Attahadi Medical Journal
2026;3(3):381-386
https://doi.org/10.69667/amj.26317

OPEN ACCESS

Original article

Characteristics of Patients with Pulmonary Tuberculosis in the Post-COVID-19 Era at Al-Quifia Hospital, Benghazi: A Cross-Sectional Study

Amina Elsaid*[1], Sara Hamad[2], Heba Alhassi[2]

[1]*Department of Community Medicine, Faculty of Medicine, Libyan International University, Benghazi, Libya*
[2]*Faculty of Medicine, Libyan International University, Benghazi, Libya*
Corresponding email. *amina.elsaid@limu.edu.ly*

Keywords:
Characteristics, Pulmonary TB, Post-COVID-19, Benghazi, Libya.

ABSTRACT

Tuberculosis persists as a major public health issue globally, even though there have been various attempts to enhance case identification and compliance with treatment. It is well known as a cause of ill health for millions of people each year and ranks as the second leading cause of death from infectious diseases worldwide. To describe the characteristics of patients with pulmonary tuberculosis in the post-COVID-19 era at Al-Quifia Hospital. A cross-sectional study of 142 patients with bacteriologically confirmed pulmonary tuberculosis (TB) was conducted at Al-Quifia Hospital in Benghazi during the post-COVID-19 period from January to December 2021. A total of 142 tuberculosis cases were included, with a mean age of 33 ± 13.6 years. The cohort was predominantly male (78.9%, n=112), with the majority being Libyan (69%, n=98), followed by Sudanese nationals (21.8%, n=31). Over half of the patients (57%, n=81) resided in Benghazi. Comorbid conditions were common, including anemia (33.1%, n=47) and diabetes (13.4%, n=19). HIV co-infection was identified in 4.1% (n=6) of cases, while 3.5% (n=5) had post-COVID-19 tuberculosis. Regarding clinical history and exposures, 11% (n=16) reported prior hospital admission, 8.5% (n=12) had household exposure to tuberculosis, and 14.1% (n=20) reported contact with a TB-positive individual. Additionally, 16% (n=23) of patients were smokers. This study concludes that tuberculosis in the study population is predominantly prevalent among young, economically productive males, likely influenced by smoking habits and increased social contact patterns, and is further compounded by a substantial burden of comorbidities, particularly anemia and diabetes.

Introduction

A widespread endemic disease, tuberculosis (TB), has had a major historical impact on human communities. TB still presents a serious global public health concern today, notwithstanding attempts to address it [1]. Tuberculosis (TB) continues to be one of the leading causes of death globally, accounting for one of the top 10 causes of death. Mycobacterium tuberculosis infection affects about one-fourth of the world's population. According to the World Health Organization's 2019 global tuberculosis report, there were an estimated 10 million new cases of TB worldwide in 2018, which led to 1.5 million deaths. Notably, the leading cause of mortality for those with HIV is tuberculosis [2]. Two categories of people are particularly vulnerable to TB: individuals suffering from immunosuppressive disorders and those recently infected with tuberculosis bacteria [3].

Effective prevention strategies require a recognition of the risk of TB infection and disease. In addition to social and behavioral risk factors like smoking, drinking, severe renal illness, low body mass index, cancers, corticosteroid use, organ transplantation, and indoor air pollution, exogenous factors like infectiousness and source case proximity to contact also increase the risk. HIV coinfection is one example of an endogenous factor that changes the immune response and raises risk. The progression of TB disease is also influenced by variables such as diabetes, alcohol, malnutrition, tobacco smoking, and indoor air pollution [4]. During the spread of infection, the start of the disease develops as the bacteria infiltrate the pulmonary system, thereby giving rise to a number of symptoms such as a chronic cough, chest pain, fatigue, loss of body weight, and night sweats.

