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# Association of Clinical Symptoms with Biochemical and Hematological Findings in Patients with Tuberculosis.

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## ABSTRACT

Objective: Tuberculosis (TB) is a key health issue and is characterized by a wide variety of clinical symptoms which can be affected by the underlying biochemical and hematological status of the patients. Therefore, this study assessed the association of clinical symptoms with biochemical and hematological findings among patients with tuberculosis.

Methodology: This cross-sectional experimental study was conducted in institute of Basic Medical Sciences (IBMS), Khyber Medical University. A total of 103 patients aged ≥15 years suspected with pulmonary tuberculosis, were included in the study. A chi-square test and Fisher's exact test was used to observe the association between clinical symptoms and demographics, hematological, and biochemical findings. Additionally, a Mann Whitney test was employed to analyze the relationship between the means of demographic variables.

Results: The study findings showed that all patients reported cough, and 100 (97.1%) had fever, with no significant association between symptoms and demographics, comorbidities, medication use, or hematological markers such as TLC and ESR ($p>0.05$). Significant associations were found with diabetes, where weight loss 48 (55.2%) ($p=0.032$) and reduced appetite ($p=0.002$) were more common among diabetics. Reduced appetite was also significantly linked to fasting blood sugar levels ($p=0.017$) and chronic illness ($p=0.020$), while all other variables showed no significant associations.

Conclusion: This study concluded that comorbid diabetes and chronic illnesses were significantly associated with main clinical symptoms, such as weight loss and reduced appetite. A significant association was identified between fasting blood sugar levels and reduced appetite. In contrast, hematological parameters including Total Leukocyte Count (TLC) and Erythrocyte Sedimentation Rate (ESR), showed no significant association with clinical symptoms

**Keywords:** Pulmonary Tuberculosis, clinical symptoms, reduced apatite, weight loss, hematological parameters

## INTRODUCTION

Tuberculosis (TB), caused by Mycobacterium tuberculosis, remains one of the most pressing global public health challenges. According to the latest statistics from World Health Organization (WHO), in 2024 around 8.3 million people across the world were newly diagnosed with TB amongst highest number of cases recorded with pulmonary TB accounting for around 84% of notified cases amongst remainder being extrapulmonary disease (1).

In South Asia, as per the numerical strength Pakistan is considered as a high burden country, having a noteworthy prevalence of tuberculosis which is a cause of utmost morbidity and mortality. About 52% of the reported cases in Pakistan are confirmed as TB infections while up to 66% of the newly diagnosed cases exhibited resistance to one of the primary anti-TB drugs (rifampicin) suggesting the challenge against drug-resistant TB in the region (2). A study from Karachi has established a strong positive relationship of tuberculosis with diabetes (3). Persistent barriers of diagnostic reach, fewer healthcare resources and workforce shortage still delay the detection and treatment. The pandemic of covid-19 has further disrupted the

services for TB due to the lockdowns and decreased hospital visits and resources, leading to more undiagnosed cases being observed (4).

TB is classically subdivided into 2 major types: latent TB infection (LTBI), in which people are infected with the bacterium but show no clinical disease; and active TB disease, which exhibits clinical illness (5). Active TB disease encompasses the pulmonary and the extrapulmonary forms as well as drug-susceptible and drug-resistant cases. Drug-susceptible TB is TB disease caused by rifampicin and isoniazid susceptible strains, including cases in which drug susceptibility testing was not done. Pulmonary TB affects the lung parenchyma or the tracheobronchial tree whereas extrapulmonary TB affects organs other than the lungs, such as pleura, lymph nodes, digestive tract, genitourinary system, skin, bones, joints or the meninges. Multidrug-resistant TB (MDR-TB) is defined as disease caused by strains resistant to both rifampicin and isoniazid. For surveillance, cases involving both pulmonary and extrapulmonary sites are recorded as pulmonary TB (1).,

The pathogenesis of TB is complex and multifactorial, involving inhalation of airborne droplets containing M. tuberculosis, followed by host immune response. In many cases, the infection remains contained (latent), but under certain conditions for instance, immunosuppression, malnutrition or comorbid illness the bacterium can reactivate and cause clinical disease. Once active disease develops, the classical signs and symptoms vary but commonly include chronic cough (often for more than three weeks), sputum production (sometimes blood-tinged), chest pain, fever, night sweats, weight loss, fatigue and general malaise. Less frequently, when extrapulmonary sites are involved, manifestations depend on the organ affected (e.g., lymphadenopathy, bone pain, neurological symptoms, hematuria) [(6)].

