devoted time to reach patients especially those live in remote or underserved areas, to supervise every patient consistently. Thus, it demands flexibility, and patient cooperation to overcome stigma issues, as individuals must be available for daily or frequent convenient visits based on the patient's situation, which need consistent funding and. In addition, the financial and infrastructural constraints in low- and middle-income countries make it difficult to maintain large-scale DOT programs. In a retrospective cohort study of 712 TB patients with comorbidities in Negeri Sembilan, Malaysia (2018–2023), aimed to estimate the proportion of successful TB treatment outcomes among patients with comorbidities and to identify the determinants of treatment success in this population in Negeri Sembilan. The study found that 76.0% achieved a successful treatment outcome, while 24.0% had unsuccessful outcomes. Among those with failed or incomplete treatment, only 37.4% received directly observed therapy (DOT) during the intensive phase, whereas 62.6% did not receive DOT. The authors recommended strengthening the use of DOT during the intensive treatment phase for TB patients who have comorbidities, as DOT was strongly associated with successful outcomes (Dashuki, et al.,2024).

2.7 Regional Distribution of TB (Incidence and Prevalence)

Globally, TB incidence in 2023 reached 134 per 100,000 population with 8.2 million newly diagnosed cases; among them, 6.8% were HIV-positive (WHO, 2024b; Adam et al., 2024). About half of TB cases occur in eight countries: India (26%), Indonesia (10%),

China (6.8%), Philippines (6.8%), Pakistan (6.3%), Nigeria (4.6%), Bangladesh (3.5%), and South Africa (3.1%) (Adam et al., 2024). India alone reported 2.95 million cases (210 per 100,000) in 2021, while China recorded 741,000 new TB cases in 2023 (52 per 100,000), including 9,500 HIV-positive individuals. Indonesia reported a high TB prevalence with district-level peaks, such as Semarang at 426.4 per 100,000 in 2023(Sulistiyani et al., 2025), while Iran reported 23.84 per 100,000 in 2024 (Khursheed et al., 2024). Ethiopia recorded 210/100,000 incidence and 200/100,000 prevalence (Damtie et al., 2025). TB incidence remains highest in South-East Asia (45%) and Africa (24%), followed by the Western Pacific (17%), with lower burdens in the Eastern Mediterranean (8.6%), Americas (3.2%), and Europe (2.1%) (Almatroudi, 2024). The African region alone reported 2.55 million cases in 2023, with an incidence of 206 per 100,000 (Cioboata et al., 2025).

According to WHO, the overall TB incidence in the Eastern Mediterranean Region was reported at 115 cases per 100,000 population. Bases on the WHO data (2020–2023) regards the Gulf region, most GCC countries have relatively low TB incidence rates (cases per 100,000 population). Concerning Gulf Cooperation Council (GCC) region, Qatar has the highest TB incidence (35/100,000), followed by Bahrain (12/100,000), Oman (11/100,000), with Kuwait and Saudi Arabia at lower rates (10/100,000); UAE consistently is the lowest in the region at 1 per 100,000. In general, GCC states remained below 24 per 100,000 (Maatoug et al., 2025). According to the Middle East, TB incidence in Saudi Arabia decreased from 18 per 100,000 in 2002 to 10 per 100,000 in 2017, stabilizing at 12–14 per 100,000 by 2015–2023, with higher rates among non-nationals (10.9 vs 7.4 per 100,000) (Alateah et al., 2020; Alshammari et al., 2025). Jeddah reported the highest incidence (25.4 per 100,000) (Semilan et al., 2021). In Oman, migrants constituted 71.4% of TB cases, with an average of 356 active TB cases annually. In Turkey, TB incidence declined from 14 in 2022 to 13 per 100,000 in 2023 (Alyaquobi et al., 2025). Concerning Bilad al-Sham TB incidence rate, Syria accounting for (17/100,000), with Lebanon (10/100,000), Jordan (3.4/100,000), Gaza (3.5/100,000), while West Bank is included among the lowest in the region with incidence of (0.18/100,000). Israel is in the pre-elimination phase (2.1 per 100,000), but localized outbreaks reached 138 per 100,000 (Fuchs et al., 2024). In accordance to the East region of Asia, TB incidence in Korea, was 80 per 100,000, with notable misdiagnosis risks (Kim et al., 2022; 2025). In Iran, incidence was 12 per 100,000 nationally, higher in border provinces counting for 23.8 per 100,000 in 2024 (Mirkarimi, 2025).Regards EMR/Middle East region, Pakistan is the overwhelmingly dominant contributor to regional TB burden accounting for about 70–71% of TB cases in the region, with an incidence well above 250 per 100,000 ,followed by Afghanistan accounting for(9%)of total TB cases, had the highest EMR incidence rate at 85.1 per 100,000 population in 2019,while TB incidence in Egypt reported 10 per 100,000 (Nour & Nour, 2024).

North Africa recorded rates above 50 per 100,000. South Africa remains a hotspot, with incidence above 500 per 100,000 in KwaZulu-Natal and an M. tuberculosis infection prevalence of about 23% among adolescents (Mzembe, 2024). Among older adults, TB prevalence was 2.9%, highest in the 50–59 age group (Akokuwebe et al., 2024). Eastern

Ethiopia showed 7.8% pulmonary TB prevalence among household contacts (Adane et al., 2020). Ethiopia overall reported 210 per 100,000 incidences (Damtie et al., 2025). In conflict-affected North Wollo, Ethiopia, prevalence reached 17.2%, with high multidrug resistance (36.2%) (Asmare et al., 2025). West Africa is heavily burdened, with TB–HIV coinfection 15–21% and TB-DM prevalence 2.4–9.4%. In West Africa, limited data suggest TB-diabetes comorbidity at 2.4% overall, but higher in Ghana (9.4% among TB patients). TB-HIV coinfection remains a major issue, affecting 15–21% of TB patients in the region, mirroring the high HIV prevalence (Osei-Wusu et al., 2025a).

Europe and Americas reported different TB incidence rates. The UK is low incidence (7.75 per 100,000), but certain urban areas show higher levels: Newham (41.3), Leicester (38.9), Brent (37.4) (Ahmed et al., 2025). In Ukraine, prison incidence exceeded 4000 per 100,000 inmates, far higher than in the civilian population. In the US, refugees showed 23.2% latent TB prevalence, with low preventive treatment completion (Shen et al., 2025). The US prison system accounted for 4.2% of national TB burden (Nyasulu et al., 2025). In summary, TB incidence rate in high-income countries generally remained below 10/100,000, whereas in many low- and middle-income countries (LMICs), incidence often exceeds 200/100,000 (Cioboata et al., 2025).

The 2024 Global Tuberculosis Report, using annual data from 215 countries, including all 194 WHO Member States, presented the number countries that reported data to WHO Table (2.1) below (WHO, 2025c).

	COUNTRIES AND AREAS		WHO MEMBER STATES	
	NUMBER	NUMBER THAT REPORTED DATA	NUMBER	NUMBER THAT REPORTED DATA
African Region	47	47	47	47
Region of the Americas	45	40	35	34
South-East Asia Region	11	11	11	11
European Region	54	40	53	39
Eastern Mediterranean Region	22	21	21	20
Western Pacific Region	36	34	27	27
Global	**215**	**193**	**194**	**178**

Table (2.1) Number of countries that reported data to WHO (2024)

Survey data show that the prevalence of bacteriologically confirmed pulmonary TB trends vary by region. In Viet Nam, apparent increases in 2017 compared to 2007 were due to improved diagnostics, with true prevalence actually declining. Results from Cambodia and Timor-Leste are pending. Reported prevalence ranged from 119 to 852 per 100,000 in African countries and from 119 to 1,159 per 100,000 in Asian countries, with higher rates often observed in older age groups (WHO, 2024b)

According to drug-resistant TB Between 2015 and 2019, global MDR/RR-TB cases declined slightly but stabilized at about 400,000 annually from 2020–2023. By 2023, the share of MDR/RR-TB fell to 3.2% in new TB cases and 16% in previously treated cases, down from 4.1% and 20% in 2015. Over half of all cases occurred in India, Russia,

Indonesia, China, and the Philippines. Regional differences are marked: <3% of new cases in Africa, South-East Asia, and the Eastern Mediterranean versus 24% in Europe; among previously treated cases, rates ranged from 8.4% to 54%. In 2023, 1.4 million developed isoniazid-resistant TB, and 19% of MDR/RR-TB cases were pre-XDR-TB (WHO, 2024b).

Within the unlimited studies conducted regards regional distribution of TB, a retrospective review of 12,494 medical records from King Abdul-Aziz University Hospital (KAUH) in Saudi Arabia between 2019 and 2021 identified 131 confirmed TB cases with detailed information on demographics, comorbidities, diagnostics, and outcomes. The highest prevalence was observed in 2020 (14.07 per 1,000) compared to 2019 (10.27 per 1,000) and 2021 (7.09 per 1,000), with a later rise again in 2022 (10.48 per 1,000). Among the TB patients, 19.8% showed resistance to a single drug, and 10.7% had multidrug resistance, while 16% died during the study period. Notably, pulmonary TB accounted for 75.6% of the cases (Mokhtar et al., 2025). Additionally, a nine-year retrospective descriptive study in Iran examined the epidemiology of children exposed to TB in Golestan city. Provincial data showed higher prevalence rates, with Sistan and Baluchestan at 44 per 100,000, Golestan at 38 per 100,000, and Khorasan at 25 per 100,000. Specifically, in Golestan province, the Pooled TB incidence and prevalence were reported as 20.88 and 38.15 per 100,000, respectively (Mirkarimi, 2025).

2.8 Mortality Rate of TB

Tuberculosis (TB) continues to be a major global health threat and one of the leading causes of death from infectious diseases, particularly among people living with HIV. In 2021, tuberculosis (TB) was responsible for about 1.6 million deaths worldwide, including 187,000 among people with HIV. It was the 13th leading cause of death and the second deadliest infectious disease after COVID-19, overtaking HIV/AIDS. An estimated 10.6 million people developed TB where 6 million men, 3.4 million women, and 1.2 million children. In 2023, an estimated 1.25 million people died from TB worldwide, including 1.09 million HIV-negative individuals and 161,000 people living with HIV, with the majority of deaths occurring in low- and middle-income countries (WHO, 2024b). TB disproportionately affects Asia and Africa, with India alone accounting for approximately 35% of global TB deaths among HIV-negative individuals in 2021 and a case fatality ratio of 17% (Hashim et al., 2024). In Africa, countries such as South Africa report high mortality due to TB-HIV co-infection, while West African nations, including Nigeria and Liberia, face persistent TB related deaths driven by weak healthcare systems (Osei-Wusu et al., 2025b). The African region has an overall TB incidence of 164 per 100,000 population, resulting in an annual mortality rate of 27.5 per 100,000 (WHO, 2024b). In Egypt, the TB case fatality ratio is lower at 4% (Nour & Nour, 2024).

In the Eastern Mediterranean Region, TB deaths rose during 2020–2021, declined in 2022, and remained stable through 2023, while in the Americas, mortality peaked in 2022 before decreasing in 2023. Globally, countries experiencing significant drops in TB case notifications, such as Indonesia, Myanmar, and the Philippines, saw noticeable increases in TB deaths between 2019 and 2021 (WHO, 2024b). By 2023, six high TB burden countries

including; Kenya, Mozambique, Nigeria, Uganda, Tanzania, and Zambia were approaching the 2025 WHO End TB Strategy milestone of a 75% reduction in TB mortality compared with 2015 (WHO, 2024b). Despite global efforts, TB incidence and mortality reductions remain below targets. Between 2015 and 2020, TB incidence decreased by only 9%, with an annual decline of approximately 2%, while mortality fell by 14%, well below the 35% target (Chakaya et al., 2021).A cross-sectional study was conducted among 392 adults in Riyadh, highlight ongoing gaps in TB awareness, further underscoring the persistent threat of the disease (Alshammari et al., 2025).

2.9 Global Burden of TB

Tuberculosis (TB) remains a major global health challenge, causing an estimated 10.8 million new cases and 1.25 million deaths in 2023, with over 95% of cases occurring in low- and middle-income countries (LMICs). Although TB incidence declined by approximately 10% between 2015 and 2021, cases have been rising again since 2020 (Bai & Ameyaw, 2024; & Fuchs et al., 2024). For example, in Indonesia, economically productive adults are disproportionately affected by TB leads to 3-4 months of lost work and a 20–30% reduction in household income (Wikurendra et al., 2021), while in India, families faced severe financial hardship due to treatment costs which accounts for about 35% of their income assigned for TB care among HIV-negative individuals (Hashim et al., 2024). Globally, over 50% of TB-affected households experience catastrophic costs, and the funding gap for TB programs was estimated at $5.7 billion in 2023 (WHO, 2023a; Adam et al., 2024).

Multidrug-resistant TB (MDR-TB) remains a significant threat, and latent TB infection is highly prevalent in high-risk groups, such as healthcare workers in Egypt (59.1% prevalence in Zagazig City) (Nour & Nour, 2024). LMICs bear the greatest burden due to limited healthcare access, TB–HIV co-infections, and comorbidities like diabetes (Cioboata et al., 2025). Regions such as West Africa lag in reducing TB incidence and mortality, with some countries showing increases in deaths (Osei-Wusu et al., 2025a). TB has likely reclaimed its position as the leading cause of death from a single infectious agent, surpassing HIV/AIDS, highlighting its ongoing medical, economic, and social impact worldwide (Kévelaitiene et al., 2025; Maatoug et al., 2025). Figure (2.2) shows the high burden countries of TB based on WHO report in 2021.

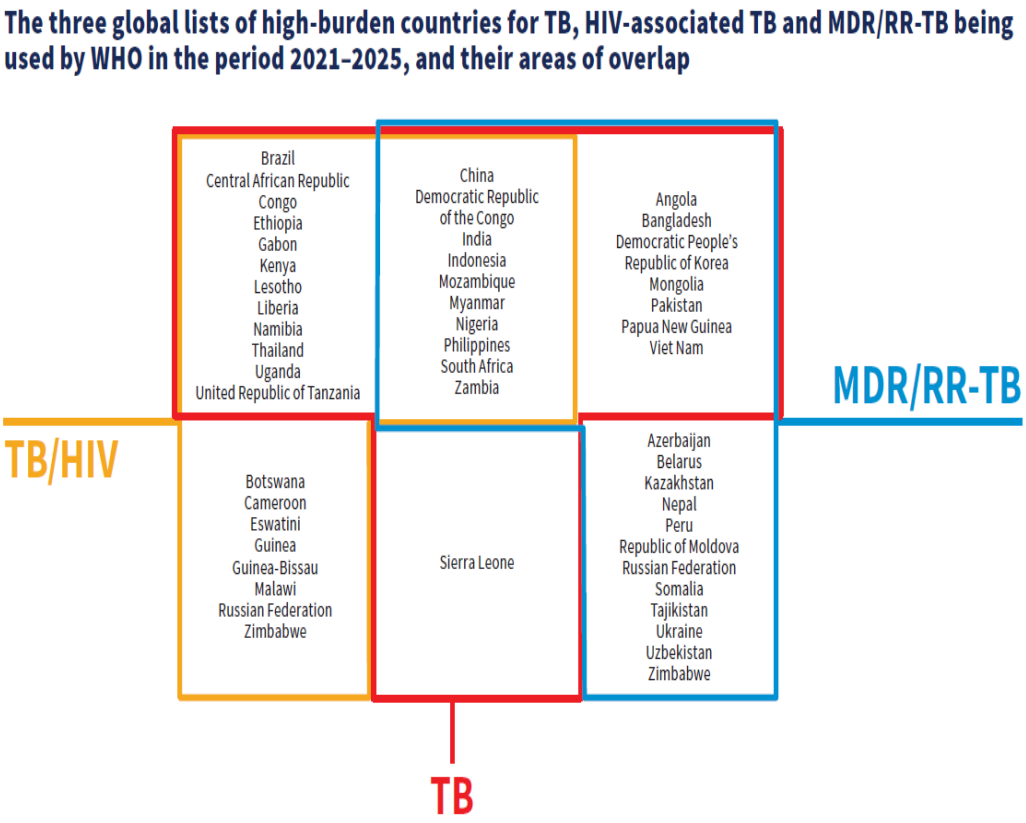

Figure (2.1) High TB Burden Countries Based on WHO Report (2021)

An empirical study conducted by The George Institute for Global Health in 2024 assessed the economic burden of tuberculosis (TB) treatment among 1,482 drug-susceptible TB patients across four states in India: Assam, Maharashtra, Tamil Nadu, and West Bengal. The study revealed that the mean total cost per TB episode was approximately $903 USD, encompassing direct medical costs, direct non-medical costs, and indirect costs such as income loss due to illness. Notably, 30% to 61% of patients experienced catastrophic costs, defined as expenditures exceeding 20% of their pre-TB annual household income. The primary contributors to these costs were delays in diagnosis and prolonged treatment periods, leading to significant financial strain on affected households. The study underscores the need for enhanced financial and social protection mechanisms to alleviate the economic burden on TB patients and their families (Chatterjee et al.,2024).

2.10 Prevention of TB

Tuberculosis (TB) prevention requires a multifaceted approach that includes early diagnosis, vaccination, preventive therapy, and community education. National TB prevalence surveys are critical tools for monitoring incidence, evaluating the impact of interventions, and informing policy decisions to reduce disease burden (WHO, 2024b). Targeted case-finding, particularly among adolescents and young adults (AYA), is vital in high-incidence settings, as this age group plays a central role in TB transmission. Household contact investigations and TB preventive therapy (TPT) remain especially important for children and immunocompromised individuals (Laycock et al., 2021).

The Bacillus Calmette-Guérin (BCG) vaccine, introduced in the 1920s, remains the only widely used TB vaccine. It effectively protects infants and young children against severe forms of TB, such as meningitis and disseminated disease, but its efficacy against pulmonary TB in adolescents and adults -the primary transmitters of the disease-is limited and inconsistent (Maani et al., 2025). This limitation has created an urgent global need for more effective vaccines. Modeling studies suggest that a vaccine with even 50% efficacy in older populations could prevent up to 76 million TB cases and 8.5 million deaths over 25 years, generating an economic return of USD 7 for every dollar invested (WHO, 2022c).

Several new vaccine candidates are in development to address these gaps. These include subunit vaccines, such as AERAS-402, which boost immunity initiated by BCG, and viral vector vaccines, including adenovirus-based platforms, designed to elicit strong cellular immune responses critical for TB control (Maani et al., 2025). As of August 2024, fifteen candidates were undergoing clinical trials, including four in Phase I, five in Phase II, and six in Phase III, covering prevention of infection, disease progression, and improved treatment outcomes, with six late-stage Phase III candidates representing significant progress toward an effective TB vaccine (WHO, 2023b; WHO, 2024b). The global health community recognizes that the introduction of such vaccines is crucial to achieving the WHO End TB Strategy targets for 2035, as they would substantially accelerate reductions in TB incidence and mortality beyond what current interventions can achieve (Adam et al., 2024).

In addition to vaccine development, preventive strategies have expanded to include shorter rifamycin-based regimens, such as 3HP (weekly isoniazid and rifapentine for 3 months), 3HR (daily isoniazid and rifampicin for 3 months), 1HP (daily isoniazid and rifapentine for 1 month), 4R (daily rifampicin for 4 months), and 6H or longer (daily isoniazid for 6 months or more), which are increasingly being implemented worldwide (WHO, 2023b). Complementing biomedical interventions, culturally adapted awareness campaigns have improved TB knowledge and reduced stigma in regions such as Saudi Arabia, Ethiopia, and South Asia (Alshammari et al., 2025; Tora et al., 2022; Bäckdahl & Sharma, 2021). Effective TB control also requires addressing underlying social determinants, including malnutrition, poverty, and HIV co-infection, and ensuring equitable access through universal health coverage (UHC) and financial risk protection (Abraham et al., 2025; Portnoy et al., 2023). Collectively, these combined efforts, including early detection, improved vaccination, preventive therapy, education, and tackling social determinants, are essential to advancing the WHO End TB Strategy goals for 2035.

Among several studies in this field, a cross-sectional study of 392 adult residents in Riyadh, Saudi Arabia, assessed knowledge, attitudes, and practices regarding tuberculosis (TB). Overall, awareness was high: 94.6% of participants had heard of TB, and 85.2% recognized that it primarily affects the lungs. Most respondents (85.5%) knew TB could spread from person to person, yet 14.5% were unaware of its transmissibility, and 31.1% did not know it was caused by bacteria. Awareness of diagnosis and treatment was moderate: 80.1% knew about a specific test for TB, and 77.6% understood that TB is

curable. Significant associations were found between TB awareness and marital status (p=0.001) as well as occupation (p=0.001), while no gender-related differences were observed. Healthcare professionals exhibited the greatest level of awareness, whereas younger individuals and housewives showed comparatively lower levels of knowledge. The study underscores the urgent need for culturally relevant health education campaigns, with particular focus on underserved groups such as housewives and younger populations. Married participants demonstrated higher levels of awareness (Alshammari et al., 2025). Studies from other regions, such as Oman and Southeast Asia, have similarly emphasized that raising public awareness plays a crucial role in combating tuberculosis (Tora et al.,2022).

2.11 Treatment of TB

Tuberculosis (TB) is generally curable with consistent and effective treatment, which typically involves a combination of anti-tubercular drugs administered over six months or longer to target susceptible bacteria (Wikurendra et al., 2021). The standard regimen for drug-susceptible TB includes Isoniazid (H), which targets actively growing TB bacteria and is critical in both the intensive and continuation phases. Rifampicin (R), which is a potent bactericidal drug that helps shorten treatment duration. Ethambutol (E) is primarily used to prevent the development of drug resistance. Pyrazinamide (Z) is particularly effective in killing dormant TB bacteria during the initial intensive phase. The typical treatment course lasts 6 months, with all four drugs administered daily for the first 2 months (intensive phase), followed by isoniazid and rifampicin for the remaining 4 months (continuation phase) (WHO, 2022d). For drug-resistant TB, second-line medications are used, including streptomycin, amikacin, kanamycin, levofloxacin, moxifloxacin, bedaquiline, and linezolid, depending on the resistance pattern (Adam et al., 2024; &Wu et al., 2022).

In Egypt, TB treatment coverage was reported at 60%, with a treatment success rate of 89% for new and relapsed cases; noncompliance, poor patient knowledge, lack of health education, and comorbid diabetes were significant predictors of treatment failure (Nour & Nour, 2024). Male sex has been associated with poorer outcomes, including death and treatment failure, but this association is primarily mediated by behavioral factors such as treatment adherence, rather than biological differences (Pedersen et al., 2025; & Barathi et al., 2023). Sociodemographic risk factors such as low education, unemployment, smoking, substance abuse, homelessness, and previous incarceration are more prevalent among males and contribute to these disparities (Dabitao & Bishai, 2023). Globally, TB treatment success rates remain high for drug-susceptible TB at 88% but are lower for multidrug-resistant or rifampicin-resistant TB (MDR/RR-TB) at 68%. In 2023, approximately 175,923 people were treated for MDR/RR-TB, representing 44% of the estimated cases, with India, Russia, Indonesia, China, and the Philippines accounting for over half of the global burden (Adam et al., 2024). Treatment coverage above 80% was reported in Brazil, India, Mozambique, Papua New Guinea, Sierra Leone, Uganda, and Zambia (Franco et al., 2024). Treatment success rates are lower among people living with HIV (79%) compared to children aged 0–14 years (90%) and slightly higher in females (89%) than males (86%).

