# Assessment of Hematological Parameters in Mycobacterium Tuberculosis-Infected Patients at Hayatabad Medical Complex, Peshawar, Pakistan

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**Disclaimers**

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## ABSTRACT

**Background**: Mycobacterium tuberculosis is a major causative agent of pulmonary tuberculosis, significantly contributing to morbidity and mortality worldwide. In South Asia, including Pakistan, TB remains a primary cause of prolonged hospital stays and economic burden. It primarily affects the lungs and can alter various hematological parameters.

**Objective**: To assess the prevalence and characterize the hematological features of pulmonary tuberculosis patients at Hayat Abad Medical Complex, Peshawar, Pakistan.

**Methods**: A descriptive cross-sectional study was conducted from April to August 2024. A total of 220 sputum samples were collected from male and female patients of all ages with suspected TB. TB was confirmed in 31 patients using TB PCR. Hematological parameters, including WBC, RBC, Hb, HCT, MCV, MCH, and platelets, were analyzed using a Sysmex hematology analyzer. Data were analyzed using SPSS version 25.

**Results**: The prevalence of TB was 14% (31/220). All confirmed TB patients had elevated WBC and neutrophil counts (100%), decreased Hb and HCT (100%), and reduced MCV (96%). Lymphopenia was present in 90% of the cases.

**Conclusion**: Hematological deviations can be cost-effective markers for early TB diagnosis in resource-limited settings.

## INTRODUCTION

Pulmonary tuberculosis (TB), caused by Mycobacterium tuberculosis, remains a major global health concern despite advancements in diagnostic and therapeutic strategies (1). The bacterium is known for its chronic infection capabilities, often leading to severe pulmonary manifestations and systemic involvement. Globally, approximately 10 million individuals are affected by tuberculosis each year, with a significant proportion succumbing to the disease, making it one of the leading causes of mortality from bacterial infections worldwide (2). In South Asia, Pakistan is considered one of the high-burden countries, with a notable prevalence of tuberculosis contributing to significant morbidity and mortality. Approximately 52% of reported cases in Pakistan are confirmed TB infections, while up to 66% of newly diagnosed cases show resistance to rifampicin, a primary anti-TB drug, indicating the challenge of drug-resistant TB in the region (3). The clinical course of tuberculosis is influenced by the host's immune response, which involves the migration of neutrophils and subsequent activation of macrophages that present antigens to T lymphocytes, orchestrating a complex immune reaction (4). This interaction between the pathogen and the host's immune system is pivotal in determining the severity of clinical manifestations observed in infected patients (5).

Tuberculosis primarily affects the lungs, but it can disseminate to other organs, notably the bone marrow, where hematological complications such as anemia and leukocytosis may develop (6). Hematological abnormalities in TB patients are not uncommon, with deviations in red blood cell (RBC) count, hemoglobin concentration, hematocrit, and other parameters frequently reported. These abnormalities often reflect the systemic impact of the disease and can be used as adjunctive diagnostic markers (7). The examination of hematological parameters such as RBC count, white blood cell (WBC) count, hemoglobin, hematocrit, mean cell volume (MCV), mean cell hemoglobin (MCH), and platelets serves as a valuable tool for clinicians to assess disease progression, treatment response, and overall prognosis in TB patients (8). The clinical utility of these parameters lies in their simplicity and cost-effectiveness, making them particularly advantageous in resource-constrained settings where advanced diagnostic facilities may be unavailable (9).

The presence of anemia in TB patients is particularly noteworthy, as it has been attributed to the suppression of erythropoiesis due to bone marrow infiltration or nutritional deficiencies secondary to chronic illness (10). Moreover, leukocytosis and elevated neutrophil counts are frequently observed, likely due to the body's attempt to mount an effective immune response against the invading pathogen (11). Previous studies have highlighted that the prevalence of anemia in TB patients ranges from 31% to as high as 77% in certain populations, depending on factors such as co-infection status and disease severity (12, 13). In Pakistan,

the high burden of TB, coupled with the prevalence of multidrug-resistant strains, complicates patient management and increases the economic burden on the healthcare system (14). This emphasizes the need for comprehensive hematological assessments to aid in early diagnosis, especially in endemic regions like Pakistan, where the disease is prevalent across various demographic groups (15).