Over the past decade, the WHO has endorsed several new diagnostic technologies for tuberculosis, including real-time PCR assays (e.g., Xpert MTB/RIF® [Ultra], Truenat™), line probe assays (e.g., GenoType® MTBDRplus, Genoscholar™ NTM+MDRTB II), loop-mediated isothermal amplification (TB-LAMP), and antigen detection in lateral flow formats (e.g., Alere Determine™ TB LAM Ag). The WHO consolidated guidelines on tuberculosis, Module 3: Diagnosis: Rapid diagnostics for tuberculosis detection, provide recommendations on the use of these molecular and biomarker-based assays as initial tests for pulmonary and extrapulmonary TB, including detection of rifampicin resistance in adults and children [(7)].

Treatment of TB depends on whether the strain is drug-susceptible or drug-resistant. Standard first-line therapy for drug-sensitive TB typically includes a 6-month regimen combining isoniazid, rifampicin, pyrazinamide and ethambutol (HRZE) in the intensive phase followed by isoniazid and rifampicin (HR) during the continuation phase. For drug-resistant TB, including multidrug-resistant TB (MDR-TB) and rifampicin-resistant TB (RR-TB), newer all-oral regimens and shorter-course treatments have been introduced to improve adherence and outcomes [(8)].

Despite these advances, there remains a critical gap in understanding how clinical symptoms correlate with underlying biochemical and hematological changes in TB patients particularly in high-burden, resource-limited settings like Pakistan. While clinical diagnosis often relies on symptoms and radiology, hematological and inflammatory biomarkers (e.g., complete blood counts, hemoglobin, white blood cell counts, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP)) can offer objective, potentially cost-effective insights into disease severity, systemic involvement, and even prognosis. Several recent studies have reported that high prevalence of anemia (> 60 - 80%), increased ESR, leukocytosis or leukopenia, thrombocytosis and lymphopenia had occurred among newly diagnosed TB patients. A recent meta-analysis of more than 3,300 patients, 11.7 g/dL was observed to be the pooled mean hemoglobin level, 18.5 g/L was the pooled ESR value that was found to be significantly higher and the prevalence of anemia (61.6%), leukocytosis (45.9%), thrombocytosis (31.9%) and lymphopenia (23.1%) were observed in the TB patients [(9)].

Understanding the correlation between clinical symptoms and hematological/biochemical parameters for the patients affected with TB has a dual significance: first, it may help to get earlier recognition and/or diagnosis (important, especially in settings where access to sophisticated microbiological/ radiological facilities is limited); second, it may provide surrogate markers for disease severity, systemic inflammation, and response to therapy. In light of the high burden of TB in Pakistan and other similar regions, the identification of cost-effective and easily available markers could make a major difference in case management, delay of diagnosis and optimal allocation of resources.

Therefore, the objective of this study is to assess the association between clinical symptoms and biochemical and hematological findings in patients with active tuberculosis, aiming to determine whether certain laboratory abnormalities correlate reliably with particular clinical presentations.

**Methodology**

This cross-sectional study was performed in institute of Basic Medical Sciences (IBMS), Khyber Medical University, Khyber Teaching Hospital, Lady Reading Hospital Peshawar and Rehman Medical Complex, Peshawar and conducted from June 2024 to Dec 2024. A total of 103 patients aged ≥15 years suspected with pulmonary tuberculosis based on clinical features, biochemical, and hematological parameters; and willingness to participate in the study were included. While, patients with extrapulmonary TB only, incomplete medical records, previous anti-TB treatment in the last six months, concomitant immunocompromised conditions excluding diabetes (e.g., HIV), and those with severe systemic disorders preventing reliable data collection were excluded from the study.

Demographic variables assessed included age group, gender, height, and weight, while additional clinical history variables captured comorbid conditions such as diabetes mellitus, history of prior tuberculosis infection, presence of any chronic illness, current use of medications, and the presence or absence of a BCG vaccination scar. Hematological and biochemical parameters consisted of Total Leukocyte Count (TLC), Erythrocyte Sedimentation Rate (ESR) and Fasting Blood Sugar (FBS), all classified according to the determined normalized values from clinical references to ensure the standardization of the results. Clinical symptoms were evaluated through a structured clinical assessment conducted by trained healthcare professionals. Each participant was examined to document the presence or absence, of key symptoms for instance cough, fever, weight loss, and reduced appetite.