The WHO recommends first-line treatment for drug-susceptible TB with a 6-month regimen of isoniazid, rifampicin, ethambutol, and pyrazinamide, with newer regimens including a 4-month course with rifapentine and moxifloxacin for specific populations (WHO, 2023a; WHO, 2022d). Drug-resistant TB, including XDR-TB, requires second-line drugs or newer regimens such as bedaquiline and linezolid, which have improved outcomes for patients with HIV co-infection (Wu et al., 2022; WHO, 2024c). Nutritional status significantly affects TB outcomes, as undernutrition and household food insecurity increase TB risk, and behavioral factors such as cigarette smoking, chat chewing, and alcohol consumption further reduce treatment success, highlighting the need to address lifestyle and nutritional determinants in TB control initiatives (Abraham et al., 2025).

Gaballah et al. conducted a retrospective cohort study in Alexandria, Egypt, from 2005 to 2015, involving 400 tuberculosis (TB) patients. The study aimed to assess treatment outcomes and identify regional variations in TB management. The results indicated an 82.3% treatment success rate, with 10.3% mortality and 3.0% treatment failure among the participants. Notably, Alexandria reported the lowest death rate among Egyptian governorates at 1.5%, suggesting effective local TB control measures. The study highlighted that noncompliance with treatment, poor patient knowledge, lack of health education, and comorbidity with diabetes mellitus were significant predictors for treatment failure. These findings underscore the importance of addressing behavioral and educational factors in TB management to improve treatment outcomes. The study's strengths included adherence to the PRISMA statement, large sample sizes, and inclusion of unpublished local research, providing a comprehensive overview of TB treatment outcomes in the region (Gahallah et al., 2021). Additionally, Dabitao and Bishai (2023) examined sex and gender differences in tuberculosis (TB) pathogenesis and treatment outcomes, highlighting that males generally experience lower treatment success rates and higher mortality compared to females. The study found that behavioral and social factors such as: smoking, occupational exposure, substance use, and delayed healthcare seeking that largely explain these disparities, rather than biological differences. Globally, treatment success rates were slightly higher in females (around 90%) than in males (approximately 86%), and males were more likely to experience unfavorable outcomes, including treatment failure and death. The authors emphasize the need to address gender-specific social determinants to improve TB outcomes.

2.12 Palestinian Situation of TB

2.12.1 National TB Burden

Tuberculosis (TB) in Palestine remains at a low burden level, with the country currently in the pre-elimination stage. Treatment outcomes are generally excellent, with success rates consistently ranging between 90-100%. However, the case detection rate has been historically low (5–10%), improving only recently to 51% in 2021, mainly due to underdiagnosis rather than overestimation of cases. In 2021, just 25 TB cases were reported nationwide,22 in Gaza (13 pulmonary and 9 extrapulmonary) and 3 pulmonary cases in the West Bank. The higher incidence in Gaza compared to the West Bank is likely

linked to lower socioeconomic conditions and the high concentration of refugee populations (65% in Gaza vs. 26.5% in the West Bank) (Palestinian Ministry of Health, Department of Preventive Medicine,2022).

Generally, individuals living in poverty, as well as those displaced by conflicts or natural disasters, face higher risks of malnutrition, crowded living conditions, poor sanitation, and limited access to healthcare, all of which increase their vulnerability to infection with MTB and the progression to active TB disease (International Society for Infectious Diseases, 2025). Despite these challenges, Palestine has made significant progress in TB prevention. The National Tuberculosis Guidelines, first published in 2011 and updated in 2022, provide comprehensive recommendations for case detection and treatment of both drug-susceptible (DS-TB) and drug-resistant TB (DR-TB). Achieving TB elimination in Palestine will require sustained multisectoral collaboration, adequate funding, continued training, and establishment of a national TB elimination committee to coordinate efforts across all stakeholders (Palestinian Ministry of Health, Department of Preventive Medicine, 2022). BCG vaccination is compulsory, and coverage remains 100%, with no reported cases of TB meningitis or miliary TB. Multidrug-resistant TB (MDR-TB) is extremely rare, with only three cases detected in the past two decades. Among them, one chronic case was referred to Jordan for second-line treatment. Additionally, all TB patients are routinely tested for HIV, though TB/HIV co-infections remain rare.

TB elimination activities are integrated into the Palestinian primary health care (PHC) system and are supported by multiple sectors: the Ministry of Health (MOH), UNRWA, NGOs, the private sector, and military medical services. Collectively, Palestine's health infrastructure includes 360 PHCs in the West Bank and 56 in Gaza run by MOH, along with 130 NGO-run centers in the West Bank, 55 in Gaza, 35 UNRWA centers in the West Bank, and 22 in although many facilities have since been severely affected by the conflict that escalated in October 2023. During 2009-2014, with Global Fund support, Tuberculosis Management Units (TBMUs) were established across all 17 districts (12 in the West Bank and 5 in Gaza). These TBMUs are staffed with trained PHC physicians, TB laboratory technicians, radiology services, and access to fixed-dose combination (FDC) drugs, with dedicated officers overseeing monitoring and supervision. Regarding diagnostic tests, Xpert MTB/RIF, a rapid automated molecular test that detects TB and rifampicin resistance, is now available in the West Bank. (Palestinian Ministry of Health, Department of Preventive Medicine,2022).

With support from the WHO through a tuberculosis control grant, the Ministry of Health (MoH) provides free diagnostic and treatment services despite difficult socioeconomic and political conditions. Key achievements have included the development of national TB guidelines, training modules for healthcare staff, and the establishment of a computerized surveillance system. Furthermore, the Department has implemented free DOTS-based treatment, routine HIV screening, and compulsory BCG vaccination. Contact tracing has also been strengthened through the provision of free Mantoux testing, prophylactic therapy for positive cases, and systematic follow-up investigations (Department of Preventive Medicine, 2010; WHO, 2012)

2.12.2 TB Incidence at National Level

Palestine is currently classified as a low TB burden country in the pre-elimination phase, with an incidence rate of fewer than 1 case per 100,000 population, and the prevalence is much less than 0.5%. Table (2.2) illustrates TB data of the number of new cases and incidence rate in Palestine reported by the Ministry of Health across 2020-2024, distributed by sex in the West Bank (Palestinian Central Bureau of Statistics,2025).

Year	Category	Tuberculosis
		A15-A18
2020	Male	4
	Female	2
	Total	6
	Incidence rate per 100,000 pop.	**0.22**
2021	Male	2
	Female	1
	Total	3
	Incidence rate per 100,000 pop.	**0.14**
2022	Male	4
	Female	4
	Total	8
	Incidence rate per 100,000 pop.	**0.23**
2023	Male	6
	Female	1
	Total	7
	Incidence rate per 100,000 pop.	**0.24**
2024	Male	7
	Female	2
	Total	9
	Incidence rate per 100,000 pop.	**0.18**

Table (2.2) Tuberculosis New Cases and Incidence Rate in Palestine (West Bank), Distributed by Sex, 2020–2024

2.12.3 Challenges Faced at the National Level

In Palestine, several interconnected challenges significantly delay TB control and impede early detection, diagnosis, and treatment. despite TB testing and treatment being largely covered by national health insurance and provided at minimal or no direct cost to patients. However, patients still face indirect financial burdens, including the cost of advanced diagnostic tests not routinely covered (e.g., IGRA, CT imaging), transportation to referral or specialized centers, and loss of income due to extended treatment or follow-up visits. The management of multidrug-resistant (MDR-TB) and rifampicin-resistant TB (RR-TB) further increases financial strain, as second-line anti-TB drugs are not consistently available locally—except for non-specific options such as levofloxacin and moxifloxacin—and treatment regimens are longer, more complex, and require specialized monitoring.

Diagnostic limitations also hinder timely care. Conventional tests, including sputum smear microscopy and culture, have low sensitivity, particularly in children, and advanced tools like GeneXpert MTB/RIF are not widely accessible. Health system weaknesses, such as understaffed laboratories, inadequate infrastructure, reduced coverage and follow-up, as there are shortages of trained personnel, including PHC physicians, nurses, TB laboratory technicians, radiologists, and preventive medicine staff, underscore the need for capacity building and training.

Sociocultural factors also impede TB control. Stigma, misinformation, and reluctance to disclose TB status reduce health-seeking behavior, delay diagnosis, and undermine treatment adherence and follow-up compliance. Limited social protection mechanisms and fear of social consequences exacerbate these challenges, particularly among vulnerable groups. The increased mobility and displacement of refugees following the October 7 conflict have further complicated early detection, contact tracing, and continuity of care.

Moreover, the COVID-19 pandemic has disrupted TB services, further delaying detection and treatment. Additionally, the National TB Elimination Program (NTEP) lacks a dedicated budget and relies heavily on external funding, particularly from the Global Fund. Collectively, these financial, systemic, diagnostic, sociocultural, and epidemiological challenges highlight the urgent need for comprehensive, context-specific interventions, health system strengthening, and sustained political commitment to achieve TB elimination in Palestine.

Chapter Three

3. Methodology

3.1 Study design

A retrospective descriptive study (population-based case series using surveillance data) was conducted from April to October 2025 across the West Bank's 11 governorates.
Data on tuberculosis (TB) cases were obtained from standardized patient investigation forms routinely collected by the Department of Preventive Medicine at the Palestinian Ministry of Health. These records were documented in Microsoft Access databases between 2016 and 2018 and subsequently in the DHIS2 electronic surveillance system since 2019 up to now, covering the period 2016–2024. The study encompassed all eleven governorates of the West Bank: Hebron, Ramallah and Al-Bireh, Bethlehem, Nablus, Jericho, Jenin, Tubas, Jerusalem, Tulkarem, Salfit, and Qalqilya. Each governorate is served by a dedicated health directorate that reports TB cases to the Preventive Medicine Department at the Ministry of Health, ensuring standardized surveillance across the region.

3.2 Study Population

All civilians residing in the 11 governorates of the West Bank in Palestine, including East Jerusalem, were considered the study population. These governorates are distributed across three central districts: the North, the Middle, and the South.

- **North governorates**: Tulkarem, Jenin, Tubas, Qalqilya, Nablus, and Salfit.
- **Middle governorates**: Ramallah and Jerusalem.
- **South governorates**: Bethlehem, Hebron, and Jericho.

According to the *Palestinian Health Annual Report (2024)*, the West Bank has a total population of **3,001,594 inhabitants**, distributed across the 11 governorates as shown in Table 1.

Table (3.1): Distribution of residents in the West Bank by governorate, 2016–2024

District/ Year	2016	2017	2018	2019	2020	2021	2022	2023	2024
West-bank	2803411	2856691	2921170	2986714	3053183	3120448	3188387	3256906	3325905
Jenin	306275	312135	318629	325271	332050	338919	345875	352875	359934
Tubas	59316	60399	61745	63114	64507	65915	67340	68779	70225
Tulkarem	182409	185140	188465	191873	195341	198856	202401	205946	209505
Nablus	378291	384953	392407	400012	407754	415606	423572	431584	439631
Qalqilya	109286	111425	113915	116454	119042	121671	124332	127025	129745
Salfit	73166	74790	76568	78380	80225	82099	84000	85920	87861
Ramallah	321234	326008	333194	340475	347818	355202	362602	370030	377465
Jericho	48820	49568	50481	51410	52355	53317	54289	55268	56256
Jerusalem	424935	431706	441585	451584	461666	471834	482064	492340	502625
Bethlehem	211342	215514	220227	225020	229884	234802	239740	244704	249689
Hebron	688337	705053	723954	743121	762541	782227	802172	822435	842969

(Palestinian Central Bureau of Statistics,2025)

3.3 Sampling Strategy

3.3.1 Sample Subject

In this study, the research subjects were composed of TB patients' investigation reports. All Dashboard-registered cases of active tuberculosis (Pulmonary TB, Extrapulmonary TB) were involved in this study.

3.3.2 Sample Size:

The study covered **all reported tuberculosis (TB) cases in Palestine between 2016 and 2024**. The total number of cases identified during this period was 70 cases

3.4 Inclusion and exclusion criteria

3.4.1 Inclusion criteria:

When analyzing TB cases registered on a national dashboard, specific inclusion criteria were applied to maintain accuracy and consistency, including the following points.

- All forms of tuberculosis, regardless of patient age or sex, including:
- ✓ Pulmonary TB
- ✓ Extrapulmonary TB
- ▪ Primary TB
- ▪ Secondary TB
- ▪ Relapsing TB
- ✓ TB–HIV co-infection
- Reported by the Preventive Medicine Department of the Palestinian Ministry of Health through primary health clinics across the West Bank.
- Registered in DHIS2 between 2019 and 2024 and on Access from 2016 to 2018.
- Newly diagnosed or retreatment TB patients within the defined study period.

- Cases with complete demographic and clinical data.
- Officially registered and confirmed according to national TB program guidelines.
- Patients who initiated treatment and have documented treatment outcomes.

3.4.2 Exclusion criteria:

- Duplicate records – if the same patient is registered more than once.
- Incomplete or missing data – such as missing diagnosis dates or demographic details.
- Transfer cases – patients transferred out of the country where the treatment outcome cannot be verified.
- Misdiagnosed or non-TB cases -individuals initially registered as TB but later confirmed not to have TB.
- Cases outside the study period – registrations before or after the defined timeframe.

3.5 Data collection

3.5.1 data collection tool

The TB investigation report is a standardized tool routinely used by the Palestinian Ministry of Health (MoH) to collect and monitor TB cases. It serves to document diagnosis, risk factors, treatment initiation, follow-up, and outcomes. This investigation is supposed to be comprehensive, helping in identifying patterns in incidence, prevalence, and treatment outcomes of TB cases. Moreover, the report designed to support the evaluation of TB program, covers the whole population through the national TB program effectiveness in Palestine., and facilitates long-term trend analysis over the infective years of TB.

Concerning the contents of such a report, it includes the following items:

- Patient demographics (age, sex, residence, nationality).
- Clinical information (type of TB: pulmonary, extrapulmonary, relapse, HIV co-infection).
- Laboratory results (sputum smear, GeneXpert, culture).
- Contact tracing and preventive interventions.

More details are present in Appendix A later on.

3.5.2 Validity and Reliability

The TB investigation reports collected by the Preventive Medicine Department of the Palestinian Ministry of Health were used as a validated primary data source, demonstrate high validity and reliability, as they are based on standardized national and WHO guidelines, utilize laboratory confirmation for diagnosis, and are systematically reported through the DHIS2 platform and on Access data base; however, some risks of underreporting and documentation gaps remain potential threatening to validity and

reliability of such collected data via these investigation reports primarily in Bedouin and marginally isolated areas.

The World Health Organization (WHO) and the Palestinian Ministry of Health collaborate on TB data collection and reporting. The WHO's Global Tuberculosis Report compiles data from national ministries of health, including Palestinian data, as it considers the primary source for national TB data and reports within Palestine, to detect TB cases early, provide a global overview of TB trends and progress, and provide estimates of TB burden. The WHO Regional Office for the Eastern Mediterranean (EMRO) also agrees on the content of such investigation reports, assisting in publishing such regional reports and specific information relevant to the Palestinian territories, particularly concerning public health initiatives like the Tuberculosis action plan. The Palestinian Central Bureau of Statistics (PCBS) Publicly disseminates data on reported TB cases and incidence in the West Bank, often including annual reports and data tables, showing how TB rates have changed over the years.

To ensure the quality of TB investigation reports, the MOH conducted training workshops for general doctors and nurses in Preventive Medicine minor departments across the 14 primary health directorates of the Palestinian governorates, aiming to enhance the comprehensibility of the investigation reports 'contents. A standardized protocol for data collection, analysis, and reporting is unified to ensure consistency across investigation reports. Quality assurance (QA) activities include verifying diagnostic accuracy, confirming outbreak genuineness, developing clear case definitions, performing methods to collect the data, and monitoring adherence to fulfill these investigation reports. Any inconsistencies between clinical and lab data are verified by the public Health laboratories affiliated by the MOH. A sufficient number of specimens asked to be collected to reconfirm initial laboratory results. Moreover, the preventive Medicine Department belongs to MOH, which regularly monitors the consistency of case reporting and the timeliness of investigations and reporting. Ongoing training for public health staff and laboratory technicians on updated protocols and best practices is kept on (Ayuningsih et al.,2022).

A remote audit by the team of the central Preventive Medicine Department in the Palestinian Ministry of Health, using readily available electronic files of the patients, provides a reasonable assessment of the gathered information of TB-eligible patients enrolled in the registry, declining the concerns of the missing patients, minimizing errors, ensuring consistency, and confirming that the data somehow truly represents the disease situation**.**

After constructing the data collection form related to research variables, it was reviewed by three experts: an infectious disease specialist and two academic learning doctors. Their comments were taken into consideration and modified before data collection, and the experts approved the data collection form.

3.5.3 Data Collection Technique

In the preparatory phase, ethical approval from the IRB was obtained after reviewing the proposal. Next, an approval was obtained from the relevant authorities belonged to the Palestinian Ministry of Health through the Al-Quds University legal channels. In the recruitment stage, more than five formal visits were done to the Preventive Medicine Department in the Ministry of Health to collect the data through the use of the standardized TB investigation reports registered on the DHIS2 surveillance system and the Access database. In the data collection phase, all registered information of the software system was gathered attentively in addition to the manual gathering of missing information form the archived paper-based TB forms to have a comprehensive completed data including sociodemographic and economic detailed information, besides the exposure event, clinical evaluation, laboratory investigation(e.g., sputum smear, GeneXpert), data related to co-infection HIV and household contact information, treatment outcomes, and follow-up visits. Noteworthy to mention is that the required data was collected through the significant contribution of the administrator of the Preventive Medicine Department, under direct supervision. Some important information was also gathered via contacting the team members of the Preventive Medicine Department and the chief of the public health laboratories for more clarification. Cross-validation data from multiple sources (e.g., lab results and treatment records) was tracked to ensure the consistency of the collected data to overcome discrepancies. After that, the data was extracted directly from the patient's files and recorded on an Excel sheet. Missing data were systematically reviewed and calculated automatically through the SPSS program's predictive modeling method. Critical variables, such as tuberculosis (TB) diagnostic results, treatment adherence, and patient outcomes, were limited to a maximum of 5% missing data. Cases exceeding this threshold were excluded. Non-critical variables, such as socioeconomic data or secondary health conditions, can tolerate up to 10% of missing data.

3.6 Data analysis

The data was analyzed using statistical software packages (SPSS) version 25. Descriptive statistics, including means and standard deviations, were used to represent the continuous variables (e.g., age, diagnostic tests), while percentages and frequencies were used to summarize the categorical data (e.g., sex, marital status, occupation, and treatment compliance). TB prevalence and incidence will be calculated for each governorate. In inferential statistics, a one-way ANOVA is used to test the association between risk factors and TB morbidity. Parametric Bivariate analysis was performed, and Logistic regression analysis was employed to identify risk factors associated with TB. The strength of the association between the variables was assessed using crude and adjusted odds ratios, along with their corresponding 95% confidence intervals (CIs). A p-value of less than 0.05 was utilized to indicate statistical significance. For data cleaning and validation, missing data below 5% was imputed using statistical methods such as mean substitution or multiple imputations, while variables with more than 10% missing data were reviewed for potential exclusion. To ensure data reliability, 5% of the entered data was re-entered and cross-checked for accuracy in the analysis.

3.7Ethical consideration

After reviewing the proposal of the study, the institutional review board (IRB) approved its conduction, as it is conducted in accordance with ethical guidelines and regulations. To obtain the necessary clearance, a formal letter from Al-Quds University was submitted to the Ministry of Health. Then, ethical permission was obtained from the Ministry of Health to collect the required data using its official DHIS 2 software site and its formal handwritten TB investigation forms, both of which are available in the Preventive Medicine Department. Confidentiality of the gathered information was maintained by focusing on anonymity, and the data was securely stored on a password-protected computer accessed only by the researcher and the supervisor.

Chapter Four

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4. Result

4.1 Study sample

The purpose of the study was to assess the prevalence and determine the contributing risk factors of tuberculosis in the West Bank from 2016 to 2024. More specifically, this study addressed all proposed research questions and the existing relationships among the contributing factors of tuberculosis incidence in the quantitative section. Findings of this study covered the specific and general objectives quantitatively. Research questions were

answered using appropriate bivariate analyses intended to numerically interpret the relationship between variables, as well as to support incidence and prevalence estimates derived from the national DHIS-2 surveillance database, the Access database, and standardized investigation forms maintained by the Preventive Medicine Directorate, Palestinian Ministry of Health. **In total, 70 cases were reviewed; 67 confirmed TB cases met the inclusion criteria and were analyzed, and 3 cases were excluded.**

4.2 Characteristics of the Study Enrolled TB Cases

4.2.1 Description of Socio-demographic Features of the Study Data

Table (4.1): Description of Sociodemographic Data of TB Cases(n=67)

Variable	Description	F	%	Missing	
				F	%
Age M±SD(age group) =4.07±1.91 M±SD =46±19 years Median=47 interquartile range=36	≤ 10-20	6	9.0	0	0
	21-30	13	19.4		
	31-40	9	13.4		
	41-50	9	13.4		
	51-60	9	13.4		
	61-70	14	**20.9**		
	> 70	7	10.4		
Sex	M	44	65.7	0	0
	F	23	34.3		
Marital Status	Single	10	14.9	5	7.5
	Married	50	**74.6**		
	Widowed	2	3.0		
Residency place	Urban	24	35.9	0	0
	Rural	33	**49.83**		
	camp	10	14.9		
No. of family members M±SD=5.3±2.5 Mode=4 persons	≤2 person	6	9.0	4	6
	3-5 person	33	**49.3**		
	6-8 person	17	25.4		
	≥9 person	7	10.4		

A total of 67 confirmed TB cases, including 49 PTB and 18 EPTB cases from 2016 to 2024, aged ≥10 years, were included in this study. The age of the study cases at the time of infection ranged from 10 to 78 years, with a median age of 47 years (interquartile range: 36–68 years). Most of the TB cases reported in the DHIS-2 board were found within the age range of 41–50 years. The majority of the cases (65.7%) were male. More than two-thirds (74.6%) of the cases were married, from rural areas (49.8%), and had medium-sized families (49.3%), as seen in Table (4.1).