The current study aims to assess the hematological parameters of patients infected with Mycobacterium tuberculosis in the Hayat Abad Medical Complex, Peshawar, Pakistan, and to evaluate the prevalence and clinical significance of these deviations. Given the paucity of recent studies on this topic in Pakistan, our research seeks to fill the gap by providing updated data on hematological changes in TB patients, which could potentially enhance clinical decision-making and improve patient outcomes (16). The identification of specific hematological abnormalities may serve as a cost-effective screening tool for early TB diagnosis, enabling timely intervention and reducing disease transmission within the community (17). As such, the findings of this study will contribute to the growing body of literature on the hematological impacts of TB and provide a foundation for future research and policy formulation aimed at strengthening TB control programs in high-burden settings (18, 19).

## MATERIAL AND METHODS

The study was conducted as a descriptive cross-sectional study from 1st April to 30th August 2024 at the Provincial Tuberculosis Reference Laboratory, Hayatabad Medical Complex, located in Peshawar, Khyber Pakhtunkhwa, Pakistan. Prior to data collection, ethical approval was obtained from the Institutional Ethical Review Committee of Sarhad University of Science and Information Technology, Peshawar, Pakistan, in accordance with the Declaration of Helsinki (IERC-SUIT 2024-032). Informed consent was obtained from all participants after explaining the purpose and procedures of the study. Both male and female patients of various ages presenting with clinical signs and symptoms suggestive of pulmonary tuberculosis were included, while patients with other lung infections, hematological disorders, or those unable to provide sputum samples were excluded.

A total of 220 sputum samples were collected using sterile containers, ensuring that the samples were obtained through deep coughs to achieve optimal specimen quality. After collection, the samples were subjected to molecular confirmation using the TB Polymerase Chain Reaction (PCR) technique to establish a definitive diagnosis of Mycobacterium tuberculosis infection. Out of the 220 collected samples, 31 cases were confirmed as positive for tuberculosis. For these confirmed TB patients, a comprehensive hematological assessment was conducted. Venous blood samples (5 mL) were collected in EDTA tubes using sterile, disposable syringes. The samples were immediately transported to the hematology laboratory for processing. The EDTA blood samples were mixed thoroughly using a blood shaker, and a complete blood count (CBC) was performed using a Sysmex hematology analyzer. Hematological parameters including white blood cell count (WBC), red blood cell count (RBC), hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and platelet count were measured and recorded.

Data collection was meticulously documented in Microsoft Excel, followed by statistical analysis using SPSS version 25. Descriptive statistics were used to summarize the demographic characteristics of the participants and the prevalence of tuberculosis in the study population. The frequency and percentages of various hematological parameters were calculated to assess the deviation of these indices from their respective normal ranges among confirmed TB patients. Further inferential analysis was performed to determine any significant associations between gender, age groups, and hematological deviations using chi-square tests, with a p-value of $<0.05$ considered statistically significant. The results were represented in tables and graphs for clarity and to facilitate comparison with existing literature. This structured approach ensured that all relevant clinical and laboratory data were comprehensively analyzed, contributing to a robust understanding of the hematological changes associated with pulmonary tuberculosis (1).

## RESULTS

A total of 220 participants were screened for pulmonary tuberculosis at the Provincial Tuberculosis Reference Laboratory, Hayatabad Medical Complex, Peshawar, Pakistan. Out of these, 31 cases were confirmed to have Mycobacterium tuberculosis infection, yielding a prevalence rate of 14%. The remaining 189 participants tested negative for the disease. The demographic distribution of the study population and TB infection status is presented in Table 1. The gender distribution showed that out of 111 male participants, 12 (39%) were positive for TB, while 19 (58%) of the 109 female participants were diagnosed with TB, indicating a higher prevalence among females. The observed gender-based differences in TB prevalence were statistically significant ($p < 0.05$).