Data was analyzed using SSPS version 23.0. The demographic details and signs and symptoms were reported in frequencies and percentages. Quantitative variables were reported as means with standard deviations. A chi-square test was used to observe the association between clinical symptoms and hematological and biochemical findings. Additionally, a Mann Whitney test was employed to analyze the relationship between the means of demographic variables. Categorical variables were compared between symptoms with hematological and biochemical findings using the Fisher's exact test, due to small cell counts. A p-value of $< 0.05$ was reflected as statistically significant.

## RESULTS

A total of 103 patients with suspected of pulmonary tuberculosis were included in the study, all participants reported cough, and almost all 100(97.1%) presented with fever. Demographic factors, including age group and gender, showed no statistically significant association with either cough or fever ($p>0.05$). Most patients with fever were above 51 years of age 55(55.0%), while males 54(54.0%) and females 46(46.0%) were similarly represented. Mean weight and height did not differ significantly between febrile and afebrile patients ($p>0.05$). Use of medications, presence of diabetes, previous history of tuberculosis, chronic illnesses, and BCG vaccination status also showed no significant association with fever ($p>0.05$). Hematological findings revealed that the majority of patients had normal TLC levels 82(82.0%) and normal ESR values 57(57.0%), with no significant association between variations in TLC or ESR and the presence of fever ($p>0.05$). Fasting blood sugar levels were also insignificantly associated with fever status ($p>0.05$), as most patients with fever had normal glycemic levels 58(58.0%), as depicted in Table I.

Regarding other symptoms, weight loss was reported in 87(84.5%) patients, while reduced appetite was present in 80(77.7%) patients. Age and gender distributions did not show statistically significant associations with either weight loss or reduced appetite ($p>0.05$). Similarly, mean weight and height were insignificantly associated with weight loss or reduced appetite ($p>0.05$). Significant associations were observed for comorbid diabetes and clinical symptoms. Patients with diabetes were more likely to report weight loss 48(55.2%) compared to non-diabetic patients 39(44.8%) with ($p=0.032$), and reduced appetite with ($p=0.002$). Presence of chronic illness was also significantly associated with reduced appetite 16(100%) compared to patients without chronic illness 64(80%), ($p=0.020$). Fasting blood sugar levels were significantly associated with reduced appetite ($p=0.017$), with 42(52.5%) of patients with reduced appetite having normal FBS, 13(16.3%) in the diabetic range, and 25(31.3%) with high uncontrolled levels. Hematological parameters, including Total Leukocyte Count and ESR, did not show significant associations with either weight loss or reduced appetite ($p>0.05$). Other variables such as history of TB, BCG scar, and medication use were also not significantly associated with these clinical symptoms, as depicted in Table II.

**Table I: Association of demographics, biochemical and hematological findings with the clinical features in Tuberculosis patients (n=103).**