4.2.2 Description of Socio-economic Features of the Study Data

Table (4.2): Description of Socioeconomic Data of TB Cases(n=67)

Variable	Description	F	%	Missing

				F	%
Working status	Working	22	32.8	11	16.4
	Not working	34	**50.7**		
Occupation	Housewife	12	**17.9**	16	23.9
	Worker	5	7.5		
	Office employee	5	7.5		
	Retired teacher	2	3.0		
	Student	6	9.0		
	Teacher	1	1.5		
	Engineer	1	1.5		
	Farmer	1	1.5		
	Doctor	1	1.5		
	Hair dresser	1	1.5		
	Truck driver	1	1.5		
	Digger truck driver	1	1.5		
	Not applicable	14	20.9		
No. of rooms M±SD= 2.94±.91 Mode =3	1 room	3	4.5	2	3
	2 rooms	18	26.9		
	3 rooms	26	**38.8**		
	4 rooms	16	23.9		
	5 rooms	2	3.0		
Housing crowdedness (>2pearson in a bedroom)	crowded	18	26.9	4	6
	Not crowded	45	**67.2**		
Housing poor ventilation	Yes	14	**20.9**	53	79.1
Migration	Yes	2	**3**	65	97

Table (4.2) presents the socioeconomic characteristics of the reported TB cases. Half of the patients (50.7%) were not working at the time of diagnosis, whereas 17.9% were housewives and 9% were students. Around one-third of the cases lived in houses with three bedrooms, and 67.2% resided in uncrowded households (≤2 persons per bedroom). Nevertheless, about one-fifth of the patients (20.9%) lived in poorly ventilated houses. Regarding migration, only 3% of cases had a documented history of migration, and this variable was largely underreported.

4.2.3 Description of Clinical Features of the Study Data

Table 4.3: Description of Medical-related TB Data (n=67)

Variable	Description	F	%	Underreported	
				F	%
Family History of TB	Yes	11	16.4	7	10.4
	No	49	**73.1**		
BCG vaccination given	Yes	38	**56.7**	0	0
	No	29	43.3		
Difference between date of	0	8	11.9	0	0

illness & notification(days) M±SD=98.5±244.3 day Median=30 days	1-15	14	**20.9**		
	16-30	13	19.4		
	31-45	5	7.5		
	46-60	4	6.0		
	61-75	4	6.0		
	76-90	1	1.5		
	91-105	5	7.5		
	106-120	1	1.5		
	> 120	12	17.9		
Difference between date of notification and investigation(days) M±SD=6.42± 16.5 days Median=0 days	0	53	**79.1**	0	0
	1-15	4	6.0		
	16-30	5	7.5		
	31-45	2	3.0		
	61-75	2	3.0		
	76-90	1	1.5		
Presence of comorbid disease (yes)	Lung transplant	1	1.5	61	91
	Pulmonary silicosis	3	**4.5**		
	COVID	1	1.5		
	HIV co-infection	1	1.5		

Table (4.3) presents the medical-related information of TB cases as provided in the investigation forms from 2016 to 2024. Regarding family history, only 16.4% of cases reported a family history of TB, but, in general, over half (56.7%) reported receiving BCG vaccination in childhood. Underreporting was especially pronounced in comorbid conditions: only 9% of cases were identified to have comorbid diseases, primarily pulmonary silicosis (4.5%). Regarding timeliness of care, 26.9% of TB cases experienced delayed reporting of more than 3 months from symptom onset to notification, whereas nearly one-third (32.8%) reported illness onset within less than 2 weeks. By contrast, the majority of cases (79.1%) received medical investigation services on the same day of notification, indicating relatively timely diagnostic action once the case was reported

4.3 Distribution Pattern of TB Cases

4.3.1 Spatial Distribution of the Reported TB across Years (2016-2024)

Table 4.4: Distribution of total reported TB cases by year (2016-2024)

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
F	6	8	10	11	6	3	8	8	7	67
%	8.9	11.9	14.9	16.4	8.9	4.4	11.9	11.9	10.4	100

Table (4.4) illustrates the distribution of total TB cases reported between 2016 and 2024 per 100,000 population. The highest frequency of reported cases was observed in 2019 (n=11, 16.4%), followed by 2018 (n=10, 14.9%). Comparable frequencies were recorded in 2017, 2022, and 2023, each accounting for 11.9% of the total cases. Further visualization of this distribution is presented in Figure (4.1).

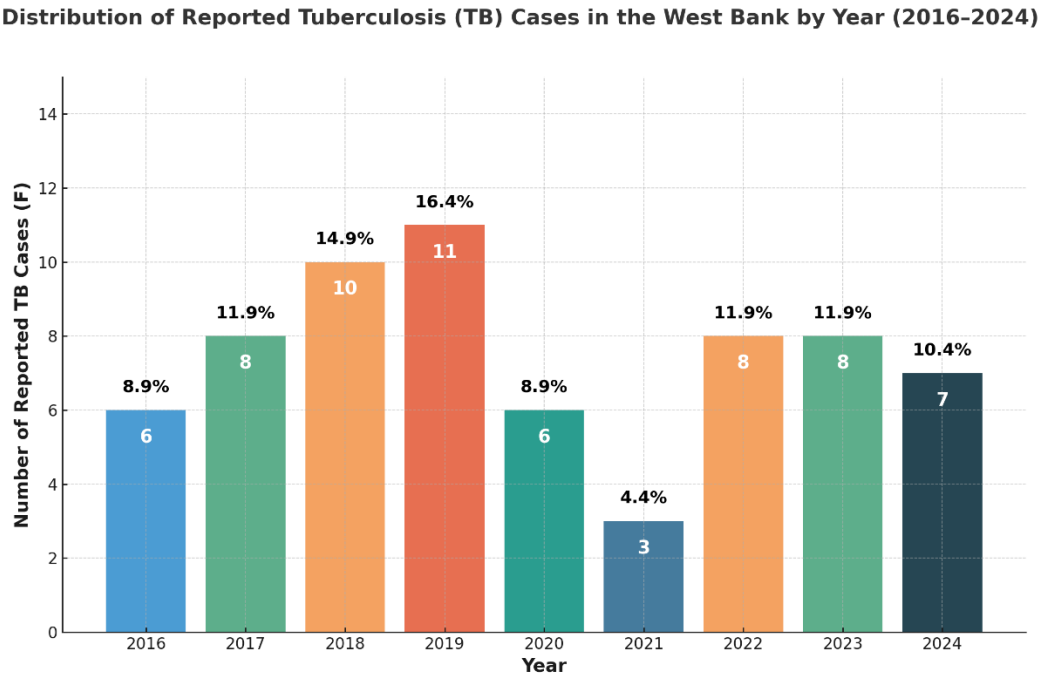

Figure 4.1: Distribution of Reported Tuberculosis (TB) Cases in the West Bank by Year (2016–2024)

4.3.2 Distribution of the Reported TB across Age

Table 4.5: Distribution of TB Cases Across Age Groups

Age at time of Disease	TB -F	%
≤ 10-20	6	9
21-30	13	19.4
31-40	9	13.4
41-50	9	13.4
51-60	9	13.4
61-70	14	20.9
> 70	7	10.5

Table (4.5) shows that the age group 61–70 years represented the highest age-specific frequency of TB cases (n = 14, 20.9%), followed by the 21–30-year group (n = 13, 19.4%). The distribution of TB cases across all age groups is illustrated in Figure (4.2), pointing out

that older adults and young adults have a high incidence of TB cases.

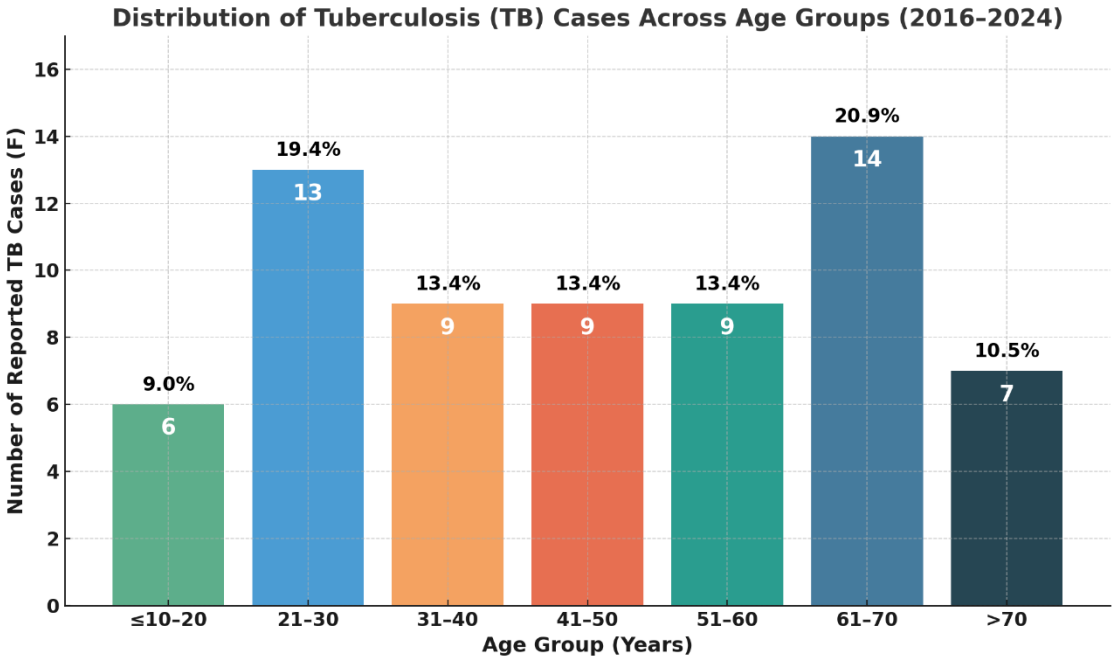

Figure 4.2: Distribution of Tuberculosis (TB) Cases Across Age Groups (2016–2024)

4.3.3 Distribution of the Reported TB across Sex

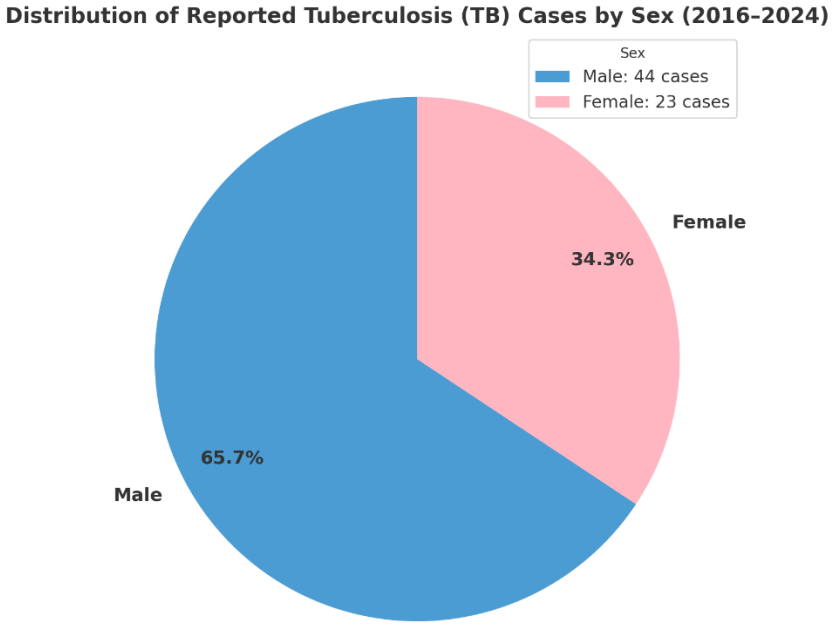

Figure 4.3: Distribution of the Reported TB across Sex

Figure (4.3) demonstrates that most reported TB cases in this study were males (n = 44, 65.7%), compared to females (n = 23, 34.3%), suggesting a male predominance in TB occurrence in the West Bank during the study period.

4.3.4 Distribution of TB Cases Depending on Forms (PTB/EPTB)

4.3.4.1 Distribution of PTB and EPTB Across Age Groups

Table 4.6: Distribution of PTB and EPTB Cases by Age Group

Age at Diagnosis (Years)	PTB		EPTB	
	F	%	F	%
≤ 10-20	5	10.2	1	5.5
21-30	8	16.3	5	27.7
31-40	7	14.3	2	11.1
41-50	6	12.3	3	16.6
51-60	6	12.3	3	16.6
61-70	10	20	4	22.2
> 70	7	14.3	0	0
Median age	47 years		36 years	

Table (4.6) shows that individuals aged 61–70 years had the greatest proportion of PTB cases (n = 10), and individuals aged 21–30 years were the second highest (n = 8). The median age of PTB patients was 47. On the other hand, the highest proportion of EPTB cases (n = 5) was observed in the 21–30-year-old age group (median age = 36 years). This suggests that PTB is prevalent in older adults, while EPTB is more common in younger adults.

4.3.4.2 Distribution of PTB/EPTP across Sex

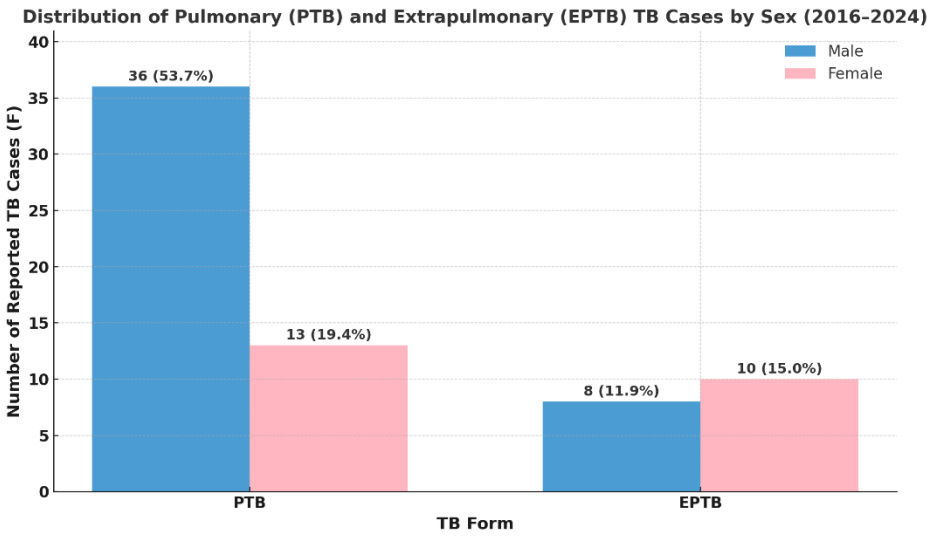

Figure 4.4: Distribution of (PTB) and (EPTB) Cases by Sex (2016–2024)

Figure (4.4) shows that the majority of PTB cases were males (n = 36, 53.7%), while females represented the majority of EPTB cases (n = 10, 15%). This indicates the possibility of sex-related differences in disease presentation in pulmonary and extrapulmonary forms.

4.3.4. 3 Distribution of PTB and EPTB Across Years (2016–2024)

Table 4.7: Distribution of TB Cases by Form Across 2016–2024

Year	PTB	EPTB
2016	4	2
2017	4	4
2018	7	3
2019	8	3
2020	4	2
2021	2	1
2022	7	1
2023	8	0
2024	5	2
Total Cases	49	18

Table (4.7) illustrates the distribution of TB cases recorded in the investigation reports, classified into two main forms—pulmonary tuberculosis (PTB) and extrapulmonary tuberculosis (EPTB)—during the period 2016–2024. Overall, the findings indicate that PTB consistently accounted for approximately two-thirds of all diagnosed cases (n = 49; 73.1%), while EPTB accounted for 18 cases (26.9%)

The annual trend shows fluctuations in reported cases: PTB peaked in 2019 and 2023 (8 cases each), whereas EPTB remained relatively low throughout most years, with a modest peak in 2017 (n = 4) and no cases reported in 2023. **Figure (4.5)** provides a clearer visualization of these variations in newly reported PTB and EPTB cases across the study years (2016–2024).

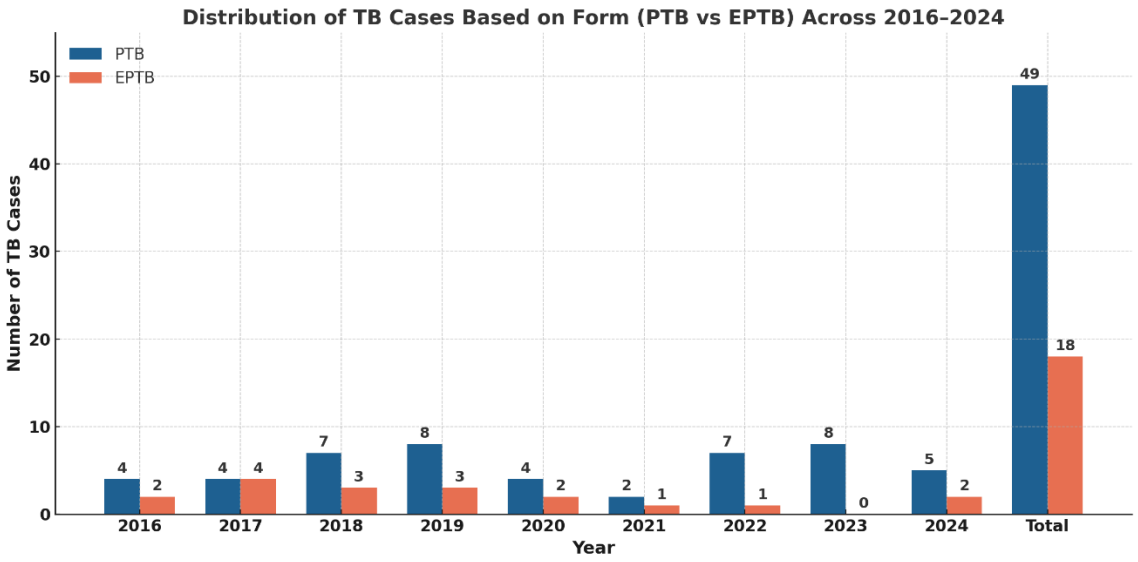

Figure 4.5: Distribution of TB Cases by Form (PTB/EPTB) Across 2016–2024

4.3.4.4 Ratio between PTB and EPTB Cases across Years

Table 4.8 Ratio of PTB to EPTB Reported Cases via Surveillance in the West Bank (2016–2024)

Year	PTB: EPTB Ratio	Percentage of EPTB
2016	4:2	50%
2017	4:4	100%
2018	7:3	43%
2019	8:3	38%
2020	4:2	50%
2021	2:1	50%
2022	7:1	14.3%
2023	8:0	0
2024	5:2	40%
Total Cases	49:18	36.7%

Table (4.8) indicates that the ratio of detected PTB cases in relation to EPTB varied considerably across the years 2016–2024, with PTB consistently showing higher values than EPTB. Corresponding to the ratio distribution, EPTB accounted for 36.7% of all documented cases. Notably, an equal distribution of PTB and EPTB (4:4) was observed in 2017, while no EPTB cases were reported in 2023. A notably low proportion of EPTB cases (14.3%) was also recorded in 2022.

Figure (4.6) below provides a clearer visualization of the ratio between PTB and EPTB across 2016–2024, illustrating fluctuations in case frequencies, with PTB remaining predominant throughout nearly all study years.

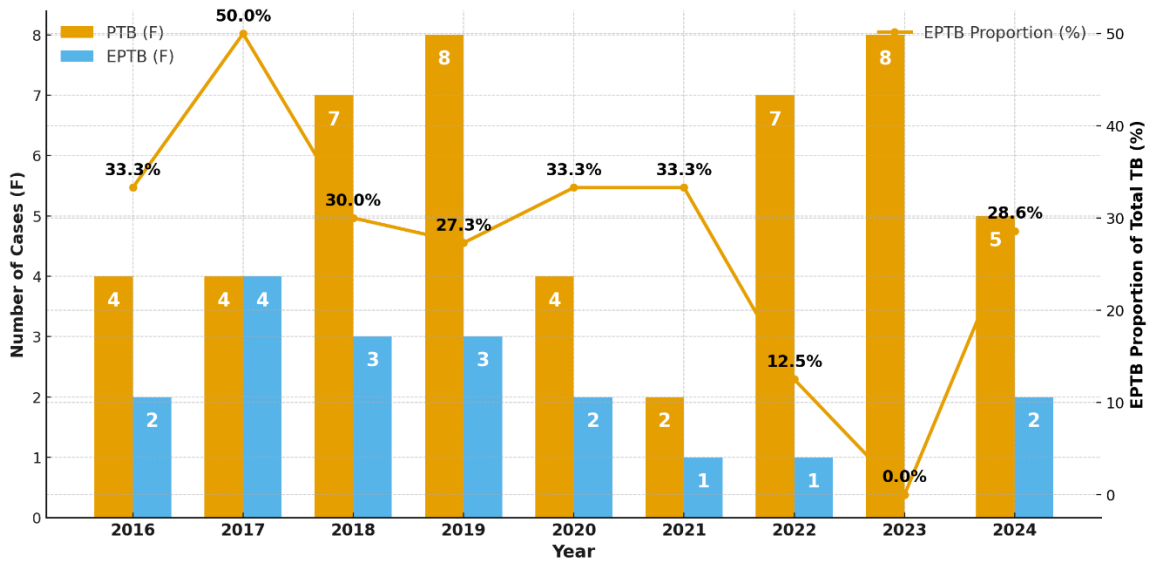

Figure 4.6 Ratio and Proportion of PTB to EPTB Reported Cases Across 2016–2024 in the West Bank

4.3.4.5 Proportion of EPTB Cases (2016–2024)

Table 4.9: Proportion of EPTB Cases Out of Total TB Cases in the West Bank (2016–2024)

Year	EPTB	Total TB cases	Proportion
2016	2	6	33.3%
2017	4	8	50%
2018	3	10	30%
2019	3	11	27.3%
2020	2	6	33.3%
2021	1	3	33.3%
2022	1	8	12.5%
2023	0	8	0%
2024	2	7	28.6%
Total Cases	18	67	26.86%

Table (4.9) illustrates the proportion of EPTB cases out of the total reported TB cases during 2016–2024. The findings reveal that the average proportion of EPTB was **26.9%** across the study period, with considerable fluctuations over the years. The proportion reached its peak in **2017 (50%)** and declined sharply to **0% in 2023**. During most years, the proportion fluctuated between **27% and 33%**, with a notable drop in **2022 (12.5%)**. These variations may suggest potential issues in the detection or underreporting of EPTB cases. **Figure (4.7)** below provides a visual representation of the yearly changes in EPTB proportions across the study period.