It is crucial to consider that not all individuals who are infected with tuberculosis (TB) bacteria exhibit symptoms. In instances of this nature, the infection remains latent, signifying that the bacteria exist in a dormant form and do not elicit any symptomatic manifestations. Nevertheless, latent tuberculosis (TB) has the potential to advance into active TB disease under specific conditions, particularly when the immune system experiences a decline in functionality [5,6]. The world has been greatly affected by the COVID-19 pandemic, which was initially discovered in Wuhan, China, in December 2019 and was brought on by the new coronavirus SARS-CoV-2 [7]. Both tuberculosis and the COVID-19 pandemic are spread by respiratory droplets, which is a similar epidemiological feature. Particularly at risk are marginalized and vulnerable groups, including the elderly and people with compromised immune systems. Both illnesses can impact different organs, and creating efficient disease control strategies requires an awareness of the mechanisms and variables affecting transmission [8]. In high-risk groups, actively seeking instances enhances detection and accelerates

Received*: 06-06-2026 -* ***Accepted****: 04-08-2026 -* ***Published****: 12-08-2026*

Attahadi Medical Journal
2026;3(3):381-386
https://doi.org/10.69667/amj.26317

treatment. In high-burden environments, this strategy lowers the incidence of tuberculosis. The TB epidemic can be greatly reduced by using current understanding to stop new infections and cases [9]. An immunological response imbalance that increases disease progression is shared by COVID-19 and TB. The risk of serious sickness is increased by medical conditions such as diabetes, smoking, liver failure, and chronic lung disease [2,9].
During the COVID-19 pandemic, Member States are being advised by the World Health Organization (WHO) to maintain vital services for those suffering from tuberculosis (TB) and other illnesses. Patient-centered care, accurate diagnostic testing, and preventative measures are essential. Increased use of digital health technologies is necessary for better care and communication. Additionally, proactive planning, supply, procurement, and risk management [10,11]. To decrease their destructive effects, TB and COVID-19 disease programs must be integrated. It's critical to evaluate COVID-19 patients for TB and vice versa. By causing TB to develop after recovery, COVID-19 can have an indirect impact on the incidence of TB. Dysregulation of the immune system may exacerbate the severity of COVID-19 and promote the advancement of TB illness [12]. The purpose of this study was to describe the characteristics of TB patients during the post-COVID-19 period of 2021 and the related clinical history. To our knowledge, no studies have been done in Libya about this issue.

Patients and Methods

This descriptive, cross-sectional study included 142 patients with bacteriologically confirmed pulmonary tuberculosis (TB) admitted to Al-Quifia Hospital in Benghazi during the post-COVID-19 period of 2021. Al-Quifia Hospital is one of the two primary specialized respiratory centers in Eastern Libya. The study population comprised male and female patients over the age of 14. Secondary data were extracted from hospital records, including demographics (age, sex, nationality, and residence), comorbidities (diabetes mellitus, hypertension, hepatitis B, HIV, bronchial asthma, COPD, anemia, and post-COVID-19 status), and risk factors such as prior admissions and household TB exposure. The study was conducted in the hospital, using existing hospital records from January to December 2021. The sampling method is Purposive (Non-probability) Consecutive Sampling.

Approach

All patients who met the inclusion criteria (bacteriologically confirmed pulmonary TB, aged >14, admitted during 2021) were included in the study until the target sample size of N = 142 was reached.

Inclusion Criteria

Patients with a positive GeneXpert MTB/RIF result, sputum smear microscopy, or culture; age >14 years; admitted to Al-Quifia Hospital between January 1, 2021, and December 31, 2021.

Exclusion Criteria

Patients with incomplete medical records regarding primary comorbidities or those with extra-pulmonary TB without pulmonary involvement.

Household Contact

Any individual who shared the same enclosed living space (house or apartment) with the index TB patient for one or more nights or for frequent/extended periods during the daytime in the 3 months before the current diagnosis.

Post-COVID-19 TB

It refers to the development of active TB disease shortly after a patient has recovered from COVID-19.

Bacteriologically Confirmed

A biological specimen (sputum) that is positive by smear microscopy, culture, or WHO-approved rapid diagnostics such as GeneXpert MTB/RIF.

Comorbid Status

Presence of pre-existing chronic conditions (e.g., DM, HIV, HBV, Asthma) explicitly documented in the patient's clinical history upon admission.

At Al-Quifia Hospital, TB was confirmed using the following standardized diagnostic algorithms:

GeneXpert MTB/RIF

The primary diagnostic tool used to detect Mycobacterium tuberculosis DNA and resistance to rifampicin.

Sputum Smear Microscopy

Performed using Ziehl-Neelsen (ZN) staining to identify Acid-Fast Bacilli (AFB).

Received*: 06-06-2026 -* ***Accepted****: 04-08-2026 -* ***Published****: 12-08-2026*

Attahadi Medical Journal
2026;3(3):381-386
https://doi.org/10.69667/amj.26317

Culture (if applicable)
Use of Lowenstein-Jensen (L-J) medium for the gold-standard growth of M. tuberculosis.