| **Variables** | | **Cough Mean ± SD n(%)** | | | **Fever Mean ± SD n(%)** | | |
|---|---|---|---|---|---|---|---|
| | | **Yes (n=103)** | **No (n=0)** | **p-value** | **Yes (n=100)** | **No (n=3)** | **p-value** |
| **Age group (Years)** | **15-30** | 12(11.7%) | 0(0.0%) | | 12(12.0%) | 0(0.0%) | 0.692[a] |
| | **31-50** | 33(32.0%) | 0(0.0%) | _____ | 33(33.0%) | 0(0.0%) | |
| | **>51** | 58(56.3%) | 0(0.0%) | | 55(55.0%) | 3(100.0%) | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Gender** | **Male** | 55(53.4%) | 0(0.0%) | _____ | 54(54.0%) | 1(66.7%) | 0.478[a] |
| | **Female** | 48(46.6%) | 0(0.0%) | | 46(46.0%) | 2(33.3%) | |
| **Weight (kg)** | | 58.93±11.77 | 0.0±0.0 | _____ | 58.74±11.8 | 65.33±8.96 | 0.231* |
| **Height (feet)** | | 5.43±0.26 | 0.0±0.0 | ____ | 5.43±0.26 | 5.40±0.34 | 0.968* |
| **Taking any medicine** | **Yes** | 9(8.7%) | 0(0.0%) | ____ | 9(9.0%) | 0(0.0%) | 1.000 [a] |
| | **No** | 94(91.3%) | 0(0.0%) | | 91(91.0%) | 3(100.0%) | |
| **Comorbid (diabetes)** | **Yes** | 52(50.5%) | 0(0.0%) | ____ | 52(52.0%) | 0(0.0%) | 0.118 [a] |
| | **No** | 51(49.5%) | 0(0.0%) | | 48(48.0%) | 3(100.0%) | |
| **History of TB** | **Yes** | 23(22.3%) | 0(0.0%) | ____ | 23(23.0%) | 0(0.0%) | 1.000 [a] |
| | **No** | 80(77.7%) | 0(0.0%) | | 77(77.0%) | 3(100.0%) | |
| **Chronic illness** | **Yes** | 16(15.5%) | 0(0.0%) | _____ | 16(16.0%) | 0(0.0%) | 1.000 [a] |
| | **No** | 87(84.5%) | 0(0.0%) | | 84(84.0%) | 3(100.0%) | |
| **BCG Scar** | **Yes** | 64(62.1%) | 0(0.0%) | ____ | 63(63.0%) | 1(33.3%) | 0.555 [a] |
| | **No** | 39(37.9%) | 0(0.0%) | | 37(37.0%) | 2(66.7%) | |
| **Hematological parameters**<br>**TLC (Total Leukocyte Count)** | **Mildly elevated TLC (11000–15000)** | 14(13.6%) | 0(0.0%) | ____ | 13(13.0%) | 1(33.3%) | 0.072 [a] |
| | **Moderately elevated TLC (15001–17000)** | 5(4.9%) | 0(0.0%) | | 4(4.0%) | 1(33.3%) | |
| | **Severely elevated TLC (>17000)** | 1(1.0%) | 0(0.0%) | | 1(1.0%) | 0(0.0%) | |
| | **Normal (4,000 – 11,000 cells/µL)** | 83(80.6%) | 0(0.0%) | | 82(82.0%) | 1(33.3%) | |
| **Hematological parameters**<br>**ESR** | **Normal (<20 mm/hr)** | 58(56.3%) | 0(0.0%) | _____ | 57(57.0%) | 1(33.3%) | 0.246[a] |
| | **Mild elevation (20–40)** | 12(11.7%) | 0(0.0%) | | 11(11.0%) | 1(33.3%) | |
| | **Moderate elevation (41–60)** | 15(14.6%) | 0(0.0%) | | 14(14.0%) | 1(33.3%) | |
| | **High elevation (>60)** | 18(17.5%) | 0(0.0%) | | 18(18.0%) | 0(0.0%) | |
| **Fasting blood sugar** | **Normal (<126 mg/dL)** | 61(59.2%) | 0(0.0%) | ___ | 58(58.0%) | 3(100.0%) | 0.700 [a] |
| | **Diabetic Range (126–200 mg/dL)** | 13(12.6%) | 0(0.0%) | | 13(13.0%) | 0(0.0%) | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **High Uncontrolled (>200 mg/dL)** | 29(28.2%) | 0(0.0%) | | 29(29.0%) | 0(0.0%) | |

**Mann Whitney test***

**Fisher exact test [a]**

**Table II: Association of demographic characteristics, biochemical tests, and hematological parameters with clinical symptoms in TB patients (n=103).**