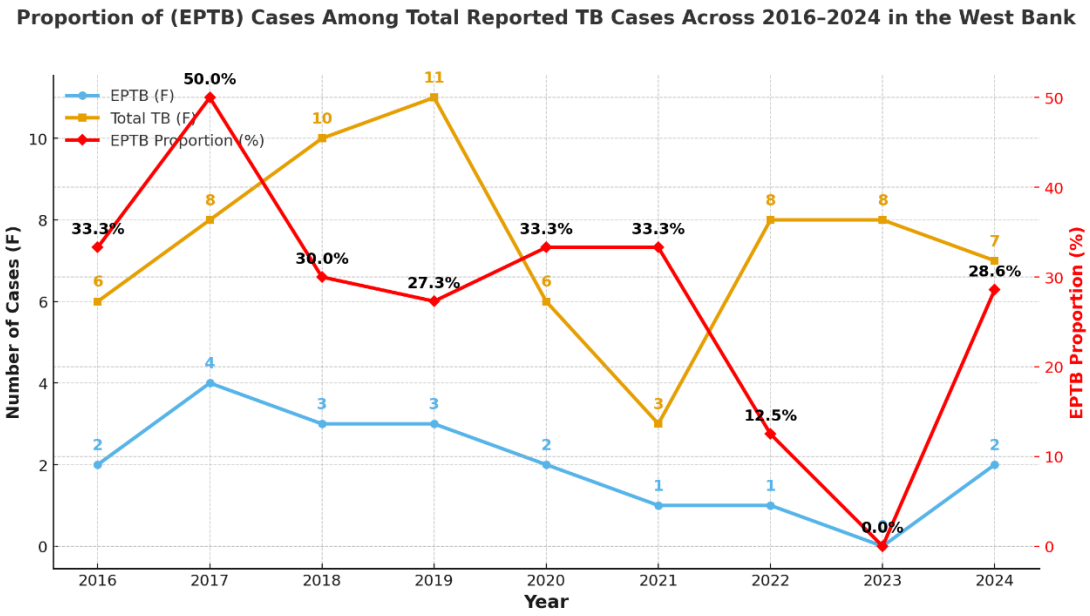

Figure 4.7: Proportion of (EPTB) Cases Among Total Reported TB Cases Across 2016–2024 in the West Bank

4.4 Reported Incidence and Prevalence of Tuberculosis in the West Bank (2016–2024)

4.4.1 Reported Incidence and Prevalence of TB Cases Across Governorates

Table 4.10: Incidence Rate and Prevalence of Tuberculosis per 100,000 Population in West Bank Governorates (2016–2024)

Governorates	2016	2017	2018	2019	2020	2021	2022	2023	2024	Prev. WB
Nablus	**1.05**	0.26	0.51				0.2		0.2	
Tulkarem			1.59	**4.17**	1.02	0.5	0.49	0.48	0.47	
Jenin	**0.65**	**0.64**	**0.63**				0.28	0.28	0.27	
Qalqilya		0.9	**1.76**	0.86	0.84		1.6	0.78	0.77	
Tubas				**1.58**						
Salfit		**1.33**								**2.01**
Bethlehem									0.4	
Hebron		0.14				0.12		0.12		
Jericho		**4.03**			1.91	1.8			**3.5**	
Jerusalem			0.23							
Ramallah				0.29	0.057		0.27	**1**		
Incidence WB	0.2	0.28	0.34	**0.36**	0.19	0.09	0.25	0.24	0.21	

Table (4.10) showed that the overall TB prevalence rate in the West Bank was **2.01** across 2016–2024. Generally, the incidence of tuberculosis in the West Bank remained relatively low between 2016 and 2024, fluctuating between **0.2 and 0.36 per 100,000 population**, with a noticeable decline in **2021 (0.09)** and a slight steady increase from **2022 onward to about 0.2**. Despite this overall stability, apparent geographical variations were evident.

Tulkarem and **Jericho** reported the highest and most unstable incidence rates, with Tulkarem peaking at **4.17 in 2019**—simultaneously with the COVID-19 period—before declining to below **0.5** in subsequent years. Meanwhile, Jericho showed unpredictable high rates in **2017 (4.03)** and **2024 (3.5)**, suggesting either localized outbreaks or challenges in TB control. **Qalqilya** also showed fluctuating trends, rising to **1.6 in 2022** before declining to **0.77 in 2024**. On the contrary, **Nablus**, **Jenin**, and **Hebron** maintained consistently low and steady rates with progressive reductions over time, while **Salfit**, **Tubas**, and **Ramallah** showed scattered, infrequent TB cases.

For visual clarification of the distribution of TB reported cases, **Figure (4.8)** highlights a comparative overview between the West Bank governorates concerning TB incidence rate findings across 2016–2024.

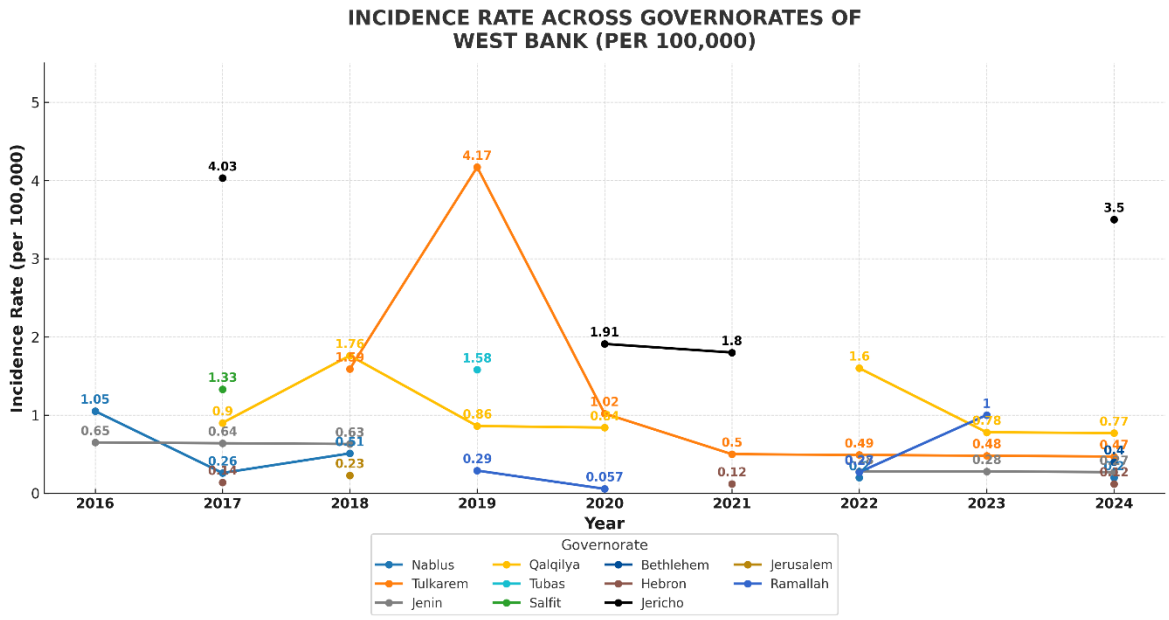

Figure 4.8: Incidence rate across West Bank Governorates

4.4.2 TB Cases Trend Across West Bank Incidence 2016-2024

Table 4.11: Distribution of PTB and EPTB cases alongside the West Bank incidence rate

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024
PTB	4	4	7	8	4	2	7	8	5
EPTB	2	4	3	3	2	1	1	0	2
Incidence WB	0.2	0.28	0.34	0.36	0.19	0.09	0.25	0.24	0.21

Table (4.11) shows fluctuating patterns across both (PTB) and (EPTB), with minor variations observed during **2022–2024**, similar to those recorded in **2016–2017**. The total

TB cases peaked in **2018–2019**, corresponding to the highest recorded incidence rates (**0.34–0.36 per 100,000 population**), before gradually declining in **2020** and reaching the lowest point in **2021**. Noticeable oscillations in PTB cases were observed again in **2022–2023**, followed by a slight decline in **2024**. Overall, the TB incidence rate in the West Bank remained relatively low and stable throughout the study period. For further clarification, **Figure (4.9)** illustrates the upward and downward trends in the distribution of TB cases by type (PTB and EPTB) alongside the corresponding incidence rates between **2016 and 2024**.

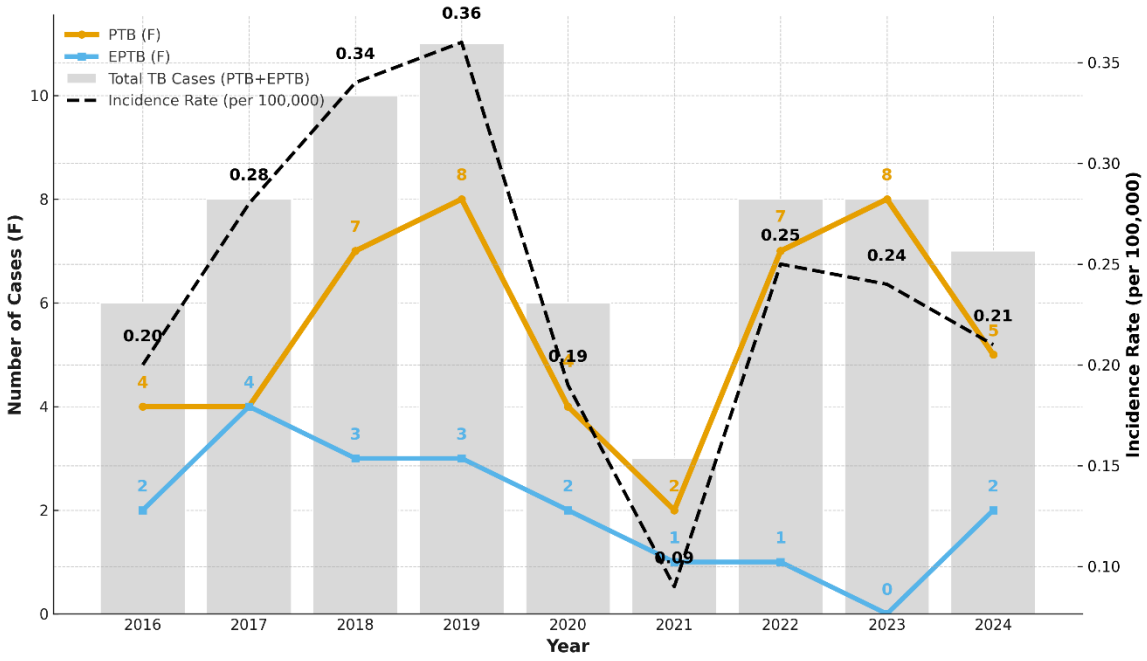

Figure 4.9: Distribution of PTB and EPTB Cases in Relation to the West Bank Incidence Rate (2016–2024)

4.4.3 Incidence of PTB/EPTB Across the Study Period

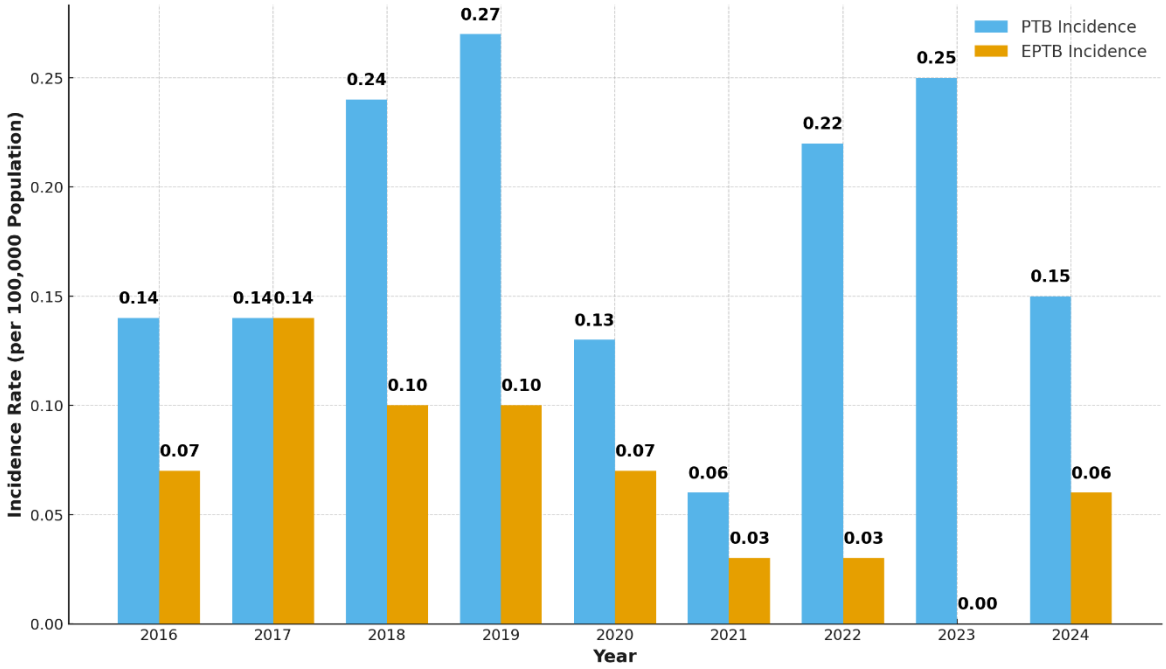

Figure 4.10: Incidence Rate of PTB and EPTB Across 2016–2024

Figure (4.10) Illustrates the incidence of PTB and EPTB in the West Bank throughout the study period. The data reveal that PTB incidence remained higher than EPTB throughout the period, except in 2017, when both had an equal incidence rate of 0.14. Noticeable increases in PTB incidence were observed in 2018–2019 (0.24 and 0.27, respectively) and again in 2022–2023 (0.22 and 0.25, respectively). In contrast, the absence of EPTB cases was clearly observed in 2023.

4.5 Description of TB Diagnostic Tests Results

4.5.1 Description of Primary and Secondary Diagnostic Tests

Table (4.12-A): Descriptive Frequencies of TB Diagnostic Tests (2016–2024)

Diagnostic Test	Done		Positive		Negative		Test done without Result	
	F	%	F	%	F	%	F	%
Primary Diagnostic Tests								
1-Histopathology (Biopsy-based Confirmation								
Lymph node smear	1	1.5	0	0	0	0	0	0
Lung tissue biopsy	7	10.5	0	0	0	0	7	1.5
Lymph biopsy & amp cervical biopsy	17	25.37	4	6	0	0	13	19.4

Table (4.12-B): Descriptive Frequencies of TB Diagnostic Tests (2016–2024)

Bone biopsy	1	1.5	0	0	0	0	1	1.5
Ovarian cyst and amp omental biopsy	1	1.5	0	0	0	0	1	1.5
Axillary Biopsy	1	1.5	0	0	0	0	1	1.5
Bladder biopsy	1	1.5	1	1.5	0	0	0	0
2-Body Fluid Analysis								
Direct smear	55	82	21	31.34	13	19.4	21	31.34
Sputum smear	38	56.7	15	22.38	4	6	19	28.35
Pleural smear	4	6	2	3	1	1.5	1	1.5
Pleural effusion PCR	1	1.5	1	1.5	0	0	0	0
Bronchoalveolar lavage & Bronchial wash	12	17.9	0	0	0	0	12	17.9
CSF Culture	1	1.5	1	1.5	0	0	0	0
Pus Culture	1	1.5	0	0	0	0	1	1.5
Sputum Culture	18	26.86	8	11.9	2	3	8	11.9
Pleural Culture	2	3	2	3	0	0	0	0
3-Molecular Rapid Diagnosis								
GeneXpert	1	1.5	1	1.5	0	0	0	0
Secondary Diagnostic Methods								
Chest X-ray	19	28.4					1	1.5
Chest CT	12	17.9					0	0
Neck CT	1	1.5	1	1.5			0	0
Screening Test Specific for Tuberculosis								
Mantoux	42	62.7	20	29.9	22	32.8	0	0

Table (4.12) provides an in-depth description of the diverse diagnostic methods—both primary and secondary—used to detect TB cases in their various forms and classifications across the West Bank. Regarding primary histopathological methods, relatively infrequent and diverse biopsies were performed (n=29), many of which lacked complete results. Lung tissue biopsy (n=7) and cervical lymph node biopsy (n=17) were the most commonly performed confirmatory procedures, despite a notable proportion of missing or unreported results (19.4%).

With respect to body fluid analysis methods, 31.3% of direct smears (out of n=55, 82%) and 28.3% of sputum smears (out of n=38, 56.7%) yielded indeterminate outcomes. Nevertheless, these two tests remain the frontline diagnostic tools for TB detection in resource-limited settings. In this study, the positivity rates for both tests were modest, but

the sputum culture also showed a significant proportion of positive results (11.9%). Interestingly, a notable proportion of cases (17.9%) underwent bronchoalveolar lavage testing, despite all specimens lacking reported results.

Regarding molecular rapid diagnosis, GeneXpert was scarcely used, with only one case reported in 2024, despite its recognized importance for confirming TB, particularly drug-resistant cases. Imaging procedures, such as chest X-rays (28.4%) and CT scans (19.4%), were commonly used as secondary diagnostic methods. Lastly, the Mantoux test, which is a test for TB, was done on almost two-thirds of the study patients (62.7%), and 29.9% of them tested positive. Overall, incomplete diagnostic follow-up and underreporting were evident across several diagnostic categories in this study.

Table (4.13): Descriptive report of present findings of imaging tests

Diagnostic Test	Result description	F	%	Missing	
				F	%
Chest X-ray	Free	4	6	1	1.5
	Infiltration	3	4.5		
	Lobe consolidation	2	3		
	Pleural Effusion &Infiltration	1	1.5		
	Lung fibrosis	1	1.5		
	Tiny lesions resembling millet seeds in lungs	1	1.5		
	Bilateral hilar infiltration	1	1.5		
	Upper lung lobe cavity	5	7.5		
Chest CT	Upper lung lobe cavity lesions	4	6	0	
	Pulmonary lesions	2	3		
	Bilateral upper lobes chronic lesions &16 RA positive	1	1.5		
	Rt.Central, Lt. hypodense lobulated lesion	1	1.5		
	Osteolytic lesion at the level of thoracic vertebrae	1	1.5		
	Rt. sided spiral cavitation	1	1.5		
	Lt. apical lung MTB	1	1.5		
	Bilateral extensive cystic bronchiectasis changes & multiple bilateral lung nodules	1	1.5		
Neck CT	(4.5*2.7) thick wall of cystic structure	1	1.5	0	
Lymph biopsy & amp cervical biopsy	Caseous necrosis or caseation	2	3	4	6
	Granulomatous inflammation	1	1.5		
	Caseating Granuloma	1	1.5		
Bladder biopsy	Caseating granuloma	1	1.5	0	
sputum smear result(3)	Two specimens positive	2	3	0	
	Three specimens positive	11	16.4		
	Positive without mention details	2	3		
	Negative	4	6		
Sputum Culture (3 specimen)	Two specimens positive	2	3	0	
	Positive without details	6	9		
	Negative	2	3		
CSF Culture	AFB 1-9	1	1.5	0	
Mantoux size induration (mm)	<5	23	34.3		
	≥5-<10	0	0		
	≥10-15	5	7.5		
	≥15	14	20.9		
Cystoscopy	Caseous granuloma	1	1.5	0	

Additionally, **Table (4.13)** illustrates the interpretative findings of imaging (X-ray and CT) that were widely employed for TB case confirmation in this study. Overall, 6% of chest X-rays were reported as "free." However, a broad spectrum of radiological abnormalities was observed, with the most frequent being **cavity lesions in the upper lung lobe (7.5%),** representing a classical hallmark of pulmonary TB. Other notable findings included infiltrations, lobe consolidations, pleural effusion with infiltration, and lung fibrosis, reflecting the diverse pulmonary manifestations of the disease.

In contrast, **CT scans** provided more detailed imaging, revealing cavitary lesions in nearly one-tenth of the cases (9.5%). Additional findings included pulmonary infiltrates and extrapulmonary involvement, such as **osteolytic vertebral lesions**, reported in a few cases. Moreover, biopsy results, which served as histopathological confirmation of TB, supported the imaging findings. The majority of biopsies—mainly **lymph node and cervical specimens**—showed **caseous necrosis** and **granulomatous inflammation**, both highly indicative of TB infection, whereas 6% of the performed biopsies lacked result documentation. Notably, the detection of **caseating granuloma** in the bladder biopsy emphasized the diagnostic value of tissue sampling in identifying extrapulmonary TB, particularly in atypical sites.

Regarding **bacteriological tests** (smear and culture), most sputum smears were positive (16.4% with three positive specimens), consistent with the use of serial samples to enhance diagnostic sensitivity. However, some specimens lacked detailed result characterization. **Sputum cultures** also demonstrated a positivity rate of 12% (two positive or unspecified positive specimens). **CSF culture** confirmed a case of TB meningitis, showing *acid-fast bacilli* (1–9 in count), although this test was performed in only one case, indicating extrapulmonary TB affecting the central nervous system.

Regarding the Mantoux test, over one-third of patients (34.3%) exhibited indurations <5 mm, indicating non-reactivity, whereas 20.9% displayed strong positive reactions (≥15 mm), indicative of latent or active TB infection. Finally, the presence of **caseating granuloma** identified during cystoscopy confirmed a rare extrapulmonary manifestation of TB in the urinary tract.

4.5.2 Description of Screening Test not specific for TB

Table 4.14-A: Description of Performed Screening Test (n=67)

Diagnostic Test	Done		Positive		Negative		Missing	
HIV in blood	61	91	1	1.5	60	89.5	6	9
HIV Screening Test Across TB Forms								
Screening Test	PTB (49)		EPTB (18)		Missing			
	F	%	F	%	F	%		
HIV test	44	65.7	17	25.4	6	9		

Table 4.14-A: Description of Performed Screening Test (n=67)

Non -Specific Screening Test for TB									
Year	2016	2017	2018	2019	2020	2021	2022	2023	2024
No. of TB cases/Year	6	8	10	11	6	13	8	8	7
HIV in the blood	6	8	10	9	6	13	7	6	6

Table (4.14) shows that the majority of the suspected TB cases underwent the essential HIV screening test (91%), with predominantly negative results, disregarding the presence of 9% underreported outcomes. Regarding the distribution of HIV screening across TB forms, the screening was performed for nearly all PTB cases (44 out of 49) and EPTB cases (17 out of 18), with only a trivial number of results remaining unreported.

The trend analysis indicated a consistent performance of HIV screening tests between 2016 and 2018, with no missing data. However, from 2019 onward, a slight decline was noted, with a few suspected TB cases not screened, reflecting minor gaps in testing completeness during the later years of the study period.

4.5.3 Trend of TB Diagnostic and Screening Methods Across the Study Period

Table(4.15-A): Distribution of TB diagnostic and screening tests across years (2016-2024)

Diagnostic Test	2016(6)	2017(8)	2018(10)	2019(11)	2020(6)	2021(3)	2022(8)	2023(8)	2024(7)
Primary Diagnostic Tests									
1-Histopathology (Biopsy -based Confirmation)-29 test									
Lymph node smear		1							
Lung tissue biopsy			1		2		2	2	
Lymph node & amp cervical biopsy	2	3	2	5	2	1	1		1
Bone biopsy			1						
Ovarian cyst and amp omental biopsy					1				
Axillary biopsy						1			
Bladder biopsy							1		
2-Body Fluid Analysis									
Direct smear	6	7	9	10	3	3	4	8	5

Table(4.15-B): Distribution of TB diagnostic and screening tests across years (2016-2024)

Sputum smear	6	2	2	6	2	3	4	8	5
Pleural smear				1				2	1
Pleural effusion PCR				1					
Bronchoalveolar lavage & Bronchial wash	1	3	2	3	1			1	1
Pus culture									1
Sputum Culture	3	3	1	3	1	1	2	3	2
Pleural Culture									2
CSF Culture				1					
3-Molecular Rapid Diagnosis									
GeneXpert									1
Secondary Diagnostic Methods									
Chest X-ray	5	3	3	1		1	3	1	2
Chest CT		1	1	3	2			5	
Neck CT				11					
Specific Screening Test for TB									
Mantoux	4	5	8	9	4	3	4	3	2

Table (4.15) presents the utilization of different diagnostic tests for TB cases in the West Bank from 2016–2024, highlighting both strengths and gaps within the diagnostic pathway.