Quality Control
All laboratory tests were conducted by the hospital's central pathology lab, following the Libyan National Tuberculosis Program (NTP) guidelines. Data analysis was performed using SPSS (version 25), utilizing descriptive statistics (mean, standard deviation, and frequencies). The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board (IRB) of [LIU's Research Ethics Committee MDC-2023-00116]. Due to the retrospective nature of the study, the requirement for informed consent was waived, and all data were analyzed anonymously.

Result

A total of 142 cases participated in the study. The patients' mean age was 33 ± 13.6 years; nearly half, 45.8% (n=65) of cases, were within the age group of 25 and 35 years. 78.9% (n=112) were male, 69% (n=98) Libyan, and the major other nationality was Sudanese (21.8% (n=31)). 57% (n=81) of them lived in Benghazi city (Table 1).

Table 1. Distribution of patients according to sociodemographic characteristics

Variables	Frequency (n)	Percentage (%)
Age		
14- 24	39	27.5
25-35	65	45.8
36 – 46	16	11.3
47 – 57	12	8.5
58 - 68	4	2.8
> 68	6	4.2
Sex		
Female	30	21.1
Male	112	78.9
Nationality		
Libyan	98	69
Egypt	2	1.4
Sudan	31	21.8
Chad	7	4.9
Bangladesh	3	2.1
Ethiopia	1	0.7
Residence		
Benghazi	81	57
Out Benghazi	61	43
Total	142	100

The data demonstrate that 19 (13.4%) of patients were diabetic, and 3.5% (n=5) were post-COVID-19 TB, and 4.1% (n=6) were seropositive for HIV. The remaining 4 patients: 2 of them are hypertensive, one patient has COPD, and the other one has bronchial asthma. 4 (2.8%) HIV cases. About a third of patients, 33.1% (n= 47), were anemic (Table 2).

Table 2. Distribution of comorbidity of patients

Comorbidity	Frequency (n)	Percentage (%)
Bronchial Asthma		
Yes	1	0.7
No	141	99.3
DM		
Yes	19	13.4
No	123	86.6
HTN		
Yes	3	2.1
No	139	97.9
HBV		
Yes	4	2.8

Received*: 06-06-2026 -* ***Accepted****: 04-08-2026 -* ***Published****: 12-08-2026*

Attahadi Medical Journal
2026;3(3):381-386
https://doi.org/10.69667/amj.26317

No	138	97.2
HIV		
Yes	6	4.1
No	136	95.8
COPD		
Yes	1	0.7
No	141	99.3
Post COVID19		
Yes	5	3.5
No	137	96.5
Anemia		
Yes	47	33.1
No	95	66.9

The study results described the prevalence of selected clinical histories and exposures among the cohort (n = 142). Specifically, 11% (n=16) of patients reported a prior history of hospital admission before their current diagnosis. Household exposure to tuberculosis, defined as living with an individual previously diagnosed with the disease, was present in 8.5% (n=12) of participants. Furthermore, 14.1% (n=20) of cases reported contact with a TB-positive individual, with a higher proportion of these source cases being male. Additionally, cigarette smoking was reported in 16% (n=23) of the study population (Table 3).

Table 3. Distribution of some patients' clinical histories

Variable	Frequency(n)	Percentage (%)
Smoking History	23	16
Contact with a TB Patient	20	14.1
Previous Hospital Admission	16	11
Household TB History	12	8.5

Discussion

The significant burden of tuberculosis (TB) in this region is inextricably linked to the demographic and socio-economic landscape. Developing effective national policies and optimizing resource allocation requires a comprehensive understanding of the epidemiological drivers unique to the population. Given the multifaceted nature of TB emergence, this study investigated various socio-demographic factors to address existing information gaps. Our findings reveal a mean patient age of 33 ± 13.6 years, with nearly half (45%) falling within the 25–35 age bracket. While our results align with the youth-centric susceptibility observed in Al-Najaf, Iraq (where the 16–24 age group was most affected [13]), they differ slightly from findings in North Ethiopia, where a broader 26–45-year age group accounted for 54.9% of cases [1]. The study revealed that the majority (78.9%) were males; the significant male predominance aligns with global World Health Organization (WHO) reports, which provide the global context, noting that men accounted for 55% of all TB cases globally in 2023[14], which consistently show higher TB notification rates among men. This disparity is often attributed to a combination of biological susceptibility, higher rates of social contact in male-dominated workspaces, and behavioral risks such as smoking [15,16]. However, previous studies reported a very high percentage of TB disease among males [10,11, 17,18].