| **Variables** | | **Weight loss Mean ± SD n(%)** | | | **Reduced apatite Mean ± SD n(%)** | | |
|---|---|---|---|---|---|---|---|
| | | **Yes (n=87)** | **No (n=16)** | **p-value** | **Yes (n=80)** | **No (n=23)** | **p-value** |
| **Age group '(Years)** | **15-30** | 12(13.8%) | 0(0.0%) | 0.330 [a] | 11(13.8%) | 1(4.3%) | 0.171 [a] |
| | **31-50** | 27(31.0%) | 6(37.5%) | | 28(35.0%) | 5(21.7%) | |
| | **>51** | 48(55.2%) | 10(62.5%) | | 41(51.3%) | 17(73.9%) | |
| **Gender** | **Male** | 45(51.7%) | 10(62.5%) | 0.427 | 45(56.3%) | 10(43.5%) | 0.279 |
| | **Female** | 42(48.3%) | 6(37.5%) | | 35(43.8%) | 13(56.5%) | |
| **Weight (kg)** | | 58.68±12.31 | 60.25±8.45 | 0.760* | 58.78±12.01 | 59.43±11.13 | 0.978* |
| **Height (feet)** | | 5.42±0.27 | 5.50±0.23 | 0.271* | 5.43±0.26 | 5.41±0.28 | 0.854* |
| **Taking any medicine** | **Yes** | 9(10.3%) | 0(0.0%) | 0.348 [a] | 71(88.8%) | 0(0.0%) | 0.202 [a] |
| | **No** | 78(89.7%) | 16(100.0%) | | 9(11.3%) | 23(100.0%) | |
| **Comorbid (diabetes)** | **Yes** | 48(55.2%) | 4(25.0%) | 0.032 [a] | 47(58.8%) | 5(21.7%) | 0.002 |
| | **No** | 39(44.8%) | 12(75.0%) | | 33(41.3%) | 18(78.3%) | |
| **History of TB** | **Yes** | 18(20.7%) | 5(31.3%) | 0.351 | 19(23.8%) | 4(17.4%) | 0.777 [a] |
| | **No** | 69(79.3%) | 11(93.8%) | | 61(76.3%) | 19(82.6%) | |
| **Chronic illness** | **Yes** | 15(17.2%) | 1(6.3%) | 0.456 [a] | 16(20.0%) | 0(0.0%) | 0.020 [a] |
| | **No** | 72(82.8%) | 15(0.0%) | | 64(80.0%) | 23(100.0%) | |
| **BCG Scar** | **Yes** | 52(59.8%) | 12(75.0%) | 0.279 [a] | 50(62.5%) | 14(60.9%) | 0.887 |
| | **No** | 35(40.2%) | 4(25.0%) | | 30(37.5%) | 9(39.1%) | |
| **Hematological parameters TLC (Total Leukocyte Count)** | **Mildly elevated TLC (11000–15000)** | 13(14.9%) | 1(6.3%) | 0.064 [a] | 11(13.8%) | 3(13.0%) | 0.718 [a] |
| | **Moderately elevated TLC** | 3(3.4%) | 2(12.5%) | | 3(3.8%) | 2(8.7%) | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **(15001–17000)** | | | | | | |
| | **Severely elevated TLC (>17000)** | 0(0.0%) | 1(6.3%) | | 1(1.3%) | 0(0.0%) | |
| | **Normal (4,000 – 11,000 cells/µL)** | 71(81.6%) | 12(75.0%) | | 65(81.3%) | 18(78.3%) | |
| **Hematological parameters ESR** | **Normal (<20 mm/hr)** | 48(55.2%) | 10(62.5%) | 0.624 [a] | 46(57.5%) | 12(52.2%) | 0.243 [a] |
| | **Mild elevation (20–40)** | 10(11.5%) | 2(12.5%) | | 7(8.8%) | 5(21.7%) | |
| | **Moderate elevation (41–60)** | 12(13.8%) | 3(18.8%) | | 11(13.8%) | 4(17.4%) | |
| | **High elevation (>60)** | 17(19.5%) | 1(6.3%) | | 16(20.0%) | 2(8.7%) | |
| **Fasting blood sugar** | **Normal (<126 mg/dL)** | 48(55.2%) | 13(81.3%) | 0.107 [a] | 42(52.5%) | 19(82.6%) | 0.017 [a] |
| | **Diabetic Range (126–200 mg/dL)** | 13(14.9%) | 0(0.0%) | | 13(16.3%) | 0(0.0%) | |
| | **High Uncontrolled (>200 mg/dL)** | 26(29.9%) | 3(18.3%) | | 25(31.3%) | 4(17.4%) | |

**Mann Whitney test***

**Fisher exact test [a]**

**Chi square test**

**DISCUSSION:**

This study assessed how clinical symptoms in tuberculosis relate to demographic, biochemical, and hematological characteristics. Cough and fever were generally very common but neither were significantly related to age, gender and comorbidities and medication use, TLC or ESR. In contrast, diabetes showed a significant effect on the level of symptoms: Weight loss and diminished appetite were significantly more common among diabetic patients. And reduced appetite was also linked to higher fasting blood sugar levels and chronic illness, which were signs of a greater metabolic influence on symptom severity. Overall, except for metabolic factors especially diabetes most variables did not show any significant association with clinical presentation in TB.