**Table 1: Distribution of Participants by Gender and TB Status**

| Gender | Total Participants (n=220) | TB Positive (n=31) | TB Negative (n=189) | Percentage TB Positive |
|---|---|---|---|---|
| Male | 111 | 12 | 99 | 39% |
| Female | 109 | 19 | 90 | 58% |
| Total | 220 | 31 | 189 | 14% |

Age-wise analysis revealed that most TB-positive cases belonged to the 30-60 years age group (77%). The prevalence in the 10-30 years age group was notably lower (4 out of 108), and only 2 cases were reported in participants

aged 60-90 years. Hematological analysis of the 31 confirmed TB cases revealed significant deviations in several parameters compared to their normal ranges.

Table 3 summarizes the variations in hematological indices among TB-positive participants All TB patients (100%) exhibited elevated WBC counts and neutrophil levels.

**Table 2: Age Distribution and Prevalence of TB among Participants**

| Age Group | Total Participants (n=220) | TB Positive (n=31) | Percentage of TB Positive |
|---|---|---|---|
| 10-30 years | 108 | 4 | 13% |
| 30-60 years | 87 | 24 | 77% |
| 60-90 years | 25 | 2 | 8% |
| Total | 220 | 31 | 14% |

while hemoglobin, hematocrit, and MCV values were reduced in all cases. Lymphocyte counts were decreased in 90% of the cases, and 41% had reduced MCH values. Only 16% of the TB patients showed a lower RBC count, while platelet counts remained within the normal range for all patients. Statistical analysis revealed that these hematological deviations were significant when compared to standard reference ranges ($p < 0.05$).

**Table 3: Hematological Parameters of TB-Positive Patients (n=31)**

| Hematological Parameter | Normal Range | Number of Patients | Percentage of Patients (%) | p-value |
|---|---|---|---|---|
| RBC Count | 4.7-6.1 M/uL | 5 | 16% | <0.05 |
| Hemoglobin (Hb) | 13.8-17.2 g/dL | 31 | 100% | <0.01 |
| Hematocrit (HCT) | 40-50% | 31 | 100% | <0.01 |
| MCV | 80-100 fL | 30 | 96% | <0.05 |
| MCH | 27-31 pg | 13 | 41% | <0.05 |
| WBC Count | 4.0-10.0 K/uL | 31 | 100% | <0.01 |
| Neutrophils | 40-70% | 31 | 100% | <0.01 |
| Lymphocytes | 20-40% | 28 | 90% | <0.01 |
| Platelets | 150-400 K/uL | 31 | 100% | NS |

The overall findings suggest that TB patients experienced marked anemia, leukocytosis, and neutrophilia, alongside lymphopenia, indicating a robust inflammatory response typical of tuberculosis pathology. The observed hematological deviations are consistent with previous reports highlighting the diagnostic utility of such parameters in TB prognosis and management (17, 18). These findings suggest that the middle-aged group (30-60 years) was significantly more affected by tuberculosis ($p < 0.05$).

These results underscore the importance of including hematological assessments in the diagnostic workup of TB patients, particularly in resource-limited settings where advanced molecular diagnostics may not be readily available. Comprehensive evaluation and monitoring of these indices could aid in early detection, appropriate clinical management, and improved outcomes in TB patients.

## DISCUSSION

The present study aimed to evaluate the hematological parameters of patients infected with Mycobacterium tuberculosis and to assess the prevalence of tuberculosis at Hayatabad Medical Complex, Peshawar, Pakistan. The findings revealed significant alterations in several hematological indices among TB patients, suggesting that these deviations could serve as valuable diagnostic and prognostic markers in clinical practice. The prevalence of tuberculosis in the study population was found to be 14%, which aligns with the general trend of high TB prevalence in South Asian countries, particularly in Pakistan, where the disease remains a major public health burden (3). The gender-based analysis demonstrated a higher prevalence of TB among females, consistent with previous studies that have reported increased susceptibility in women due to socio-economic, nutritional, and immunological factors (14). However, the findings contradict some regional studies that have reported a higher TB prevalence in males, indicating that gender-specific factors may vary across different demographic settings (15).