Firstly, histopathological confirmation through biopsy (29 tests in total) was applied selectively, with lymph node and cervical biopsies being the most frequently performed and consistently used procedures, particularly in 2017 and 2019 (3–5 cases each). Other biopsy procedures—including lung, bone, ovarian, axillary, and bladder biopsies—were performed infrequently and appeared limited to atypical or complex presentations.

Secondly, body fluid analysis remained the cornerstone of TB diagnosis. Direct smear and sputum smear examinations were the most frequently conducted tests across all years, showing noticeable peaks in 2018–2019 (up to 10 direct smears and 6 sputum smears). In contrast, sputum culture, though considered more sensitive, was performed less often—approximately 1–3 times annually. Tests such as pleural smears, CSF culture, and pus culture were used only occasionally.

Thirdly, the use of advanced diagnostic modalities was minimal. Bronchoalveolar lavage was performed sporadically, mostly between 2017–2019, while molecular rapid diagnostic tests (GeneXpert) appeared only once in 2024, indicating limited integration of WHO-recommended rapid testing within the local diagnostic framework.

Fourthly, secondary diagnostic tools, particularly imaging techniques, were used more consistently but with variable frequency. Chest X-rays were performed routinely each year, peaking in 2016 (5 cases), while chest CT scans showed a marked increase in 2023 (5 cases), reflecting growing reliance on advanced imaging for complex presentations. Neck CT was conducted only once in 2019, likely to aid the diagnosis of lymph node TB.

Finally, the screening test (Mantoux) was carried out annually, reaching its highest utilization in 2019 (approximately 9 cases).

4.5.4 Description of diagnostic Tests differentiated by TB Forms

Table (4.16-A).: Diagnostic Tests across TB forms (PTB/EPTB) 2016-2024

Diagnostic Test	PTB (49)		EPTB (18)		Missing	
	F	%	F	%	F	%
Primary Diagnostic Tests						
1-Histopathology (Biopsy -based Confirmation						
lymph node smear	0	0	1	5.6	17	94.4
Lung tissue biopsy	6	9	1	1.5	60	89.5
Lymph biopsy & amp cervical biopsy	1	1.5	16	23.9	50	74.6
Bone biopsy	0	0	1	5.6	17	94.4
Ovarian cyst and amp omental biopsy	0	0	1	5.6	17	94.4
Axillary biopsy	0	0	1	5.6	17	94.4
Bladder biopsy	0	0	1	5.6	17	94.4
2-Body Fluid Analysis						
Direct smear	43	64.2	12	17.9	12	17.9
Sputum smear	32	47.8	6	9	29	43.2
Pleural smear	4	6	0	0	63	94
Pleural effusion PCR	0	0	1	5.6	17	94.4
bronchoalveolar lavage & Bronchial wash	12	24.5	0	0	37	75.5
Pus Culture	0	0	1	5.6	17	94.4
Sputum Culture	16	23.9	2	2.3	49	73.8
Pleural Culture	2	4	0	0	65	96
CSF Culture	0	0	1	5.6	17	94.4

Table (4.16-B).: Diagnostic Tests across TB forms (PTB/EPTB) 2016-2024

3-Molecular Rapid Diagnosis						
GeneXpert	0	0	1	1.5	66	98.5
Secondary Diagnostic Methods						
Chest X-ray	14	20.9	5	7.5	48	71.6
Chest CT	11	16.4	1	1.5	55	82.1
Neck CT	0	0	1	5.6	17	94.4
Specific screening test for TB						
Mantoux	29	43.3	13	19.4	25	37.3

Table (4.16) highlights the key differences in diagnostic approaches utilized for detecting PTB and EPTB. Biopsy-based histopathology was predominantly used for EPTB cases, with cervical and lymph node biopsies the most common, accounting for 16 cases (23.9%), while lung tissue biopsy was more commonly performed among PTB patients (9%). In contrast, body fluid analysis represented the primary diagnostic approach for PTB, including both direct smears (64.2%) and sputum smears (47.8%). EPTB, however, accounted for a smaller proportion of direct (17.9%) and sputum smears (9%).

Additionally, sputum and pleural cultures were performed in both groups (23.9% and 4%, respectively), though a high proportion of results remained underreported—exceeding 70% for sputum culture and 96% for pleural culture. Advanced diagnostic methods, such as GeneXpert, showed very limited utilization, being applied to only one EPTB case (1.5%). Moreover, bronchoalveolar lavage was used exclusively in PTB (24.5%), whereas pleural effusion PCR and CSF culture were performed solely in EPTB cases, reflecting their use in specific clinical presentations.

Secondary diagnostic methods were widely used but varied between TB forms, showing higher application among PTB (43.3%) compared to EPTB (19.4%). Chest X-ray (20.9%) and chest CT (16.4%) followed a similar pattern, whereas EPTB cases relied more on targeted imaging such as neck CT (5.6%). Notably, a high proportion of underreported results, ranging from 37% to over 90% across several tests, indicated potential weaknesses in the completeness of surveillance data. Finally, the Mantoux test was performed as a screening tool in approximately two-thirds of the total reported cases in both PTB and EPTB groups.

4.5.5 Diagnostic and Screening TB Tests alongside TB classification

Table 4.17: Description of TB diagnostic and screening tests done across TB classification (2016-2024)

Diagnostic Test	Primary	Secondary	Relapsing	Total
Primary Diagnostic Tests				
1-Histopathology (Biopsy -based Confirmation)				
lymph node smear	0	1	0	1
Lung tissue biopsy	7	0	0	7
Lymph node & amp cervical biopsy	14	3	0	17
Bone biopsy	0	1	0	1
Ovarian cyst and amp omental biopsy	1	0	0	1
Axillary biopsy	0	1	1	2
bladder biopsy	1	0	0	1
2-Body Fluid Analysis				
Direct smear	50	3	1	54
Sputum smear	36	1	0	37
Pleural smear	4	0	0	4
Pleural effusion PCR	1	0	0	1
Bronchoalveolar lavage	12	0	0	0
Pus Culture	1	0	0	1
Sputum Culture	17	1	0	18
Pleural Culture	2	0	0	2
CSF Culture	0	1	0	1
3-Molecular Rapid Diagnosis				
GeneXpert	1	0	0	1
Secondary Diagnostic Methods				
Chest X-ray	17	1	1	19
Chest CT	12	0	0	12
Neck CT	1	0	0	1
Specific Screening Test				
Mantoux	36	4	2	42

Table (4.17) displayed the distribution of diagnostic methods across TB classifications (primary, secondary, and relapsing). Initially, histopathology-based methods were largely utilized in primary TB, especially lymph node and cervical biopsies (14 cases), projecting the predominance of extrapulmonary presentations demanding tissue confirmation. Biopsy was used less frequently in secondary TB, as an axillary biopsy was used in one case, whereas relapsing TB reflected negligible reliance on biopsy. Importantly, body fluid analyses continued to be the backbone of TB detection. Direct smear microscopy accounted for the majority of tests, including 50 cases in primary TB, three in secondary, and one in relapsing. Additionally, sputum smear was applied in 36 primary cases and bronchoalveolar lavage in 12 cases. Similarly, sputum culture was commonly used among 17 cases, while advanced methods such as pleural smear, pleural effusion PCR, and CSF culture were rarely used. Furthermore, secondary diagnostic tools were widely applied across classifications, where imaging was also used widely, as chest X-ray was applied to 19 cases, while chest CT was performed among 12 cases, mainly belonging to primary TB. However, secondary and relapsing TB relied less profoundly on imaging. At last, the Mantoux test, as a screening one, was commonly used among 42 cases.

4.5.6 Bivariate analysis of Risk factors across TB Diagnostic Approaches

4.5.6.1 Contributing Factors to Direct Smear Positivity Test

Table 4.18: bivariate analysis of lag period between onset of illness till notification date and direct smear positivity

Factors with Direct Smear tests	Linear by Linear Association		Relation strength		Compare Means		Median	Significancy
	p	value	P(r)	value	variable	Value		
Illness till notification date	.035*	4.321	.035	.362	46-60	2	30 days IQR (31-45)	significant
					61-75	2		

Table (4.18) reflected the bivariate analysis between delays in reporting TB infectivity and the positivity of the direct smear test. Findings showed a moderate positive, statistically significant relationship between delayed notification of the illness since the starting point and the positivity of the direct smear test (p = .038; r = .035–.362). The median diagnostic delay from the onset of illness to the notification date was 30 days (IQR: 31–45). Patients with diagnostic delays of more than 46 days had markedly higher proportions of direct smear positivity, indicating increased bacterial load and infectivity.

4.5.6.2 Contributing Factors to Sputum Smear Positivity Test

Table (4.19-A): bivariate analysis of occupation and sex with sputum smear positivity

Factors with Sputum Smear tests	Linear by Linear Association		Relation strength		Compare Means		Interpretation	Significancy
	p	value	P(r)	value	variable	Value		
Occupation	.02*	15	.003	-.703	Housewife	2	Housewife lower bacterial load	significant
					Workers, employees, retired teachers, farmer, student	1		
Sex	.015*	5.867	.011	.571	Female	1.6	Females higher bacterial load	Significant
					Male	1.07		

Table (4.19) indicated a statistically strong, inverse, and significant association between occupation and sputum smear test positivity (p = .02; r = .003, –.703). In other words, patients who work outside and have frequent contact with the community (such as workers, teachers, farmers, students, and employees) showed markedly higher proportions of sputum smear positivity, reflecting a higher bacterial load and greater infectivity.

Additionally, sex showed a statistically strong, positive, and significant association with increased sputum smear positivity (p = .015; r = .011, .571), indicating that males were exposed to a higher bacterial load and greater infectivity compared to females.

4.5.6.3 Contributing Factors to Sputum Culture Positivity Test

Table 4.20: bivariate analysis of poor housing and sputum culture positivity

Factors with TB Sputum Culture tests	Linear by Linear Association		Relation strength		Compare Means		Interpretation	Significancy
	p	value	P(r)	value	variable	Value		
Poor housing - poor ventilation	.046*	4	.035	.667	Yes	2	Yes, poor ventilated Higher bacterial load	Significant
					No	1.1		
Poor housing - crowdedness	.033*	4.571	.018	.756	Yes	1.67	Yes crowded Higher bacterial load	Significant
					No	1		

Table (4.20) revealed that poor housing—either due to inadequate ventilation or limited space—had a strong, statistically significant association with higher proportions of positive

sputum culture tests (r = .035, .667; r = .018, .756, respectively). Hence, patients living in poorly ventilated and/or crowded houses (p = .046; .033, respectively) were exposed to a higher bacterial load and greater infectivity than those living in healthier housing conditions. It is noteworthy that other contributing factors did not show statistical significance with the various diagnostic approaches. Additionally, other diagnostic methods, apart from the three tests mentioned, were not significantly attributable to any risk factors suggested in the current study.

4.6 Clinical Manifestations of TB Cases

4.6.1 Description of TB Documented Clinical Manifestations

Table 4.21: Description of TB Reported Clinical Manifestations

Sign &Symptoms	Yes		N0		Total reported		Not reported	
	F	%	F	%	F	%	F	%
Weight. loss	40	70.2	17	29.8	57	85.1	10	14.9
Cough	52	85.2	9	14.8	61	91	6	9
Dyspnea	36	67.9	17	32.1	53	79.1	14	20.9
Hemoptysis	22	45.8	26	54.2	48	71.6	19	28.4
Fever	41	74.5	14	25.5	55	82.1	12	17.9
Chest pain	25	53.2	22	46.8	47	70.1	20	29.9
Back pain	4	100	0	0	4	6	63	94
Night sweat	6	100	0	0	6	9	61	91
Loss of appetite	1	100	0	0	1	1.5	66	98.5
Nausea	1	100	0	0	1	1.5	66	98.5
Diarrhea	1	100	0	0	1	1.5	66	98.5
Abdominal pain	4	100	0	0	4	6	63	94
Headache	4	100	0	0	4	6	63	94
Altered level of consciousness	1	100	0	0	1	1.5	66	98.5
Skin abscess	1	100	0	0	1	1.5	66	98.5
Neck swell	2	100	0	0	2	3	65	97

Table (4.21) reflects the hallmark clinical spectrum of TB presentation, with classical pulmonary symptoms dominating overtly alongside some extrapulmonary manifestations. Primarily, cough was the most prevalent classical symptom of TB (85.2%), followed by weight loss (70.2%), which remained one of the most sensitive indicators of pulmonary TB in this study. Also, fever and dyspnea were reported in nearly two-thirds of the cases (74.5% and 67.9%, respectively), showing consistency with the clinical cornerstones of pulmonary TB. Hemoptysis was present in less than half of the cases (45.8%), indicating pleural irritation associated with cavitary lesions. Additionally, chest pain was reported in 53.2% of them, reinforcing pulmonary involvement. Moreover, night sweats (9%), back pain (6%), and loss of appetite (1.5%) were infrequently documented, showing low prevalence in this dataset. It is noteworthy that the majority of cases had missing or unreported symptoms, reaching up to 98.5% for appetite loss, nausea, and diarrhea, highlighting the likelihood of under-documentation bias. Additionally, some atypical clinical features, including headache, abdominal pain, altered consciousness, skin abscess,

and neck swelling, were reported at low frequency, corresponding to the smaller proportion of EPTB cases in this dataset. Additional visual illustration is provided in **Figure (4.10)**, exhibiting the frequencies of all documented signs and symptoms of TB cases in the West Bank across the study period.

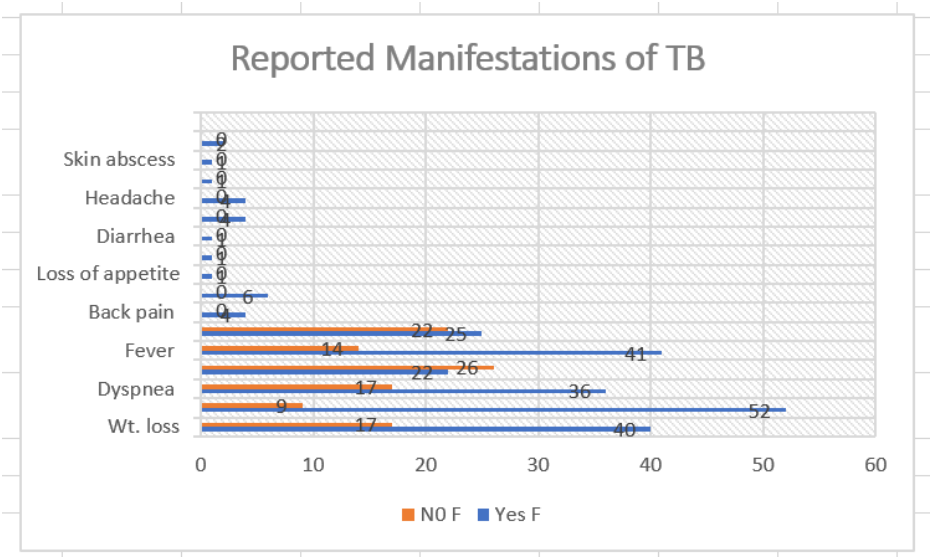

Figure 4.11: Clinical spectrum of reported Tuberculosis cases 2016-2024

Table 4.22: Description of the hallmarks of TB clinical manifestations across age

Signs and symptoms	≥ 10-20	21-30	31-40	41-50	51-60	61-70	> 70
wt. loos+ cough+ hemoptysis	1	3	4	3	2	2	16
cough+ hemoptysis	2	3	1	0	6	4	17
cough +hemoptysis +dyspnea	2	0	1	1	1	0	6
Total	39 cases			P=.357	Not significant		

Table (4.22) reported that individuals aged 70 years and above showed severe TB clinical manifestations, including cough, hemoptysis, weight loss, and dyspnea (n = 39), followed by the age group 51–60 years (n = 9). This finding may suggest that the respiratory clinical manifestations of TB become more aggressive with increasing age, regardless of their statistical insignificance.

4.6.2 Risk Factors Contribution to TB Clinical Manifestations

Table (4.23-A): Bivariate analysis of contributing factors among patients with TB (cases = 67) in relation to clinical Manifestations

Variables	Weight loss			Cough			Dyspnea			Fever		
	P X^2	r	val	P X^2	r	val	P X^2	r	val	P X^2	r	val
Residency place	.265	.60	.07	.04*	.446	.099	.63	.96	.007	.06	.22	.16
Age	.483	.22	-1.6	.61	.3	-.13	.013*	.013*	-.34	.63	.38	-.11
Sex	.613	.965	-.006	.37	.5	.08	.34	.47	-.1	.42	.59	-.07
Marital status	.189	.072	1.25	.65	.37	-.12	.006*	.001*	-.46	.80	.64	-.06
Occupation	.544	.318	.152	.17	.70	.05	.06	.52	.10	.46	.13	.22
Comorbidity	.041	.041*	-.271	.51	.39	.11	.38	.43	-.11	.26	.25	-.15
crowdedness	.477	.718	-.05	.61	.86	.02	.24	.31	-.14	.27	.36	-.12
Poor ventilated housing	.424	.60	-.07	.09	.09	.21	.58	.91	-.01	.35	.43	.10
Family History	.493	.649	.06	.50	.58	.07	.55	.82	-.03	.27	.29	.15
Lag period (illness & notification)	.423	.70	.05	.54	.51	.08	.39	.38	-.12	.033*	.678	.058
Lag period (notification & investigation)	.334	.50	.08	.15	.14	.19	.27	.10	.22	.20	.36	.12

Table 4.24: Explanation of significancy based on Compare means of variables' groups

Dyspnea (compare means)					
Marital status			Age		
Groups	Mean	Std. Deviation	Groups	Mean	Std. Deviation
Single	1.19	.483	≤ 10-20	1.50	.548
Married	1.70	.397	21-30	1.60	.516
Widowed	1.00	.	31-40	1.25	.463
			41-50	1.33	.500
			51-60	1.20	.447
			61-70	1.18	.405
			> 70	1.00	.000

Table 4.25: Explanation of significancy based on Compare means of the variables' groups

Cough and Residency place			
Residency place	Mean	N	Std. Deviation
Urban (city and town)	1.10	20	.308
rural (village and Bedouin)	1.23	31	.425
camp	1.00	10	.000
Total	1.15	61	.358

Table (4.23; 4.24; 4.25) gave insight concerning the significant association pattern among the contributing risk factors of Tuberculosis and the hallmark manifestations reported in this data, including weight loss, cough, hemoptysis, chest pain, dyspnea, and fever. Weight loss showed a statistically inversely weak significant association with comorbidity (p = 0.041, r = –.271, –.271), suggesting that patients with co-existing health conditions (e.g., pulmonary silicosis, HIV coinfection, chronic lung disease) were more prone to experience weight loss badly, with a mean of 1.75.

Suffering of cough reflected a statistically significant association with place of residency (p = 0.04, r = .446), though not strongly significant according to the Spearman rank value, implying those TB cases living in rural areas may have suffered less cough symptoms than urban and camp areas.

Age and marital status demonstrated a statistically significant inverse moderate relationship with dyspnea, where younger TB cases were more likely to present with shortness of breath (p = 0.013; r = .013, –.34). Expressly, those TB cases belonging to younger ages had less severe dyspneic status than aging groups (≥61 years). Similarly, suffering of more severe status of dyspnea was strongly associated with marital status (p = 0.006; r = .001, –.46), where single and widowed cases developed worse dyspneic status, which might be linked to delayed access to healthcare services due to lack of family support.

Interestingly, lag periods (illness-to-notification) showed a statistically significant association with fever (p = 0.033, r = .446), though not strongly significant according to the Spearman rank value (r = .678*), predicting that patients with delayed notification to medical health authorities about onset of illness may experience a worse blunted febrile response. However, the lag period of notification-to-investigation didn't show any significant associations with all major reported TB symptoms, suggesting that delay in performing diagnostic investigations was not strongly predicted by symptom type but may be more influenced by health system factors, such as service accessibility and patient pathways. Finally, hemoptysis and chest pain showed no statistically significant association with the above-mentioned sociodemographic, socioeconomic, and clinical factors of the TB dataset.

4.7 Tuberculosis Household Contacts' Description

4.7.1 Clinical Description of Household Contacts of TB

Table 4.26: Demographic and clinical description of household contacts of TB.

Age (Years) Contact			Sex			Mantoux Result			TPT Given	
	F	%		F	%		F	%	+ve case (21 cases)	
≤5	8	5.8	M	61	43.9	Positive	21	23.1	Yes	15(71.4%)
>5-15	27	19.4	F	78	56.1	Negative	70	76.9	No result	6(28.6%)
>15-25	42	30.2	Miss			Missing	48	34.5		
>25-35	21	15.1								
>35-45	16	11.5								
>45-55	14	10.1								
>55-65	8	5.8								
> 65	3	2.2								
Total=139 μ± SD =3.7±1.7	mode=15-25 median=15-25		Mode = F Median=F			Mode & Median =negative				

Table (4.26) displayed the household close contact persons data for (n=139), with moderate latent infection prevalence and suboptimal TPT coverage. The table showed that the majority of individuals being exposed to tuberculosis infection were within the 15–25-year age group (30.2%), with median of (15-25 years old), indicating that adolescents and young adults represented the highest susceptible group. Regarding sex distribution, females accounted for a higher proportion of contacts (56.1%), which might be attributed to caregiving roles. The Mantoux test revealed a positivity rate of (23.1%), while the majority (76.9%) tested negative, with mode and median both aligning with negative results. Importantly, one thirds of the household contacts' result of Mantoux test (n=48,34.5%) were not documented. However, among the reported Mantoux-positive individuals (71.4%) received tuberculosis preventive therapy (TPT), while nearly one-third remained underreported, which poses a bias risk in interpreting results for some cases. Figure (4.12;4.13; 4.14;4.15) illustrated the table (4.26) findings in visual pattern.