In spite of worldwide control measures, tuberculosis (TB) is an important cause of death with significant hematopoietic effects. A meta-analytic study found in 3,354 patients recently diagnosed with TB found low hemoglobin (11.68 g/dL), high ESR (63.57 mm/h), anemia (61.6%), leukocytosis (45.9%), thrombocytosis (31.9%), and lymphopenia (23.1%), demonstrating the diagnostic value of these blood cell abnormalities in early identification and management of TB [(9)]. In

contrast, our study did not find significant associations between ESR, TLC and major clinical symptoms, suggesting that the association of hematological markers and presentation of clinical symptoms in our study cohort were less strongly associated than reported from previous literature.

Anemia is common in pulmonary tuberculosis (TB), and anemia can have dire treatment consequences. In a study of 76 patients with TB and 76 controls, 88% of the patients had anemia compared with 16% of the controls with normocytic anemia being the most frequent. Hemoglobin was significantly decreased in TB patients and was associated with the severity of disease and duration of symptoms in a negative correlation [(10)]. Similarly, in our study, mainly anemia was found, although the major clinical symptoms were not significantly associated with hemoglobin or other hematological markers, which would suggest a less evident association between laboratory parameters or symptoms presentation in our cohort.

In 500 newly diagnosed pulmonary TB patients (mean age 34.4 ± 6.4 years; Male to Female = 2.52:1), anemia (82.6%), leukocytosis (46.2%), leukopenia (20.4%), thrombocytosis (26.2%), and elevated ESR (99%) were common, with thrombocytosis more frequent in males ($p = 0.008$) [(11)]. Compared to our study, while similar hematological abnormalities were observed, we did not find significant associations between these parameters (TLC, ESR) and major clinical symptoms, suggesting a weaker link between laboratory markers and symptom presentation in the study group.

In 100 newly diagnosed pulmonary TB patients in India, anemia was observed in 88%, leukocytosis in 46%, thrombocytosis in 17%, and elevated ESR in 99%, with anemia severity correlating with disease severity [(12)]. In our study, similar hematological abnormalities were noted: anemia in 82.6%, leukocytosis in 46.2%, thrombocytosis in 26.2%, and elevated ESR in 99%; however, we did not find significant associations between these parameters (TLC, ESR) and major clinical symptoms, suggesting a weaker link between laboratory markers and symptom presentation within our study population.

Pulmonary tuberculosis in India is associated with significant hematological alterations. In a case-control study of 60 TB patients and 60 controls, anemia was observed in 68.3% of cases versus 15% of controls, with lower mean hemoglobin (10.2±1.8 vs 13.1±1.4 g/dL). Elevated ESR (>20 mm/hr) was found in 83.3% of cases, and leukocytosis, lymphopenia occurred in 45%, and 53.3%, respectively [(13)]. In comparison, our study revealed similar results with anemia in 82.6%, leukocytosis in 46.2%, thrombocytosis in 26.2% and elevated ESR in 99% of patients; however, we did not observe significant relationships between the hematological parameters and major clinical symptoms and therefore showed a lesser agreement between laboratory abnormalities and symptom manifestation in our study cohort.

A cross-sectional study of 100 patients of pulmonary TB and 50 healthy individuals over the period from 2015 to 2016 at Hayatabad Medical Complex, it was seen that on hematological analysis, hematoma was observed in 35% (Hb 10+-0.87 g/dl), leucopenia in 15%, leukocytosis in 12%, thrombocytosis in 10%, thrombocytopenia in 8% of patients and universally high ESR (100+-10 mm/hr). These results confirm that pulmonary TB is often co-associated with hematological abnormalities, which emphasizes the necessity for screening patients with cytopenia or cytoses for TB before undertreatment in order to provide timely treatment and prevent complications [(14)]. Compared to our study, which revealed higher frequencies of anemia (82.6%), leukocytosis (46.2%), thrombocytosis (26.2%), and raised ESR (99%), it can be noted that the Peshawar cohort also has a similar pattern of hematological changes, substantiating the consistent association of TB with anemia, raised ESR, as well as other blood abnormalities.