The hematological profile of TB patients in this study showed marked anemia, characterized by a significant reduction in hemoglobin and hematocrit levels, which were present in 100% of the confirmed TB cases. This is consistent with prior research that has documented anemia as a common complication in TB patients, primarily due to the infiltration of bone marrow by the Mycobacterium pathogen and the resultant suppression of erythropoiesis (12). Studies conducted in sub-Saharan Africa also reported similar trends, where up to 77% of TB patients were found to be anemic, which further supports the notion that anemia is a global manifestation of tuberculosis, irrespective of geographical location (13). Moreover, the elevated WBC and neutrophil counts observed in all TB patients are indicative of an active inflammatory response, which has been widely documented in the literature as a hallmark of tuberculosis infection (11). The lymphopenia seen in 90% of the patients is also in agreement with previous studies that have highlighted the role of reduced lymphocyte counts as a marker of disease severity and progression in TB patients (16).

The age distribution analysis revealed that the highest prevalence of TB was among the middle-aged group (30-60

years), accounting for 77% of all confirmed cases. This observation is consistent with earlier studies that have shown that middle-aged adults are at a higher risk of TB infection, possibly due to increased exposure and a higher likelihood of comorbidities that can compromise immunity (14). In contrast, the lowest prevalence was observed in the older age group (60-90 years), which may reflect lower healthcare-seeking behavior or underdiagnosis in this population. These age-related variations suggest that targeted screening and diagnostic interventions should focus more on middle-aged adults to enhance early detection and treatment outcomes.

The study's strengths include a well-defined study population and the use of PCR-based TB confirmation, which ensured the accuracy of TB diagnosis. Additionally, the detailed assessment of various hematological parameters provides a comprehensive understanding of the systemic impact of TB, contributing to the growing body of evidence on the utility of hematological markers in TB diagnosis and management. However, certain limitations must be acknowledged. The cross-sectional nature of the study precludes the establishment of causality between TB and the observed hematological changes. Furthermore, the relatively small sample size, particularly for TB-positive cases, may limit the generalizability of the findings to broader populations. Another limitation is the lack of comparison with healthy controls, which could have provided more robust baseline values for the hematological parameters under investigation.

Future studies should aim to include larger, multicentric cohorts to validate these findings and explore the role of hematological parameters as predictors of treatment response and disease progression in TB patients. In addition, longitudinal studies are recommended to establish the temporal relationship between hematological abnormalities and TB infection. Implementing routine hematological assessments in high TB burden areas, especially in resource-limited settings, could facilitate early diagnosis and enable prompt intervention, ultimately reducing TB-related morbidity and mortality. Furthermore, efforts should be made to investigate gender-specific and age-specific factors that may influence TB prevalence and hematological profiles, as these could guide the development of tailored public health strategies to combat tuberculosis more effectively (1, 17). The findings of this study underscore the potential of hematological markers as cost-effective, easily accessible tools for TB diagnosis and highlight the need for integrating these assessments into standard clinical practice for TB management.

## CONCLUSION

The study demonstrated significant deviations in hematological parameters, particularly hemoglobin, hematocrit, WBC, and neutrophil counts, among patients with pulmonary tuberculosis. These findings suggest that routine hematological assessments can serve as a simple, cost-effective approach for early diagnosis and prognosis of TB in resource-constrained settings. The higher prevalence observed in females and the middle-aged population highlights the need for targeted screening and intervention strategies. Integrating these hematological markers into routine clinical evaluations could improve patient management and reduce TB-related complications, thereby enhancing overall healthcare outcomes and contributing to the global TB control efforts.

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