The presence of a significant Sudanese population among the cases (31% non-Libyan) underscores the importance of migrant health in Libya's TB control strategy. As a major transit and destination hub in North Africa, Benghazi's health system must address the unique challenges faced by migrant populations, including potential barriers to healthcare access, language differences, and living conditions that may facilitate transmission [19,20]. Previous studies in Libya have similarly identified Sudanese nationals as one of the most frequent nationalities among immigrant TB cases. [20]. Chronic illness such as diabetes mellitus reduces the competency of the immune system, pulmonary diseases minimize the function of the cilia and the removal of inhaled substances, and hence increase the risk of TB [21]. Diabetes is well-documented to impair the immune response, including the dysfunction of neutrophils, macrophages, and the adaptive T-cell response, effectively tripling the risk of developing active TB [22,23].

The prevalence of Diabetes Mellitus (13.4%) in this cohort is also noteworthy. This finding suggests that integrated screening for DM among TB patients at Al-Quifia Hospital is essential to ensure adequate glycemic control and improve cure rates, as bidirectional screening has been shown to enhance case detection and treatment outcomes [23,24]. However, this is in accordance with the findings reported in another systematic review that DM patients have a pooled prevalence of type 2 DM, and the prevalence of type 2 DM-TB was significantly higher in countries with a high TB burden [21]. While the HIV seropositivity rate (4.1%) remains relatively low compared to sub-Saharan African averages, which can exceed (50%) in

Received*: 06-06-2026 -* ***Accepted****: 04-08-2026 -* ***Published****: 12-08-2026*

Attahadi Medical Journal
2026;3(3):381-386
https://doi.org/10.69667/amj.26317

some regions, it remains clinically significant and necessitates continued mandatory co-infection screening due to HIV's role in accelerating TB progression [25,26].

Proximity is a major determinant of TB risk, as the likelihood of infection remains higher among immediate family members compared to more distant social circles [21]. This is largely due to the duration of exposure, with research identifying 18 hours or more of contact as a major risk factor [27]. Within our study, the 8.5% of participants living in crowded homes with a TB history highlight a critical need for Active Case Finding. Because TB spreads so efficiently in these spaces, waiting for symptomatic individuals to self-report (passive finding) often results in missed opportunities to stop secondary infections [28]. Our findings indicate that 14.1% of tuberculosis cases originated from close contact, with a male often identified as the index case. This trend is consistent with global epidemiological data, which confirms that men consistently account for more than half of the total TB burden [14]. One of the most striking findings in this study is the high prevalence of anemia (33.1%).

Anemia in TB patients is often multifactorial, frequently manifesting as "anemia of chronic disease" or resulting from nutritional deficiencies [29]. Given that anemia is a known predictor of poor clinical outcomes and increased mortality in TB patients, this highlights a critical need for nutritional assessment and support during treatment [30,31]. According to systematic and meta-analyses, anemia was a risk factor for TB, and the risk was increased with anemia severity [30,32]. In the present study, 16% of cases were identified as current smokers, a finding that mirrors trends observed in previous research from Vietnam and Egypt [11,17]. This underscores the role of smoking as a critical driver of TB infection, likely due to its detrimental impact on respiratory immunity. While only 11% of our study's cases reported a prior hospital admission, this interaction with the health system remains a vital point for intervention. Velen et al. noted a much higher frequency, with 75% of cases visiting facilities in the 12 months before diagnosis [11]. Tuberculosis after recovering from COVID-19 is becoming more common, potentially leading to a TB outbreak in the post-COVID-19 era. The immunosuppressive nature of the disease and its treatment modalities may contribute to post-COVID-19 TB [10,18]. The identification of post-COVID-19 TB cases (3.5%), though a small percentage, reflects an emerging global concern. The immunological exhaustion or "immune debt" caused by severe COVID-19, combined with the use of corticosteroids during the pandemic, may have reactivated latent TB infections.

Limitation

The sample size was small, and as a result of the COVID-19 pandemic and the lockdown caused by the pandemic, there was incomplete data in the records in that year in which the data was collected.