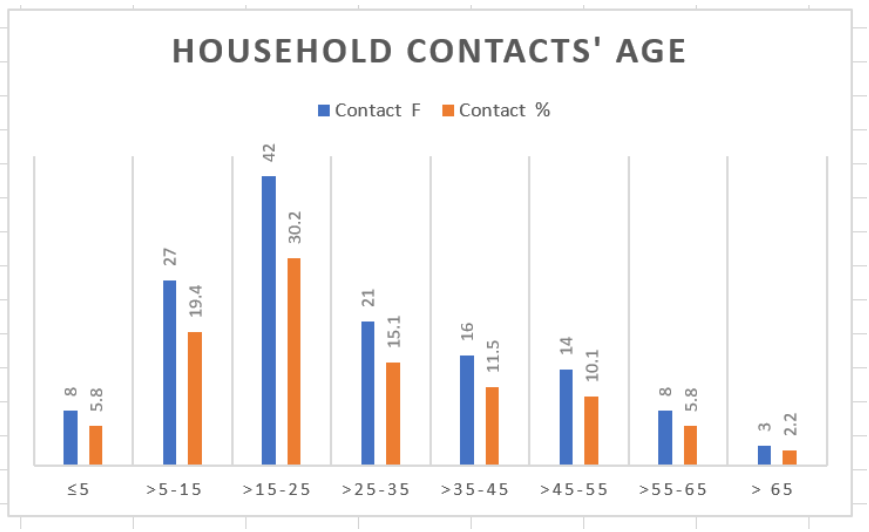

Figure 4.12: Distribution of closed household contacts' age

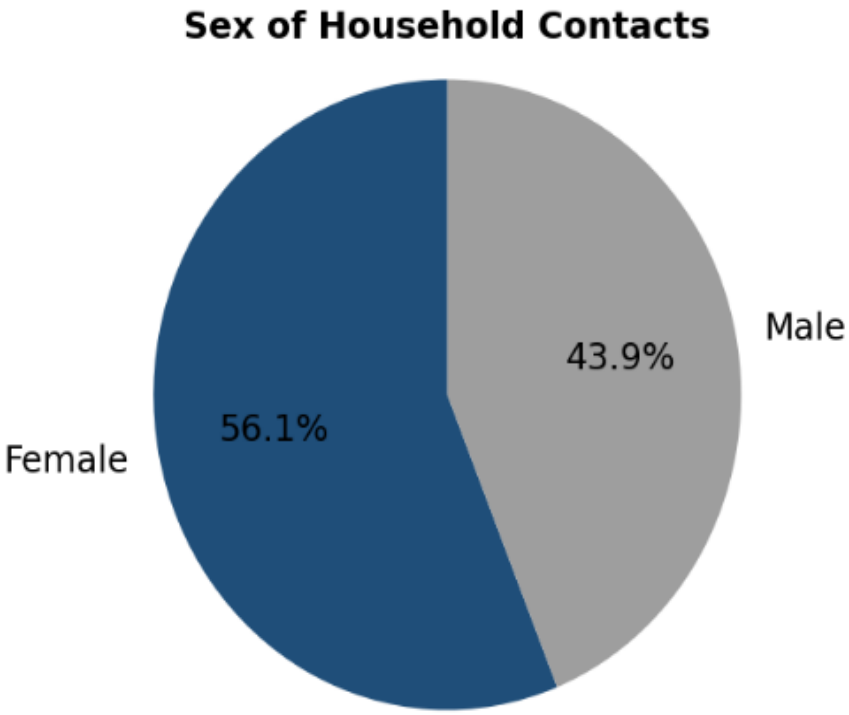

Figure 4.13: Description of sex of household contacts

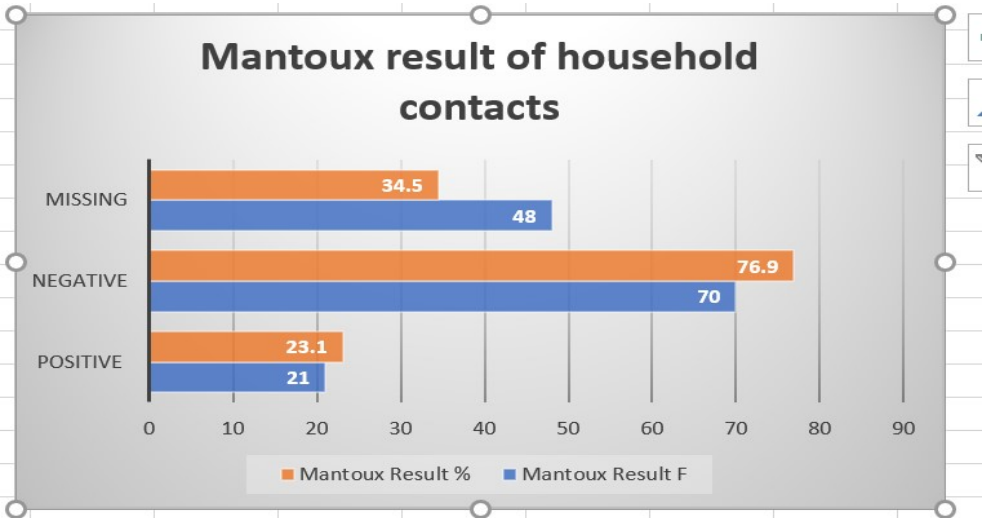

Figure 4.14: Description of Mantoux result linked to household contacts

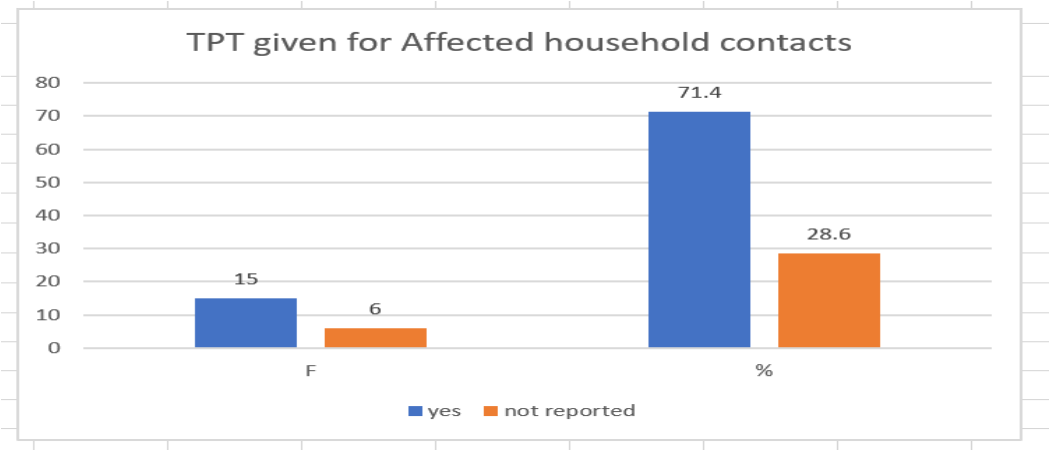

Figure 4.15: Distribution of TPT given to infected household contacts

4.7.2 Bivariate Analysis of Contributing Factors and Probability of Latent TB

Bivariate analysis of household contact age and positivity of the Mantoux

Table 4.27: Bivariate analysis of the contributing factors in relation to the positivity of the Mantoux test

Variable	Description	Positive		Negative		Total	
		F	%	F	%	F	%
Household contact	≤5 years	4	19	0	0	4	4.39
	>5-15 years	5	23.8	13	18.57	18	19.78
	>15-25 years	4	19	21	30	25	27.47
	>25-35 years	2	9.52	10	14.28	12	13.18
	>35-45 years	4	19	10	14.28	14	15.38
	>45-55 years	0	0	8	11.42	8	8.79
	>55-65 Years	2	9.52	5	7.14	7	7.69
	> 65 Years	0	0	3	4.28	3	3.29
	Total	21	100	70	100	91	100

Table (4.27) illustrated the relationship between household contact age which was distributed across several age groups and Mantoux test positivity among 91 contacts, of whom 21 (23.1%) were positive and 70 (76.9%) were negative. The highest proportions of Mantoux positivity were detected among individuals aged >5-15 years (23.8%) compared to other age groups. Notably, older age groups of (45–55) years and ≥65 years showed no Mantoux positivity. Additionally, the highest number of Mantoux-negative results was detected among the age group in the 15–25-year age group (30%).

Table (4.28): Bivariate analysis of the contributing factors in relation to the positivity of the Mantoux test

Factors With positive Mantoux	Chi-Square Tests		Pearson -r		Compare Means		Significancy
	P value	Sig*	P	value	Variable	Value	
Residency place	.322						Not Significant
Sex	.694		.	.			Not significant
Age	.001	.*	.004	.615	>15-35	3.7	significant
Family history	.868						Not significant
Family Size	.633						Not significant
No. of rooms	.364						Not significant
Factor	p-chi-square	Sig*	Risk-odd ratio		CI 95%		Significancy
			variable	value	upper	lower	
Poor housing crowdedness	.443		Yes	.766	.375	1.567	Not significant
Poor air ventilation	.086		Yes	1.387	.506	3.797	Not significant

Table (4.28) indicated that residency place, sex, family size, number of house rooms and crowdedness didn't show statistically significant contribution to the infectivity with latent TB reflected by the positivity of Mantoux test except for age (p=.001; r=.004), which

indicated a strong positive statistical significancy with Positivity of Mantoux test for the side of age >15-35 years old. This group constituted the highest age group susceptible to develop active TB far along. No significant association with residency place, sex, family history, family size, number of rooms, and poor housing conditions.

Concerning poor housing conditions, Risk estimation analysis showed no statistically significant associations between poor ventilation, limited space and the positivity of Mantoux test among household's contacts. However, those close contacts with TB index who live in poor air ventilated houses was independently associated with having 1.387 higher odds of Mantoux positivity than others live in better conditions (AOR=1.387,95 % CI:.506 -3.797).

4.8 Bivariate Analysis of Contributing Factors to TB Infection Occurrence

4.8.1 Risk Factors of TB in Across TB Forms (PTB, EPTB)

Table (4.29): Bivariate analysis of contributing factors among patients with TB (cases = 67) in relation to TB Diagnosis based on its Forms

Factors With TB Diagnosis	Fisher's Exact Test		Spearman rank		Odd ratio		CI 95%		Significancy
	P value	Sig*	P	value	Variable	Value	upper	lower	
Sex	.041	*	.027	.271	female	0.478	0.256	0.89	Significant
Family History	1.000		.960	.006	Yes	0.97	0.293	3.21	Not significant
Smoking	1.000		.548	.075	smoker	.980	.941	1.02	Not significant
Migration	1.000		.392	.106	Migrated	0.959	.905	1.016	Not significant
Comorbidity	1.000		.932	.011	Yes have	1.102	0.122	9.924	Not significant
Housing-Crowdedness	.760		.788	-.035	crowded	0.885	0.374	2.095	Not significant
Housing -poor ventilation	.090		.063	.229	Poor ventilated	4.776	0.672	33.934	Not significant
Marital status	1.000		.724	-.044	Married with Live husband	0.945	0.701	1.274	Not significant
Working status	1.000		.866	.023	working	1.067	0.510	2.231	Not significant
BCG vaccination	.783		.666	-.054	BCG Taken	0.902	0.577	1.410	Not significant
HIV positivity	.721		.539	.08	HIV	.977	.934	1.020	Not significant
Household contact positive Mantoux	.742		.503	.083	Positive Mantoux	1.469	0.468	4.613	Not significant

Table (4.29) illustrates the association between demographic, clinical, and contextual variables and TB diagnosis using Fisher's Exact Test, Spearman correlation, and odds ratios. **Sex** was the only significant factor (p = 0.041), where females showed lower odds of TB than males (OR = 0.478; 95% CI: 0.256–0.890). No statistically significant associations were observed for family history (p = 1.000; OR = 0.970; 95% CI: 0.293–3.210), smoking (p = 1.000; OR = 0.980; 95% CI: 0.941–1.020), migration (p = 1.000; OR = 0.959; 95% CI: 0.905–1.016), comorbidity (p = 1.000; OR = 1.102; 95% CI: 0.122–9.924), housing crowdedness (p = 0.760; OR = 0.885; 95% CI: 0.374–2.095), housing ventilation (p = 0.090; OR = 4.776; 95% CI: 0.672–33.934), marital status (p = 1.000; OR = 0.945; 95% CI: 0.701–1.274), employment status (p = 1.000; OR = 1.067; 95% CI: 0.510–2.231), BCG vaccination (p = 0.783; OR = 0.902; 95% CI: 0.577–1.410), HIV positivity (p = 0.721; OR = 0.977; 95% CI: 0.934–1.020), and Mantoux-positive household contacts (p = 0.742; OR = 1.469; 95% CI: 0.468–4.613). Spearman correlations yielded similar results, with no significant associations except for sex (r = 0.271, p = 0.027).

Table 4.30: Other Risk Factors across TB Form Diagnosis

Factors With TB Diagnosis	Chi-Square Tests		Spearman rank		Compare Means		Significancy
	P value	Sig*	P	value	Variable	Value	
Residency place	.297		.337	.093			Not Significant
Marital status	.607		.926	.012			Not significant
Occupation	.252		.379	.126			Not significant
ANOVA test							
Factors with TB Diagnosis Forms	ANOVA test		Pearson-r		Compare Means		Significancy
	p	F value	p	value			
Age	.664	.683					Not significant
Family Size	.601	1.68					Not significant
Illness till notification date	.126	1.639					Not significant
Notification till investigation date	.078	2.097					Not significant

Table (4.30) showed no significant associations between residency, marital status, or occupation and TB diagnostic form (all p > 0.05), and ANOVA results indicated no significant differences for age (F (6,60) =0.683, p=0.664), family size (F=1.68, p=0.601), time from illness onset to notification (F (9,57)=1.639, p=0.126), or notification to investigation (F(5,61)=2.097, p=0.078). Overall, demographic variables and diagnostic time intervals did not significantly influence TB form in this sample.4.8.3 Bivariate analysis of Risk factors across TB Classifications

Table(4.31): Bivariate analysis of contributing factors among patients with TB in relation to TB Classification

Factors With TB Classification	Chi-square Test		Spearman rank		Compare Means		CI 95%		Significancy
	P value	Sig *	P	value	Variable	Value			
Sex	.313		.402	.105					Not Significant
Governorate	.650		.558	.073					
Residency place	.856		.639	.059					
Family History	.306		.955	.008					Not significant
Smoking	.950		.755	.039					Not significant
Migration	.902		.656	.056					Not significant
Comorbidity	.808		.522	.08					Not significant
Housing-Crowdedness	.257		.103	.209					Not significant
Housing -poor ventilation	.411		.188	.164					Not significant
Marital status	.658		.681	.054					Not significant
Working status	.128		.672	.058					Not significant
Occupation	.026	*	.179	.193	Doctor	2			Significant
					Digger Truck Driver	2			
BCG vaccination	.206		.205	.158					Not significant
Household contact positive Mantoux	.379		.169	.171					Not significant

Table (4.31) indicated that, among the investigated contributing factors for patients with tuberculosis (n = 67), the majority did not demonstrate a statistically significant association with TB classification except for occupation which showed a statistical significance disregards its insignificant strength association (p = 0.026, r=.179), with specific occupational categories such as doctors, diggers, and truck drivers appearing more frequently among TB-classified cases. In other words, being a doctor and a digger truck driver are riskier to develop variant classifications of TB than other categories, with a p-value equal to (.026).

4.8.4 Other Risk Factors Across TB classification

Table 4.32 bivariate analysis of other contributing factors across TB classifications

Factors with TB classification	ANOVA test		Pearson-r		Compare Means				Significancy
	p	F value	p	value	variable	Value			
Age(years)	.002*	3.135	.797	-.032	22	3			significant
					72	3			
					43	1.33			
Illness till notification date	.369	1.113	.151	.179					Not significant
Notification till investigation date	.000*	6.857	.283	.134	36 days	3			Significant
					43days	2			
No. of Family members	.097		.278	.140					Not significant

Table 4.32 highlights that, among the contributing factors analyzed, age and the time interval from notification to investigation date showed statistically significant associations, whereas the other inspected factors did not. Age was statistically significant risk factor in relation to TB classification disregards its insignificant strength of association based on Spearman rank result ($p = 0.002$, $r=.797$), suggesting that certain ages, particularly younger (22 years), middle-aged (43 years) and oldest age (72 years) individuals, may be more vulnerable to develop different TB classifications. Similarly, the time interval between notification and investigation date was also significant ($p < 0.001$), with longer delays observed in some groups (mean of 43 days versus 36 days), indicating that delays in the TB diagnostic catchment may contribute to being affected by different TB classification. On the contrary, neither the duration of taking action since the start of illness to notification nor the number of family members presented significant associations.

4.9 Tuberculosis Outcome

Remarkably, TB outcome for documented cases was not reported clearly in the investigation report yet, unless for one case (1.5%) was cured in addition to 3(4.5%) died because of pulmonary silicosis, COVID, & HIV co-infection. Concerning other possible outcomes including treatment completed. treatment failure, lost to follow up, and not evaluated outcome, trends disappointedly were neglected.

Chapter Five

5. Discussion

5.1 Introduction

During 2016–2024, 70 TB cases were reported; three were excluded—two infants (<1 year) likely misdiagnosed as EPTB due to BCG-related adverse events per WHO guidance, and one adult female with insufficient data. Thus, 67 confirmed cases (PTB = 49; EPTB = 18), aged ≥10 years (IQR: 36–68), were analyzed.

Males had a higher risk of TB than females, and certain occupations—particularly doctors and digger-truck drivers—were significantly associated with different TB classifications ($p = 0.026$). Age and the interval between disease onset and investigation were also significant ($p = 0.002$), suggesting vulnerability among younger and middle-aged groups. Longer notification-to-investigation delays (mean 43 vs. 36 days) were significant ($p = 0.0001$), indicating that diagnostic delays may influence TB classification.

Poorly ventilated housing increased the odds of TB (OR = 4.776, 95% CI: 0.672–33.934). Females had significantly lower odds than males (OR = 0.478, 95% CI: 0.256–0.890). Mantoux-positive contacts were more likely to develop active TB (OR = 1.469, 95% CI: 0.468–4.613).

Comorbid cases were more prone to weight loss ($p = 0.041$, $r = –0.271$). Rural residence was associated with more severe cough ($p = 0.04$, $r = 0.446$). Older adults (≥61 years) ($p = 0.013$, $r = –0.34$) and single/widowed individuals ($p = 0.006$, $r = –0.46$) showed more severe dyspnea.

5.2 Reported Incidence and Prevalence of TB

Between 2016 and 2024, TB incidence in the West Bank remained low (0.09–0.36 per 100,000). The lowest incidence occurred in 2021 (0.09), likely reflecting COVID-19–related underreporting or service disruption, while peaks in 2018–2019 (0.34–0.36) indicate modest fluctuations. This pattern aligns with Eastern Mediterranean Region data, though Palestine consistently reports among the lowest incidence compared to neighbouring high-burden countries such as Egypt, Sudan, and Pakistan (10–100 per 100,000) (WHO, 2023a).

Governorate-level variation was notable. Tulkarem showed a marked rise in 2018–2019 (1.59–4.17), far above the WB average, suggestive of enhanced detection or misclassification during early COVID-19. Jericho recorded elevated values in 2017 (4.03) and 2024 (3.5), and Qalqilya reported higher rates in 2018 (0.9–1.76), indicating localized vulnerabilities. In contrast, Hebron, Nablus, and Jenin consistently showed low incidence (0.12–0.65). Sporadic or inconsistent reporting from Tubas, Salfit, Bethlehem, and Ramallah may obscure the true burden. Such heterogeneity likely reflects socioeconomic, access-related, and migratory/occupational influences.

Compared globally (134 per 100,000) and regionally within the EMR (115 per 100,000), WB incidence is substantially lower (WHO, 2024b). It also remains lower than Gulf states (Qatar 35; Bahrain 12; Oman 11; Kuwait 10; Saudi Arabia 10), while the UAE reports even lower levels (~1 per 100,000) (Maatoug et al., 2025). Rates are similarly below those in Bilad Al-Sham (Jordan 3.4; Syria 17; Lebanon 10) (Fuchs et al., 2024). Thus, despite being a low-burden setting, inter-governorate variation underscores the need for targeted surveillance to prevent localized outbreaks and support WHO End TB Strategy goals.

For prevalence, the WB recorded 2.01 per 100,000 from 2016–2024, indicating persistent challenges to elimination. Prevalence was lower than Gaza (3.5) but similar to Israel (2.1) (Fuchs et al., 2024), and lower than South Africa (3.9%), sub-Saharan Africa (7.8%), Tanzania (6.4%), Iran (9–20%), and Afghanistan (17.6%) (Mzembe, 2024; Khursheed et al., 2024; Asmare et al., 2025). Conversely, it exceeded Nepal (1.6%), India (1.15%), and Ethiopia (1%), but remained below the Philippines (12.8%) and Pakistan (15.6%) (Adane et al., 2020). These differences reflect variation in population characteristics, living conditions, and crowding. Notably, the absence of data on drug-resistant TB, household LTBI follow-up, and treatment outcomes limits interpretation of the true disease burden.

5.3 Proportion of PTB to EPTB Cases

Pulmonary TB affected 36 of 49 males (73.5%), indicating a higher burden among males, consistent with findings from Saudi Arabia, where 71% of cases were PTB (Almatroudi, 2024). In contrast, most EPTB cases here were females (55.6% vs. 44.4%), aligning with evidence showing higher EPTB prevalence among females (P = 0.003) (Ulusoy et al., 2024; Humayun et al., 2022). Other studies reported the opposite pattern, with males more affected (Semilan et al., 2021; Almatroudi, 2024). These sex differences likely stem from behavioral exposures (e.g., workforce, smoking, delayed care, crowded settings) and biological factors such as immune and hormonal variation.

Age distribution showed the highest incidence among individuals aged 61–70, who were most frequently affected by both PTB and EPTB (20.4% and 22.2%). Notable incidence was also observed among those aged 21–30 (16.3% and 27.7%), matching findings from Saudi Arabia and Egypt where adults aged 25–35 were most affected (Almatroudi, 2024; El-Masry & Muzaheed, 2022). A lower incidence was observed among ages ≥10–20 (5.5–

10.2%), consistent with Saudi data showing a low incidence among ages 0–15 (5%) (Almatroudi, 2024). The median age of PTB patients (47 years) was slightly lower than Turkish data (53.5 years), while EPTB patients were younger (36 vs. 45 years) (Ulusoy et al., 2024). Higher rates among men may relate to occupational/community exposure, while older adults reflect weaker immunity and comorbidity burden.

Overall, PTB accounted for two-thirds of cases (n = 49; 73.1%), while EPTB accounted for 18 cases (26.9%), consistent with WHO figures (81% PTB, 19% EPTB), though geographic variation exists (India: 15–24% EPTB) (VidyaRaj et al., 2025). PTB predominates due to respiratory transmission, whereas EPTB relates to host factors such as immunosuppression, malnutrition, and comorbidities (Saati et al., 2021; Ulusoy et al., 2024). Annual fluctuations were observed, with PTB peaking in 2019 and 2023 (n = 8; IR = 0.27; 0.25), and EPTB remaining lower and reaching zero in 2023, suggesting detection or reporting effects.

The lower proportion of EPTB aligns with global trends (15–30% in LMICs) (Saati et al., 2021; WHO, 2024b; Ulusoy et al., 2024). However, EPTB exceeded 30% during 2016–2017 and 2020–2021, possibly due to diagnostic delays, limited testing capacity, or risk factors such as HIV and comorbidities. EPTB underreporting and misdiagnosis remain challenges due to its heterogeneous presentation. The absence of EPTB cases in 2023 likely reflects under-detection rather than true elimination.

A sharp reduction in PTB in 2021 (n = 2; IR = 0.06), followed by increases in 2022–2023 (IR = 0.22; 0.25), likely reflects COVID-19 disruptions to healthcare access and surveillance. Despite fluctuations, the persistently low TB incidence in the West Bank suggests that TB remains comparatively controlled.