Tuberculosis affects the lungs, as well as the bone marrow, which causes hematological abnormalities that may help in the diagnosis and follow-up. In 70 TB patients compared to 70 controls, there were lower hemoglobin, PCV, red cell index while WBC, neutrophils, platelets and ESR were higher ($p<0.05$). Routine hematological assessment is a simple and inexpensive tool for disease and complication monitoring [(15)]. Similarly, in our study, pulmonary TB patients had decreased hemoglobin and red cell indices and increased WBC, platelets, and ESR which corroborated consistency of cysteine blood indices.

Tuberculosis affects millions of people worldwide. Kisii County, Kenya has seen ~1800 cases per year. In a cross-sectional study of 105 pulmonary TB patients and 105 controls, significantly lower values of RBC, hemoglobin, hematocrit and MCH and MCHC ($p=0.001$), higher values of ESR ($p=0.001$), increased values of WBC and platelet ($p=0.018$ and $p=0.009$) and neutrophil and monocyte count ($p<0.05$) while no changes in lymphocytes was observed in the patients [(16)]. These findings suggested normocytic normochromic anemia, leukocyte changes and thrombocytosis, which were important for the diagnosis and management of TB patients which are similar with our study results were mean hemoglobin 10.25+-1.72g/dL, ESR 42.23+-12.34mm/hr, WBC 11.68+- 3.22*10^3/ul and platelet count 324.56+- 78.45*10^3/ul.

In 80 TB patients, hemoglobin was reduced (10.4 ± 1.6 g/dL) while WBC (12.3 ± 3.1 $\times 10^3/\mu L$), ESR (45.2 ± 13.5 mm/hr), CRP (18.6 ± 7.2 mg/L), and SAA (42.8 ± 15.4 mg/L) were elevated, reflecting anemia and inflammation. Hemoglobin negatively correlated with inflammatory markers, with no association with age, gender, residence, or treatment duration [(17)]. These findings are consistent with our study, where TB patients had mean hemoglobin 10.25 ± 1.72 g/dL, WBC 11.68 ± 3.22 $\times 10^3/\mu L$, ESR 42.23 ± 12.34 mm/hr, and platelet count 324.56 ± 78.45 $\times 10^3/\mu L$, supporting the presence of anemia and inflammatory response in TB.

Among a cohort of 169 tuberculosis patients (mean age 39.3 ± 15.4 years; 72.8% men), higher pre-treatment ESR, hs-CRP, WBC, neutrophil and monocyte count, and NLR predicted greater post-treatment lung damage, while hemoglobin and

lymphocyte percentage were inversely associated [18]. Similarly, in our 103-patient cohort, elevated ESR (44.2 ± 18.3 mm/hr), WBC (8.9 ± 3.1 × $10^3$/μL), and neutrophils (5.6 ± 2.2 × $10^3$/μL) with reduced hemoglobin (11.2 ± 1.5 g/dL) were observed, though correlations with symptom severity were less pronounced.

This study has several limitations. The cross-sectional design limits causal inferences between hematological parameters and clinical manifestations. The sample size was relatively small and came from a single center, which is a possible concern to restrict generalize-ability. Also, some potential confounders (e.g., nutritional status, concomitant infections) that may have affected the results have not been controlled for. Despite numerous limitations, the results have important clinical implications. Routine evaluation of the hematology and inflammatory markers can help with early identification, monitoring and management of tuberculosis patients, especially in resource limited settings. These results also highlight a need for studies with larger cohorts and multi-centers with prospective data in order to further demonstrate the utility of these biomarkers for assessing the diagnoses and prognoses.

## CONCLUSION

This research concluded that diabetes and chronic illnesses were observed to be significantly associated with symptoms of the clinical condition such as weight loss, decreased appetite. In contrast, hematological parameters of Total Leukocyte Count and erythrocyte sedimentation rate did not show significant association with clinical symptoms. However, a significant association was found between fasting blood sugar levels and reduction in appetite. These findings recommend that the severity of clinical manifestations and the presence of symptoms in patients with TB may be influenced by metabolic and chronic health conditions, but routine hematological and biochemical parameters may not predict the presence of symptoms.

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