Conclusion

The findings of this study provide a critical profile of the tuberculosis (TB) landscape in Benghazi, revealing that the disease predominantly impacts a young, productive demographic, with a mean age of 33 years and nearly half of all cases concentrated in the 25–35 age bracket. The heavy male predominance suggests that TB in this region is driven by gender-specific risks, likely tied to the 16% smoking prevalence and broader social or occupational contact patterns characteristic of the male workforce. The study highlights a significant burden of comorbidities, particularly anemia (33.1%) and diabetes (13.4%), alongside emerging concerns such as post-COVID-19 TB and HIV co-infection. These factors, combined with the 11% rate of prior hospital admissions, point to "missed diagnostic opportunities" within the healthcare system. Furthermore, the 14.1% rate of transmission via close contact, often from male source cases, underscores the high risk of household infection.

Recommendations

- Prioritize active case finding among high-risk groups, particularly young adult males (25–35 years), smokers, and individuals with known TB contacts.
- Establish integrated care pathways linking TB services with diabetes and anemia screening and management.
- Patients with prior hospital admissions or persistent respiratory symptoms should be systematically evaluated for TB.
- Implement targeted smoking cessation programs as part of TB care and prevention strategies.
- Ensure routine HIV testing for all TB patients.
- Further longitudinal and multicenter studies are recommended to explore causal pathways, particularly the role of gender-specific exposures, post-COVID-19 TB, and comorbidity interactions in the Libyan context.

Acknowledgement

The authors would like to acknowledge all members of the archive unit at AL-Quifia Hospital.

Conflict of interest. Nil

Received*: 06-06-2026 -* ***Accepted****: 04-08-2026 -* ***Published****: 12-08-2026*