5.4 Utilized Diagnostic Tools in Detecting TB Cases

Specimens were obtained from pulmonary (n = 49) or extrapulmonary (n = 18) sites. Early detection was hindered by limited affordable diagnostics in public health laboratories and persistent shortages. Over half of PTB cases (n = 38) and 18 EPTB cases were smear-positive (direct, sputum, pleural). Diagnosis relied largely on clinical presentation, direct smear, and sputum culture. As in resource-limited settings, body fluid analysis remained the most commonly used method despite low sensitivity for paucibacillary and extrapulmonary disease. Biopsy confirmation was uncommon; only 30 specimens (mainly lymph node, cervical, lung) were processed between 2016–2024.

IGRA and GeneXpert were almost absent despite strong utility for early and drug-resistant TB detection. Although Palestine's National TB Program nominally supports molecular diagnostics, GeneXpert cartridge supply was not replenished due to cost and weak integration, while IGRAs were never implemented in governmental labs. Biopsy supplies were intermittently available due to political and funding constraints. Diagnostic limitations resembled other LMIC settings (e.g., Pakistan), where conventional microscopy dominates and molecular/PPD resources are insufficient (Khursheed et al., 2024).

Comparative findings showed similar specimen patterns to Pakistan, where two-thirds were sputum, then pleural fluid (1.4%) and BAL (1%), comparable to 3% and 18% in this study. Culture positivity was slightly higher here (16.4% vs. 12.8%) (Khursheed et al.,

2024) but much lower than in central Israel, where 93.9% had microbiological confirmation vs. 74.6% here; sputum culture positivity was 72% vs. 26.8%. PCR positivity was 6% vs. 1.5%. Conversely, smear positivity was higher in this study (56.7% vs. 37.2%) (Fuchs et al., 2024). The large proportion of negative cultures suggests underdiagnosis, consistent with modest body-fluid positivity in both Pakistan and this cohort (Khursheed et al., 2024).

Mantoux testing was consistently used, peaking in 2019 (n = 9), reflecting its screening role despite reduced specificity in BCG-vaccinated and immunocompromised populations. Over half of tested individuals had <5 mm indurations (non-reactive), potentially reflecting immunosuppression, malnutrition, or false negatives, while 33.3% showed ≥15 mm reactions consistent with latent/active disease. HIV positivity was low (1.5%) compared to 7% in Israel (Fuchs et al., 2024).

Despite reliance on microscopy, serology, and Mantoux testing, high proportions of missing biopsy and imaging data and modest smear positivity rates indicate diagnostic gaps that may contribute to underdiagnosis and misclassification. Strong reporting infrastructures—such as in South Korea—demonstrate feasibility, where 25 culture-confirmed TB cases were detected among 9,877 screened individuals during COVID-19 (Choi et al., 2021).

Imaging practices varied. Older adults and children require more sensitive tests than smear to avoid misclassification (Goroh et al., 2020; Khursheed et al., 2024; Zhu et al., 2024). In central Israel, chest imaging showed pulmonary infiltrates (9.3%), lymph node involvement (14%), and cavitary lesions on CT (Fuchs et al., 2024). In this study, 22.4% had abnormal imaging; chest infiltration occurred in 7.46% and cavitary lesions in 10.9%. Imaging abnormalities predict progression: LTBI patients with abnormal radiographs had a 4.9-fold increased risk of active TB (Zhu et al., 2024), and those aged 50–70 with lesions had 6.77-fold higher risk (Gao et al., 2017). A Malaysian study reported advanced radiographic disease (58–81%), indicating late detection (Goroh et al., 2020).

Caution is required when classifying miliary TB from chest X-ray alone, as true miliary disease shows diffuse 1–3 mm nodules from hematogenous spread and can mimic metastatic carcinoma, sarcoidosis, pneumoconiosis, hypersensitivity pneumonitis, or fungal infections (Choe et al., 2021). Without clinical and microbiological evidence, such reporting risks overdiagnosis (Ali et al., 2025). HRCT, TST/IGRA, and microbiological confirmation are recommended prior to diagnosis.

Regarding classification, microscopy confirms active PTB but cannot distinguish primary, secondary, or relapse disease; cultures assist relapse assessment; GeneXpert identifies resistance patterns. GeneXpert was unavailable since 2020, and classification documentation was vague.

Delays in diagnosis are known to increase smear/culture positivity and cavitation. Delays ≥46 days significantly increased smear positivity in this study ($p = .035$; $r = .362$), matching Ethiopian findings where delays >30–43 days (median 49) worsened disease severity (Getnet et al., 2019; Alemayehu et al., 2020).

Certain occupations were associated with smear positivity ($p = .02$), consistent with evidence that roles involving close interaction (e.g., schools) increase transmission, especially among adolescents and young adults prone to LTBI reactivation and additional

risks (migration, incarceration, smoking, substance use) (Fang et al., 2021; Laycock et al., 2021). Blue-collar workers show delayed smear conversion (Bhatti et al., 2021; Khor et al., 2023), and housewives may acquire infection via household exposure (Adane et al., 2020). However, Ethiopian data showed associations with family history, smoking, HIV, previous TB, BCG, and sociodemographics (Mantefardo et al., 2023). Females showed higher smear positivity in this study (mean 1.6 vs. 1.07; p = .015), contrary to meta-analyses indicating males are more affected (Ahmad et al., 2021; Chidambaram et al., 2021; Mantefardo et al., 2023), likely reflecting small sample size and missing smear data.

Poor housing, crowding, and ventilation correlated with higher smear/culture positivity in this study and others (Deol et al., 2022; Meaza et al., 2023), highlighting contextual risk in settings with limited services and poor living conditions.

5.5 Clinical Manifestations of Reported TB Cases

In this study, weight loss was reported in 70.2%, cough in 85.2%, hemoptysis in 45.8%, fever in 74.2%, chest pain in 53.2%, and dyspnea in 67.9% of cases. Hemoptysis occurred in less than half of patients, while the higher frequency of chest pain and dyspnea suggests pleural or parenchymal irritation rather than extensive cavitary disease. Fatigue and other hallmark symptoms were not documented. Symptom frequencies were higher than those reported by Al-Salih et al. (2024), who found lower rates of cough (24.3%), hemoptysis (39.4%), and weight loss (11%). Differences were also observed compared to a prospective Indian cohort in which fever was most common (61.3%), followed by cough (54.3%) and dyspnea (32.9%) (Bhattacharya et al., 2020), whereas this study showed cough (85.2%), fever (74.2%), and dyspnea (67.9%). High frequencies of cough, weight loss, and dyspnea align with WHO screening algorithms (WHO, 2025c). Similarly, a Turkish study found PTB patients exhibited more systemic symptoms such as weight loss and night sweats, indicating a stronger acute phase response than EPTB patients (Ulusoy et al., 2024).

Night sweats (9%), back pain (6%), and loss of appetite (1.5%) were infrequently documented, likely reflecting reporting gaps rather than true absence, indicating underdocumentation of systemic symptoms such as appetite loss, nausea, and diarrhea. Rare symptoms (headache, abdominal pain, altered consciousness, skin abscess, neck swelling) corresponded to specific EPTB forms (e.g., meningitis, abdominal TB, lymph node TB), consistent with the lower proportion of EPTB and selective symptom reporting. Heavy reliance on classical PTB symptoms with limited EPTB documentation may introduce bias.

Weight loss was significantly associated with comorbidity (n = 6, p = 0.041), consistent with literature showing that silicosis, HIV, and chronic lung disease produce more systemic catabolic responses (Ulusoy et al., 2024; Barreto-Duarte et al., 2024; Adakun et al., 2024). No significant associations were observed between comorbidity and other symptoms, contrasting studies reporting comorbidity-related increases in cough, hemoptysis, dyspnea, and fever (Mollalign et al., 2022; Alsehali et al., 2024).

Cough was significantly associated with place of residence (p = 0.04), suggesting that rural patients may experience worse respiratory symptoms due to environmental exposures, delayed care, or limited access, consistent with Indian and Malaysian findings (Goroh et

al., 2020; Khursheed et al., 2024). Dyspnea was significantly associated with age (p = 0.013), with older patients showing more shortness of breath due to lung function decline and higher chronic respiratory disease burden, consistent with Mollalign et al. (2022). A moderate inverse correlation between age and dyspnea severity (p = .013, r = –.34) indicated worse dyspnea among those >70 years, consistent with Al-Saleh et al. In contrast, age showed no significant association with cough, hemoptysis, or weight loss, unlike Iraqi data where older adults exhibited worse respiratory symptoms (Al-Salih et al., 2024). Dyspnea was also inversely associated with marital status (p = 0.006; r = –.46), with single and widowed individuals experiencing worse symptoms; this differed from Al-Salih et al. (2024), who found no marital effect but did report gender differences, whereas this study found no significant sex association (p = .285). The significant weight loss–comorbidity association matched previous findings (Al-Saleh et al., 2024).

Fever showed strong associations with marital status (p = 0.006) and comorbidity (p = 0.001), possibly reflecting earlier care-seeking among married individuals and stronger febrile responses among comorbid patients with altered immunity. This aligns with a TB/COVID co-infection review where fever was prominent (86.7%) in severe cases with comorbidities and widowed status (Mollalign et al., 2022). Although comorbid TB patients typically exhibit more severe systemic symptoms (Alvarez-Sekely et al., 2023; Nowiński et al., 2023; Alsehali et al., 2024), lack of significant associations in this study likely reflects small sample size and underreported symptoms. Diagnostic delays showed weak or non-significant associations except with fever, suggesting that delays may be driven more by access and health system factors than symptom severity, contrary to studies linking delays to more severe presentations (Alemayehu et al., 2020; Mollalign et al., 2022; Nowiński et al., 2023).

Overall, occupation showed no significant association with symptom severity, contrasting multiple studies linking occupational exposure (patient contact, dust/silica, poor housing) to more severe disease (Semilan et al., 2021; Asmare et al., 2025). Such exposures remain biologically relevant risk determinants, and the lack of association here likely reflects limited sample size or underreporting, reducing statistical power.

5.6 Pattern of Household contacts Attributed to TB Cases

Evidence indicates that sharing a bedroom and prolonged exposure to an index TB case increases infection risk, making household and dormitory contacts more vulnerable than the general population (Nduba et al., 2019; Reichler et al., 2020; Asmare et al., 2025). This aligns with the current study, where all household contacts (n = 139) were close family members, consistent with airborne transmission in shared spaces. However, the number of tested contacts per index case (<2; 139/67) was substantially lower than the global average of 3–4 (Manuel et al., 2023). A prospective US–Canada investigation tested 14,490 contacts, identifying 1,406 positives (~3 per index case), matching WHO expectations but contrasting with this study. Among positive contacts, TB developed in 9.8% without preventive therapy, 1.8% with partial therapy, and 0.2% with completed treatment (Reichler et al., 2020). The unusually low contact counts here may reflect PPD shortages due to political/financial constraints or underreporting.

Interpretation of Mantoux results among household contacts lacked clarity. Although positives were recorded, LTBI classification was not documented. Moreover, only TST-positive contacts (n = 15/21) received tuberculosis preventive therapy (TPT), while others—including positives and negatives (n = 91)—did not, despite national 2022 guidelines recommending TPT for all close contacts. This inconsistency raises concern over standardized diagnostic interpretation and adherence to WHO and national LTBI management protocols.

A strong association was found between age and Mantoux positivity (p = .001; r = .004, .615), with adolescents and young adults (15–35 years) showing highest susceptibility, reflecting exposure within schooling and early occupational settings. Similar trends were reported in Ethiopia and global reviews (Dolla et al., 2019; Laycock et al., 2021; Mzembe, 2024). Contrasting findings from Uganda and South Africa showed no such association (Marquez et al., 2020), and other studies identified school-aged children (6–11 years) as most affected (Mzembe, 2024).

Reviews consistently highlight household exposure as a major determinant of TB infection (Adane et al., 2020; Asmare et al., 2025; Wachinou et al., 2025). Reichler et al. (2020) also suggested that induration size may predict future TB. In this study, positive indurations ranged between 10–30 mm, but follow-up of Mantoux-positive contacts after TPT was not documented, and no data indicated subsequent active TB. Additional variables such as occupation, socioeconomic status, BCG status, prior TB history, comorbidities, lifestyle, and accurate contact numbers were largely missing, limiting full interpretation.

Mantoux positivity showed no significant association with place of residence (p = .322), inconsistent with Adane et al. (2020) who found higher infection among rural contacts. Likewise, sex and family history were not significant predictors (p = .694, .868), despite other studies reporting higher risk among married females.

Housing characteristics—poor ventilation and limited living space—also showed no significant associations, despite extensive evidence linking inadequate housing and TB infection (Pan et al., 2019; Adane et al., 2020; Daniel et al., 2025). Adane et al. (2020) reported that smaller room sizes tripled infection risk. In the present study, poor ventilation showed elevated odds of positivity (AOR = 1.387; 95% CI: 0.506–3.797), though lower than reported in Adane and Daniel's studies (AOR 4.02–4.2). This remains biologically plausible, as enclosed poorly ventilated spaces facilitate airborne transmission. Overall, ventilation and crowding continue to represent recognized environmental determinants for TB transmission among household contacts.

5.7 Risk Factors Associated with TB Infectivity

Tuberculosis (TB) infectivity is shaped by interacting sociodemographic, socioeconomic, biological, healthcare-system, and behavioral factors. These determinants influence exposure, disease progression, and diagnostic timeliness, potentially hindering TB elimination efforts through delayed detection and prevention gaps.

5.7.1 Sociodemographic Factors

5.7.1.1 Sex

Global evidence consistently shows higher TB rates among males compared to females (Goroh et al., 2020; Akokuwebe et al., 2024; Semilan et al., 2021). A meta-analysis across 209 MICs identified male sex among the strongest contributors to TB incidence (Bai & Ameyaw, 2024). Findings of the current study aligned with this trend, indicating females had 0.478 times the odds of TB infection compared to males (≈2.1 higher odds among males; p = .041), consistent with Mzembe (2024), Wachinou et al. (2025), and Ulusoy et al. (2024). Few studies contradicted this pattern, reporting higher risk among females or no significant association (Fang et al., 2022; Asmare et al., 2025). Regarding bacteriological burden, females demonstrated higher smear positivity rates (p = .015), contrasting an Iraqi cohort reporting higher male bacterial loads and delayed culture conversion (Al-Salih et al., 2024). Hormonal, occupational, and sociocultural behaviors may partially explain sex differentials in TB burden.

5.7.1.2 Age

Globally, peak TB incidence occurs among adults aged 25–54, while in some WHO regions it increases consistently among older adults (≥65 years) (WHO, 2025b). This study demonstrated significant age-related differences in TB classification (p = .002), with increased vulnerability among young (~22 years), middle-aged (~43), and elderly (~72) groups. Older patients (≥61) exhibited more dyspnea, likely attributable to chronic respiratory comorbidities and immunosenescence. Several reviews identified ≥55 years as the high-risk category (Bai & Ameyaw, 2024; Akokuwebe et al., 2024; Damtie et al., 2025), while others reported peaks among 30–34 years (Khursheed et al., 2024; Rickman et al., 2025). Explanations include increased social mixing and unhealthy lifestyles among younger adults, occupational burden among middle-aged groups, and malnutrition, comorbidities, and reduced immunity among elderly individuals**.**

5.7.1.3 Marital Status

Marital status showed no significant association with TB infectivity in the current study, aligning with Asmare et al. (2025) and Zhu et al. (2024). Other studies reported higher TB prevalence among widowed or never-married individuals (Akokuwebe et al., 2023; Akokuwebe et al., 2024; Damtie et al., 2025), potentially linked to financial instability, reduced care support, and chronic stress.

5.7.1.4 Family Size

The current findings did not demonstrate a significant association between family size and TB infectivity, consistent with Asmare et al. (2025). However, other studies indicated that larger family size increases the number of household contacts, thereby potentiating latent infection (Pan et al., 2019; Dolla et al., 2019).

5.7.1.5 Residency Place

No significant association was found between place of residence and TB vulnerability, comparable to findings from Ethiopia and South Africa (Asmare et al., 2025; Akokuwebe et al., 2024). However, studies in Malaysia, India, and China reported higher TB prevalence in rural settings (Goroh et al., 2020; Khursheed et al., 2024; Zhu et al., 2024), whereas other studies found higher odds in urban areas due to increased social contact (Fuchs et al., 2024; Braga et al., 2024). Variations likely reflect differences in housing density, health-seeking behavior, and healthcare access.

5.7.2 Socioeconomic Factors

5.7.2.1 Occupation

Employment status was not significantly associated with TB development in this study, though certain occupations increased hazard exposure, consistent with Semilan et al. (2021) and Asmare et al. (2025). Conversely, Turkish data linked regular employment with lower PTB risk ($P < .001$) (Ulusoy et al., 2024). Reviews indicate that unemployment, poverty, and unstable income increase TB risk through malnutrition, comorbidities, and weakened immunity (Akokuwebe et al., 2024; Sánchez-Pérez et al., 2024). Despite overall non-significance, occupational category was significantly associated with TB ($p = .026$), particularly among doctors and digger truck drivers, while housewives represented lowest risk. This aligns with studies linking mining, construction, and silica dust exposure with TB (Khursheed et al., 2024; Asmare et al., 2025), and studies identifying healthcare workers as high-risk due to close contact and aerosol-generating procedures (Main et al., 2023; Meregildo-Rodríguez et al., 2023; Leo et al., 2023).

5.7.2.2 Migration

Migration status was not significantly associated with TB in the current study, contrary to evidence from Israel and Ethiopia demonstrating increased TB among migrants (Fuchs et al., 2024; Asmare et al., 2025). Economic hardship, crowded housing, and disrupted healthcare access may explain heightened risk elsewhere; lack of statistical significance here may relate to underreporting.

5.7.2.3 Housing Conditions

Although crowdedness and poor ventilation did not reach statistical significance ($p = .386$), 26.9% of cases lived in crowded spaces and 20.9% in poorly ventilated homes. Most literature supports a strong association between inadequate housing and TB (Pan et al., 2019; Khursheed et al., 2024; Asmare et al., 2025). Shared dormitories particularly elevate risk among adolescents and young adults (Laycock et al., 2021; Pan et al., 2019), consistent with student cases in this dataset (9%).

5.7.3 Biological Factors

5.7.3.1 Comorbidities

Despite strong evidence linking HIV and other comorbidities to TB (Adakun et al., 2024; Khursheed et al., 2024; Akokuwebe et al., 2024), no significant associations were observed in this study (HIV n=1; AOR ≈ 0.994; P ≈ .932). Ethiopian studies reported HIV-positive individuals were ~3–5 times more likely to develop TB (p = .014; p = .007) (Asmare et al., 2025; Kenu et al., 2025). Lack of significance here likely reflects underreporting and small sample size.

5.7.3.2 BCG Vaccination

No association was observed between BCG vaccination and TB infection, consistent with literature highlighting challenges in interpreting TST results in vaccinated populations (Pelzer et al., 2018; Mzembe, 2024; Wachinou et al., 2025). Evidence remains mixed regarding the protective impact of visible BCG scars (Trollfors et al., 2021; Huang et al., 2022).

5.7.3.3 Family History

Family history was not significantly associated with TB development, in agreement with Bongomin et al. (2021) and Shaukat et al. (2023), but contrary to strong associations reported in South Africa, India, and Ethiopia (MacPherson et al., 2020; Chawla et al., 2020; Asmare et al., 2025). Lack of systematic documentation of contact history may explain this discrepancy.

5.7.4 Healthcare System Factors

5.7.4.1 Diagnostic Sensitivity

Evidence shows GeneXpert outperforms smear microscopy in sensitivity, especially for drug-resistant TB (Rimal et al., 2022; Karuniawati et al., 2023). NAATs also reduce diagnostic and treatment delays (Lee et al., 2022). In the West Bank, absence of GeneXpert and IGRA resulted in heavy reliance on low-sensitivity methods, contributing to undetected infections, comparable to Pakistan and Nepal (Khursheed et al., 2024; Maharjan et al., 2021).

5.7.4.2 Diagnostic Delays

A significant association was observed between notification-to-investigation delay and TB development ($p < .001$), with delayed diagnosis associated with higher direct smear positivity ($p = .038$; median >30 days). This aligns with studies linking longer delays with higher bacillary load and cavitary disease (Han et al., 2024; Ko et al., 2022; Dey et al., 2022). Delayed diagnosis sustains community transmission and worsens disease outcomes.

5.7.5 Behavioral Factors

5.7.5.1 Smoking

Multiple studies identified smoking as a significant TB risk factor (RR ≈ 1.5–2) (Bay et al., 2022; Wachinou et al., 2025), but the current study found no significant association, consistent with Zhu et al. (2024) and Asmare et al. (2025). However, smoking is mechanistically linked to impaired mucociliary clearance, alveolar macrophage dysfunction, cavitation, and smear/culture positivity (Al-Salih et al., 2024; WHO, 2024b; Shinde et al., 2024; Kenu et al., 2025). Lack of association here likely reflects the very small proportion of smokers (≈1.5%) and missing data.

Chapter Six

6. Conclusion

Altogether, tuberculosis (TB) remains a notable public health challenge, particularly in low- and middle-income countries where healthcare resources are limited, such as Palestine. This study provides important insights for policymakers, healthcare providers, and community stakeholders regarding the prevalence and associated risk factors of TB in the West Bank. Identifying and addressing these factors is essential to highlight key challenges that hinder TB control, improve early detection among vulnerable groups, and optimize treatment outcomes.

The current study suggests that sex and age disparities, the nature of occupation, housing conditions (especially poor ventilation), comorbidities, and delays in the diagnostic process are key determinants influencing TB occurrence and clinical severity. While some variables (such as marital status and family size) did not show a strong direct association with TB infectivity in multivariable analysis, marital status was related to the severity of specific clinical manifestations, such as dyspnea and fever, highlighting complex social and contextual influences.

Over the past decade, the West Bank has maintained a low TB incidence rate, ranging from 0.09 to 0.36 cases per 100,000 population, with an overall prevalence of 2.01 per 100,000. These findings underscore that TB is relatively well controlled in this setting, yet complete eradication remains challenging. Importantly, the diagnostic approaches used in this context are still suboptimal for detecting dormant and paucibacillary cases, especially in the absence of sustained access to molecular tests such as GeneXpert and IGRAs. Financial and political constraints appear to underpin the plateau in the development and availability of these tools.

Despite these constraints, the results of this study can serve as a foundation for identifying social and clinical risk factors and for strengthening integrated TB control programmes in Palestine. Continued efforts are needed to enhance case finding, improve surveillance and reporting systems, and ensure that prevention and control strategies remain responsive to the epidemiological realities of the West Bank.

6.1 Recommendations

The findings of this study underscore several priorities for TB control and health system strengthening:

1. **Enhance early detection and reduce diagnostic delays**
    - Strengthen medical awareness among healthcare providers regarding timely notification and investigation, particularly in primary healthcare settings.
    - Emphasize the importance of prompt evaluation of individuals with prolonged cough, weight loss, and other key symptoms to avoid diagnostic delays and prevent disease progression and transmission.
2. **Standardize and complete surveillance documentation**
    - Ensure strict adherence to WHO-recommended case definitions and treatment outcome categories (cured, treatment completed, treatment failure, died, lost to follow-up, and not evaluated).
    - Improve the completeness of investigation forms by systematically documenting TB outcomes, smoking status, alcohol and substance use, housing conditions (ventilation, crowding), and other relevant risk behaviors.
    - Revise the TB investigation form to include more detailed socio-demographic and clinical variables, thereby enabling more accurate risk-factor analysis and program planning.
3. **Strengthen integration of TB with other programmes (TB–HIV–HCV)**
    - Integrate TB screening, diagnosis, treatment, and follow-up with HIV and hepatitis C virus (HCV) programmes, particularly among high-risk groups.
    - Implement routine TB screening for people living with HIV and other immunocompromised patients, and ensure that TB patients are systematically offered HIV and HCV testing.
    - Establish clear protocols for coordinated follow-up of co-infected patients to improve outcomes and reduce mortality.
4. **Improve diagnostic capacity and access to sensitive tests**
    - Prioritize the introduction and sustained availability of more sensitive diagnostic tools (e.g., GeneXpert, IGRAs) as a strategic objective in Ministry of Health planning. including ensuring a continuous supply of cartridges and laboratory materials to prevent operational interruptions.
    - Secure adequate and continuous supplies of essential diagnostic materials, including PPD for Mantoux testing, culture media, histopathology services, and imaging facilities (X-ray, CT), particularly in underserved areas.
    - Strengthen laboratory networks and referral systems to ensure timely sample transport and reporting.
5. **Optimize case finding among vulnerable groups**
    - Implement targeted screening strategies for vulnerable populations, such as elderly individuals, household contacts, healthcare workers, camp residents, the Bedouin community, and people living in poorly ventilated and overcrowded housing.

- Ensure systematic follow-up of household contacts, especially during the first year after exposure, and monitor adherence to tuberculosis preventive treatment (TPT) where indicated.

6. **Reinforce community awareness and health education**
    - Activate and expand the National TB community programme to improve public knowledge of TB symptoms, transmission, prevention, and the importance of early care-seeking.
    - Use culturally appropriate health education campaigns to reduce stigma, promote treatment adherence, and encourage household contacts to be screened.
7. **Leverage digital health and data quality improvement**
    - Improve the use of digital technologies (e.g., DHIS2 and electronic medical records) to enhance data accuracy, completeness, and timeliness.
    - Strengthen monitoring and supervision of data entry and reporting, including regular audits of TB registers and investigation forms.
8. **Support further research**
    - Conduct controlled and mixed-methods studies with more comprehensive data, including socioeconomic status, education, lifestyle factors, detailed comorbidity profiles, and documented exposure events.
    - Explore qualitative aspects (e.g., stigma, health-seeking behavior, health system barriers) to better understand delays in diagnosis and gaps in follow-up.

6.2 Limitations of this study

This study has several important limitations that should be considered when interpreting the findings:

1. **Study design**: The descriptive retrospective design did not allow control over confounding variables, limiting the ability to determine the precise effect of each factor on TB onset and outcomes.
2. **Small sample size**: The relatively small number of TB cases may have led to under-representation of the target population and reduced the statistical power to detect associations, particularly for less common risk factors.
3. **Retrospective data**: The decade-long retrospective nature of the study introduced limitations related to missing, incomplete, or non-standardized records. In many instances, it was not possible to ascertain whether specific exposures occurred before or after TB onset.
4. **Changes in documentation systems**: Data collection methods changed over time (e.g., from Microsoft Access to DHIS2), and the study did not control for these transitions. This may have affected data comparability and quality and introduced recall bias in patient histories.

5. **Selection bias**: The captured cases may not be fully representative of all TB cases in the West Bank, especially if diagnostic or reporting practices varied by governorate or facility.
6. **Diagnostic variability**: Advances in diagnostic techniques, evolving case definitions, and limited availability of molecular tests (such as GeneXpert) may have introduced variability in diagnosis and reporting over the study period. Although GeneXpert machines were available, shortages of cartridges and laboratory materials periodically limited their use, potentially affecting case confirmation and classification
7. **Underestimation of associations**: The large proportion of missing and underreported data in several variables likely led to underestimation of odds ratios and bivariate associations, and may have contributed to reporting errors and unstable estimates.
8. **Residual confounding**: Important variables such as ventilation, detailed environmental conditions, and some socio-economic indicators were poorly captured or not measured, leaving room for residual confounding that compromises internal validity and generalizability.
9. **Single-center data source**: The study relied on National Tuberculosis Program (NTP) information from the Preventive Medicine Department of the Palestinian Ministry of Health. Although this is the national reference, reliance on a single surveillance system may limit external validity.
10. **Lack of drug resistance and outcome data**: Information on drug-resistant TB, MTB infection status (latent versus active), treatment response, and progression from latent to active TB was unavailable or incomplete. Diagnostic documentation regarding follow-up and outcomes was often slow or insufficient.
11. **Restricted socio-demographic data**: Socio-demographic variables were largely limited to age, sex, and governorate. Data on education, occupational details, income, lifestyle habits (smoking, alcohol use, substance use), nutritional status, and early exposure events were frequently missing or poorly recorded.
12. **Incomplete information on household and living conditions**: Surveillance data contained incomplete or poorly documented information on household socio-economic status, number of residents, housing conditions, migration history, and comorbidities.
13. **Loss to follow-up**: Documentation of follow-up, particularly regarding treatment outcomes and the status of household contacts, was limited, making it difficult to track disease progression or secondary cases.
14. **Potential inaccuracies in incidence estimates**: TB incidence per 100,000 population appeared inconsistent in several governorates, particularly between 2019 and 2022, when COVID-19 measures may have disrupted health services and reporting.
15. **Underreporting of symptoms**: Systemic and atypical symptoms of TB, especially those associated with extrapulmonary disease, were often underreported, suggesting limitations in clinical documentation and possible underestimation of true disease burden.

16. **Self-reported data**: Many epidemiological, socio-economic, and clinical variables were based on self-report, raising concerns about reporting bias and accuracy.
17. **Operational and logistical constraints**: Resource constraints, insufficient funding, limited access to some field sites, transportation challenges, and low response or follow-up rates may have further affected data completeness and operational efficiency.

6.3 Nursing Implications

This study expands the nursing knowledge base regarding the epidemiology of pulmonary and extrapulmonary TB in the West Bank. It clarifies how specific host and contextual factors contribute to disease occurrence and clinical presentation. From a nursing perspective, the findings highlight the following implications:

1. **Risk-based screening and assessment**
    - Nurses should adopt screening strategies that explicitly consider age, comorbidity status, marital and social support, and living environment (urban/rural, ventilation, crowding).
    - Particular attention should be paid to elderly individuals, those with chronic comorbidities, and household contacts of active TB cases, as these groups may present with more severe clinical manifestations or be at higher risk for disease progression.
2. **Early identification of latent TB infection (LTBI)**
    - Greater emphasis should be placed on the appropriate use and interpretation of the Mantoux tuberculin skin test (TST), especially among household contacts and other high-risk groups.
    - Nurses can play a central role in identifying LTBI cases and in coordinating TPT initiation, adherence, and follow-up to prevent progression to active TB.
3. **Household contact follow-up and continuity of care**
    - Nursing staff should be actively involved in tracing and monitoring household contacts, ensuring that they are screened promptly and followed over time, particularly during the first year after exposure.
    - Clear documentation and communication with the TB team are necessary to avoid losing high-risk contacts to follow-up and to identify early signs of disease.
4. **Health education and counseling**
    - Primary healthcare nurses should prioritize patient and family education on TB transmission, symptom recognition, adherence to treatment, and the risks of harmful lifestyle behaviours such as smoking and heavy alcohol use.
    - Counseling should address misconceptions and stigma surrounding TB, encourage early health-seeking behavior, and support psychosocial needs, especially among vulnerable or socially isolated patients.

5. **Professional development and clinical competence**
    - There is a need for ongoing training of nurses and other healthcare providers on updated TB guidelines, diagnostic algorithms, infection prevention and control measures, and management of co-morbid conditions (e.g., HIV, diabetes, chronic lung disease).
    - Strengthening nurses' competencies in history-taking, physical examination, and interpretation of basic diagnostic tests (TST, smear results, radiology reports) will enhance early detection and appropriate referral.
6. **Advocacy and system-level engagement**
    - Nurses, particularly those in primary health care, are well-positioned to advocate for improved diagnostic resources, better documentation tools, and more comprehensive TB/HIV integrated services.
    - By participating in multidisciplinary teams and TB committees, nurses can help shape protocols, contribute to quality-improvement initiatives, and ensure that patient-centred perspectives are embedded in TB control strategies.

In summary, the study highlights the pivotal role of nurses not only in direct patient care but also in surveillance, prevention, education, and advocacy. Strengthening nursing capacity in these domains is essential for improving TB control and achieving better health outcomes in the West Bank.

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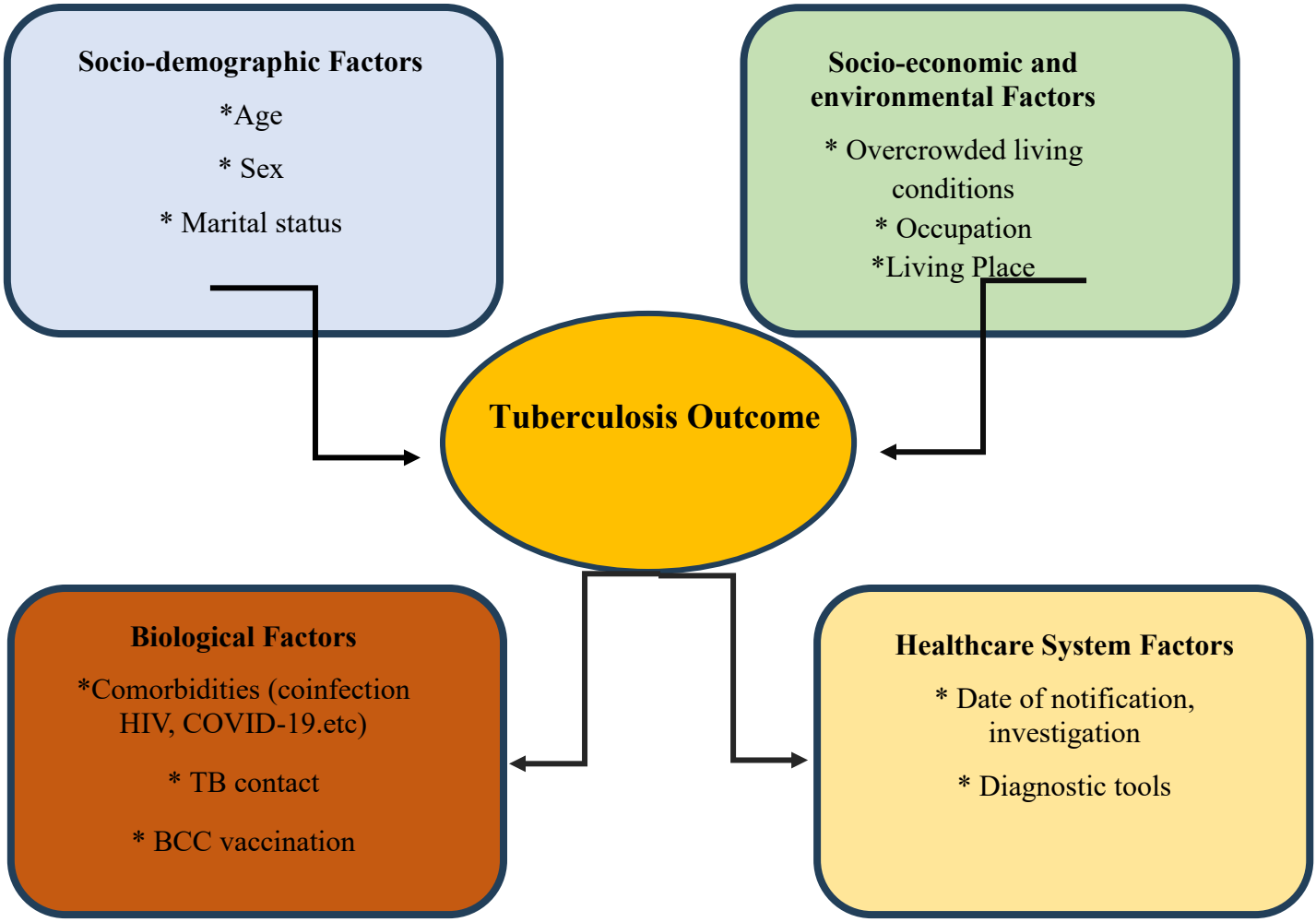
Appendix
Structural Framework



Annex (1): IRB Approval

Al-Quds University
Jerusalem
School of Public Health

جـامـعـة الـقـدس
القدس
كلية الصحة العامة

التاريخ: 18/2/2025
الرقم: REF.9 /25

عزيزتي الطالبة روان عبد الحق المحترمة
برنامج ماجستير الوقاية وضبط الامراض المعدية

الموضوع: موافقة لجنة اخلاقيات البحث العلمي

قامت اللجنة الفرعية لأخلاقيات البحث التابعة لكلية الصحة العامة بمراجعة مشروع الرسالة بعنوان:
"Prevalence and Risk Factors of Tuberculosis in the West Bank (2016-2024)"

المقدم من (مشرف البحث/د. اسعد رملاوي).

يعتبر مشروعك مستوفيًا لمتطلبات أخلاقيات البحث في جامعة القدس.

نتمنى لكم كل التوفيق في تسيير المشروع.

ملاحظة: في حالة الحاجة الى موافقة من اللجنة المركزية في الجامعة، تستطيع التقدم باستخدام هذه الموافقة على الرابط https://research.alquds.edu/en/ethics/48-how-to-apply.html

رئيسة اللجنة الفرعية لاخلاقيات البحث
كلية الصحة العامة
د. نهى الشريف

نسخة/ أعضاء لجنة البحث
نسخة/ الملف

Jerusalem Branch/Telefax 02-2799234
Gaza Branch/Telefax 08-2644220 -2644210
P.O. box 51000 Jerusalem

فرع القدس / تلفاكس 02-2799234
فرع غزة / تلفاكس 08-264420-2644210
ص.ب. 51000 القدس

Annex (2): Facilitate the task

State of Palestine
Ministry of Health
Education in Health and Scientific
Research Unit

دولة فلسطين
وزارة الصحة
وحدة التعليم الصحي
والبحث العلمي

Ref.: ………………
Date:………………

الرقم: ٢٠٢٥/٨٧٧/١٦٤/عح
التاريخ: ٢٠٢٥/٤/٨

عطوفة الوكيل المساعد لشؤون الصحة العامة وصحة الاسرة المحترم،،،

الاخت رئيس وحدة التخطيط والسياسات الصحية المحترمة،،،

تحية واحترام...

<u>الموضـــوع: تسهيل مهمة بحث</u>

يرجى تسهيل مهمة الطالبة: **روان عبد الحق** – برنامج ماجستير الوقاية وضبط الامراض المعدية– جامعة القدس، تحت اشراف د. أسعد رملاوي، في عمل بحث بعنوان:

Prevalence and Risk Factors of Tuberculosis in West Bank (2016–2024)

من خلال السماح للطالبة بجمع المعلومات تتعلق بمرض السل، من خلال مراجعة ملفات المرضى، دون الحصول على الاسماء او اية معلومات تعريفية للمرضى، وباشراف دائرة الطب الوقائي.

على ان يتم الالتزام باساليب واخلاقيات البحث العلمي، والحفاظ على سرية المعلومات.

على ان يتم تزويد الوزارة بنسخة PDF من نتائج البحث، التعهد بعدم النشر لحين الحصول على موافقة الوزارة على نتائج البحث.

مع الاحترام...

د. عبد الله القواسمي
رئيس وحدة التعليم الصحي والبحث العلمي

نسخة: عميد الصحة العامة المحترم/ جامعة القدس

Telfax.:09-2333901 scientificresearch.dep@gmail.com تلفاكس: 09-2333901

Annex (3): Collected data forms (TB investigation Form)

Palestinian National Authority
Ministry of Health
General Directorate of Primary Health Care
Preventive Medicine Department

السلطة الوطنية الفلسطينية
وزارة الصحة
الإدارة العامة للرعاية الصحية الأولية
دائرة الطب الوقائي

Tuberculosis Investigation Form

District: .....

Date of Investigation: ..... Date of Notification: .....

Patient Information:

Name: ..... ID: .....

Age: .....Sex: .....Occupation: ..... Marital Status: .....

Address /Street .....Area: ..... Phone: .....

Work or School Name and Address: .....

Resident: Yes ☐ No ☐ If No, Original Residency: .....

No. of Rooms: ( ) No. of Family Members: ( )

Date of Illness ...../...../..... Date of Notification: .../...../.....

BCG Vaccination: 1=Yes ☐ 2= No ☐ if yes, Vaccination date.../.../....

History of T.B cases in the Family: 1=Yes ☐ 2=No ☐

If yes, Still alive: 1=Yes ☐ 2= No ☐

Clinical Picture: Weight Loss ☐ Cough ☐ Dyspnea ☐
Hemoptesis ☐ Fever ☐ Chest pain ☐
Others ☐ Specify .....

Diagnostic Examination:

Direct Smear Specimen (3 times): Yes ☐ No ☐
Sputum ☐ Pleural Effusion ☐ Others ☐ Specify .....

Culture: Yes ☐ No ☐
Sputum ☐ Pleural Effusion ☐ Others ☐ Specify .....

Mantoux test (PPD): ..... Size of Induration: .....

Type of Biopsy: ..... Biopsy result: .....

١٩٠

Radiological findings: ……..

Screening of HIV: 1=Yes ☐ 2= No ☐ if Yes

Result: 1=Positive ☐ 2= Negative ☐ Date ……

Diagnosis:

Pulmonary T.B ☐ Extra Pulmonary T.B ☐

Primary T.B: ☐ Secondary T.B ☐ Relapsing ☐

House Hold Contacts

Serial No	Name	Age	Sex	Mantoux Test.	Action Done
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Remarks and Comments

……

……

……

Name of Investigator: …… Signature: ……

Name of Preventive Medicine Dr. …….. Signature: ……

انتشار وعوامل خطورة مرض السل في الضفة الغربية(2016–2024)

اعداد الباحثة: روان مروح عبد الحق
اشراف: الدكتور أسعد الرملاوي

الملخص:

الخلفية:لا يزال مرض السلّ (TB) يمثل تحديًا صحيًا عالميًا مهمًا، خاصة في السياقات ذات معدل الإصابة المنخفض ولكن عالية الخطورة مثل فلسطين. ورغم الإبلاغ عن أقل من حالة واحدة لكل 100,000 نسمة، قد يكون العبء الفعلي للسل في الضفة الغربية أقل من الواقع بسبب محدودية القدرات التشخيصية، ونقص الإبلاغ، والقيود التشغيلية في النظام الصحي. إن فهم الاتجاهات الوبائية وعوامل الاختطار والخصائص السريرية وأنماط الانتقال داخل الأسر يُعدّ أمرًا حاسمًا لتعزيز نظام الترصد وتحسين استراتيجيات مكافحة السل.

المنهجية:أُجريت دراسة وصفية استعادية بالاعتماد على بيانات برنامج ترصد السل الوطني بوزارة الصحة الفلسطينية للفترة 2016–2024. جُمعت البيانات من نماذج الاستقصاء القياسية ومن نظام DHIS2الإلكتروني. استُخدمت الإحصاءات الوصفية وتحليلات ثنائية المتغيرات لدراسة المتغيرات الاجتماعية–الديموغرافية والاقتصادية والسريرية والتشخيصية وبيانات مخالطي الأسر، وتحديد العوامل المرتبطة بأشكال السل المختلفة (الرئوي وخارج الرئوي) ونتائج الفحوص التشخيصية.

النتائج:خلال الفترة 2016–2024، تم الإبلاغ عن 67 حالة سل مؤكدة في الضفة الغربية (49 سل رئوي و18 سل خارج رئوي) لمن هم بعمر ≤10 سنوات، بما يعكس معدل إصابة منخفضًا لكنه متقلبًا تراوح بين 0.09 و0.36 لكل 100,000 نسمة، ومعدل انتشار كلي بلغ 2.01 لكل 100,000 نسمة. شكّل الذكور النسبة الأكبر من الحالات (65.7%)، بمتوسط عمر 47 سنة. كان السل الرئوي أكثر شيوعًا بين البالغين الأكبر سنًا، بينما ظهر السل خارج الرئوي بنسبة أعلى نسبيًا بين البالغين الأصغر سنًا.

أظهر التحليل الثنائي وجود ارتباط معنوي بين المهنة وتصنيف السل، حيث بدت بعض المهن مثل الأطباء وسائقي شاحنات الحفر أكثر ارتباطًا بأنماط مختلفة من المرض .($p = 0.026$) كما ارتبط كلٌّ من الجنس وظروف السكن وفترات التأخير التشخيصي بارتفاع نسبة إيجابية الفحوص البكتريولوجية في بعض الاختبارات، بما يعكس زيادة العدوى في فئات محددة.

اعتمدت المسارات التشخيصية أساسًا على الفحص المجهري للطاخة، والزراعة البكتيرية، ووسائل التصوير، واختبار مانتو، مع استخدام محدود جدًا لاختبارGeneXpert ، إلى جانب وجود نقص ملحوظ في توثيق نتائج بعض الفحوص والأمراض المرافقة.

من بين 139 من مخالطي الأسر، بلغت نسبة إيجابية اختبار مانتو 23.1%، إلا أن العلاج الوقائي للسل وُثّق فقط لنحو ثلثي المخالطين المؤهلين، في حين كانت مخرجات المعالجة للحالات المفهرسة موثّقة بشكل ضعيف.

الاستنتاج: على الرغم من انخفاض معدل الإصابة بالسل في الضفة الغربية، تُبرز هذه الدراسة أنماطًا وبائية وسريرية مهمة تستدعي التركيز، من بينها المخاطر المهنية، وتأخر التشخيص، واحتمال انتقال العدوى داخل الأسر. إن تعزيز القدرات التشخيصية، وتحسين الاكتشاف المبكر، ورفع جودة التوثيق الروتيني، وتنفيذ استراتيجيات وقائية موجهة للفئات الأكثر عرضة، قد يسهم في خفض العبء المستقبلي للسل ودعم التقدم نحو تحقيق أهداف استراتيجية إنهاء السل لمنظمة الصحة العالمية.

الكلمات المفتاحية:السل؛ السل الرئوي؛ السل خارج الرئوي؛ الوبائيات؛ عوامل الخطورة؛ الضفة الغربية؛ الترصّد؛ مخالطو الأسر؛ التأخر التشخيصي؛ الانتشار؛ عدوى السل الكامنة.(LTBI).