References

1. Wei M, Zhao Y, Qian Z, Yang B, Xi J, Wei J, et al. Pneumonia caused by Mycobacterium tuberculosis. Microbes Infect. 2020;22(6–7):278–84.
2. Shimeles E, Enquselassie F, Aseffa A, Tilahun M, Mekonen A, Wondimagegn G, et al. Risk factors for tuberculosis: a case-control study in Addis Ababa, Ethiopia. PLoS One. 2019;14(4):e0214235.
3. Narasimhan P, Wood J, MacIntyre CR, Mathai D. Risk factors for tuberculosis. Pulm Med. 2013;2013:828939.
4. Luies L, Du Preez I. The echo of pulmonary tuberculosis: mechanisms of clinical symptoms and other disease-induced systemic complications. Clin Microbiol Rev. 2020;33(4):10–1128.
5. Esmail H, Barry CE 3rd, Young DB, Wilkinson RJ. The ongoing challenge of latent tuberculosis. Philos Trans R Soc Lond B Biol Sci. 2014;369(1645):20130437.
6. Ryu YJ. Diagnosis of pulmonary tuberculosis: recent advances and diagnostic algorithms. Tuberc Respir Dis (Seoul). 2015;78(2):64–71.
7. Wang H, Lee TW, Misra A, Tay A. Q&A: The COVID-19 pandemic. MRS Bull. 2020;45(7):592–4.
8. World Health Organization. COVID-19 and TB: Global tuberculosis report 2022 [Internet]. Geneva: World Health Organization; 2022 [cited 2026 May 7]. Available from: https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022/covid-19-and-tb
9. Zhu H, Wei L, Niu P. The novel coronavirus outbreak in Wuhan, China. Glob Health Res Policy. 2020;5(1):6.
10. Rajagopal J, Konaka Gautamdas S, Sivakumar G, Ramaraju K. A case series on post-COVID tuberculosis: an underrated duo of COVID-19 and tuberculosis. Cureus. 2023;15(10):e48013.
11. Velen K, Nhung NV, Anh NT, Cuong PD, Hoa NB, Cuong NK, et al. Risk factors for tuberculosis (TB) among household contacts of patients with smear-positive TB in 8 provinces of Vietnam: a nested case-control study. Clin Infect Dis. 2021;73(7):e1681–9.
12. TB/COVID-19 Global Study Group. Tuberculosis and COVID-19 co-infection: description of the global cohort. Eur Respir J. 2022;59(3):2102538.
13. Al-Hadraawy SK, al Hadrawi KK, Aljanaby IAJ, Aljanaby A. Prevalence of pulmonary tuberculosis in Al-Najaf governate, Iraq. F1000Research. 2022;11:675.
14. World Health Organization. Global tuberculosis report 2023. Geneva: World Health Organization; 2023.
15. Gupta M, Srikrishna G, Klein SL, Bishai WR. Genetic and hormonal mechanisms underlying sex-specific immune responses in tuberculosis. Trends Immunol. 2022;43(8):640–56.
16. Nguyen HV, Brals D, Tiemersma E, Gasior R, Cobelens F, Nguyen HB. Influence of sex and sex-based disparities on prevalent tuberculosis, Vietnam, 2017–2018. Emerg Infect Dis. 2023;29(5):917–25.
17. Abdel Fattah E, Safwat T, Soliman A. Gender differences in pulmonary tuberculosis in Abbassia Chest Hospital. Egypt J Bronchol. 2019;13(3):408–13.
18. Alemu A, Bitew ZW, Seid G, Diriba G, Gashu E, Berhe N, et al. Tuberculosis in individuals who recovered from COVID-19: a systematic review of case reports. PLoS One. 2022;17(11):e0277807.
19. Meaza A, Tola HH, Eshetu K, Mindaye T, Medhin G, Gumi B. Tuberculosis among refugees and migrant populations: systematic review. PLoS One. 2022;17(6):e0268696.
20. Miller LN, Elmselati H, Fogarty AS, Farhat ME, Standley CJ, Abuabaid HM, et al. Using One Health assessments to leverage endemic disease frameworks for emerging zoonotic disease threats in Libya. PLOS Glob Public Health. 2023;3(7):e0002005.
21. Wu Q, Liu Y, Ma YB, Liu K, Chen SH. Incidence and prevalence of pulmonary tuberculosis among patients with type 2 diabetes mellitus: a systematic review and meta-analysis. Ann Med. 2022;54(1):1657–66.
22. Kumar NP, Babu S. Impact of diabetes mellitus on immunity to latent tuberculosis infection. Front Clin Diabetes Healthc. 2023;4:1095467.
23. Nyirenda JLZ, Bockey A, Wagner D, Lange B. Effect of tuberculosis (TB) and diabetes mellitus (DM) integrated healthcare on bidirectional screening and treatment outcomes among TB patients and people living with DM in developing countries: a systematic review. Pathog Glob Health. 2023;117(1):36–51.
24. Jali MV, Mahishale VK, Hiremath MB. Bidirectional screening of tuberculosis patients for diabetes mellitus and diabetes patients for tuberculosis. Diabetes Metab J. 2013;37(4):291–5.
25. Kharsany ABM, Karim QA. HIV infection and AIDS in sub-Saharan Africa: current status, challenges and opportunities. Open AIDS J. 2016;10:34–48.
26. Lawn SD, Wood R. Tuberculosis in antiretroviral treatment services in resource-limited settings: addressing the challenges of screening and diagnosis. J Infect Dis. 2011;204(suppl 4):S1159–67.
27. Laghari M, Sulaiman SAS, Khan AH, Talpur BA, Bhatti Z, Memon N. Contact screening and risk factors for TB among the household contact of children with active TB: a way to find source case and new TB cases. BMC Public Health. 2019;19(1):1274.
28. Jerene D, Melese M, Kassie Y, Alem G, Daba SH, Hiruye N, et al. The yield of a tuberculosis household contact investigation in two regions of Ethiopia. Int J Tuberc Lung Dis. 2015;19(8):898–903.
29. Minchella PA, Donkor S, Owolabi O, Sutherland JS, McDermid JM. Complex interplay between iron metabolism, inflammation, and anaemia in Sudanese and Gambian tuberculosis patients. Eur J Clin Nutr. 2015;69(2):170–6.
30. Gelaw Y, Getaneh Z, Wondmagenehu A. Anemia as a risk factor for tuberculosis and its effect on treatment outcomes: a systematic review and meta-analysis. PLoS One. 2021;16(10):e0258077.
31. Lee SW, Kang YA, Yoon YS, Um SW, Lee SM, Yoo CG, et al. The prevalence and clinical significance of anemia in patients with tuberculosis. Int J Tuberc Lung Dis. 2016;20(3):396–401.
32. Nguyen HV, Tiemersma EW, Nguyen HB, Cobelens FGJ, Maine DP. The male-to-female ratio of tuberculosis in Vietnam: a secondary analysis of two national prevalence surveys. PLoS One. 2023;18(6):e0286944.

***Received**: 06-06-2026 - **Accepted**: 04-08-2026 - **Published**: 12-08-2026*