ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

INNOVARE ACADEMIC SCIENCES
Knowledge to Innovation

Vol 18, Issue 6, 2025

Online - 2455-3891
Print - 0974-2441

Research Article

BIOCHEMICAL MARKERS OF INFLAMMATION IN TUBERCULOSIS PATIENTS FROM TRIBAL AND NON-TRIBAL COMMUNITIES OF UDAIPUR REGION

NISHA TRIPATHI[1], MONTEY NARUKA[2], SUMAN JAIN[3]*

[1]Department of Biochemistry, Government Medical Colleg, Satna, Madhya Pradesh, India. [2]Department of Biochemistry, School of Medical Sciences and Research, Sharda University, Greater Noida, Uttar Pradesh, India. [3]Department of Biochemistry, Government Medical College, Hanumangarh, Rajasthan, India.

***Corresponding author: Suman Jain; Email: drsumanjain10@gmail.com**

Received: 03 March 2025, Revised and Accepted: 21 April 2025

ABSTRACT

Objective: Tuberculosis (TB) continues to pose a serious health threat, especially in rural parts of India. Inflammation is a key to how TB develops and progresses. Tracking certain blood markers – such as C-reactive protein (CRP), tumor necrosis factor-alpha (TNF-α), and interleukin-6 (IL-6) – can help us understand how severe the disease is and predict how it might unfold. This study looks at the levels of these markers in TB patients from tribal and non-tribal backgrounds in rural India.

Methods: We conducted a cross-sectional study involving 150 TB patients – 75 from tribal and 75 from non-tribal communities. Blood samples were analyzed using enzyme-linked immunosorbent assay to measure CRP, TNF-α, and IL-6 levels. We also gathered clinical and demographic data, including symptoms, disease duration, and treatment details. We compared inflammatory marker levels across groups using statistical analysis.

Results: TB patients from tribal communities had notably higher levels of CRP, TNF-α, and IL-6 than those from non-tribal groups ($p<0.05$). These elevated levels were also linked to more severe symptoms and longer treatment durations. Interestingly, females showed higher levels of these markers compared to males across both communities.

Conclusion: Our findings suggest that TB patients from tribal areas may experience a stronger inflammatory response, which could be tied to delays in diagnosis or treatment. There's a clear need for early intervention and better access to care in these underserved regions to improve outcomes and reduce TB's impact.

Keywords: Tuberculosis, Inflammation, C-reactive protein, Tumor necrosis factor-alpha, Interleukin-6, Tribal communities, Non-tribal communities, Rural India.

© 2025 The Authors. Published by Innovare Academic Sciences Pvt Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/) DOI: http://dx.doi.org/10.22159/ajpcr.2025v18i6.54439. Journal homepage: https://innovareacademics.in/journals/index.php/ajpcr

INTRODUCTION

Tuberculosis (TB) continues to be one of the world's leading infectious diseases, and India carries a large share of the global burden. Even with progress in diagnosis and treatment, TB remains a major health challenge – especially in rural and tribal regions, where access to healthcare is often limited. Inflammation plays a central role in how TB develops and progresses, and certain blood markers can give us important clues about how active or severe the infection is. These include C-reactive protein (CRP), tumor necrosis factor-alpha (TNF-α), and interleukin-6 (IL-6), all of which reflect how the immune system is responding to the infection [1,2].

People living in tribal communities often face unique health-related challenges. Delayed diagnoses, poor nutrition, and limited healthcare access can all impact how TB presents and progresses. Some studies have found that TB tends to be more severe in tribal populations, possibly because of these social and environmental factors [3-5]. These same issues might also influence the body's inflammatory response, potentially leading to differences in how TB behaves in tribal versus non-tribal patients [6].

This study addresses the limited evidence comparing inflammatory markers in TB patients from tribal and non-tribal communities in rural India. Existing research has not adequately explored how CRP, TNF-α, and IL-6 levels vary across these groups or how gender influences these responses. We aim to determine whether significant differences exist in these markers and how they relate to disease severity. By doing so, the study seeks to uncover biological and healthcare access disparities. The findings may inform more equitable, community-specific approaches to TB care.

METHODS

Ethical considerations

This study received approval from the Institutional Ethics Committee (Ref No. STU/IEC/2022/106). All participants gave informed consent before joining the study. We ensured that all personal data remained confidential, and participants were made aware that their involvement was voluntary and they could withdraw at any time without consequences.

Study design

This was a cross-sectional comparative study designed to identify immediate changes in biomarkers between both groups. The levels of three inflammatory markers – CRP, TNF-α, and IL-6 – in TB patients from tribal (n=75) and non-tribal (n=75) communities in rural India. The goal was to explore potential differences in inflammation and their association with disease severity.

Study population

The study included 150 adult TB patients – 75 from tribal communities and 75 from non-tribal rural communities. Both men and women aged between 18 and 60 years, diagnosed with active pulmonary TB based on clinical signs and radiological evidence following the World Health Organization guidelines, were eligible to participate.

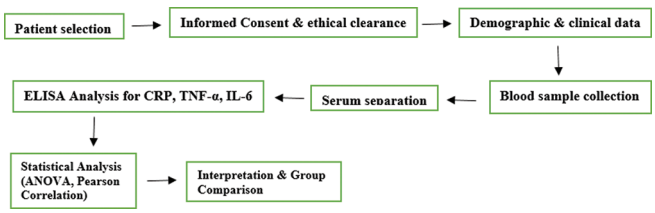
Inclusion criteria
- Confirmed diagnosis of active pulmonary TB (via sputum smear or culture)
- Aged between 18 and 60 years
- Residents of rural tribal or non-tribal communities
- Willingness to provide informed consent.

Exclusion criteria
- History of chronic inflammatory conditions (other than TB)
- Presence of comorbidities, such as diabetes, human immunodeficiency virus, or cancer
- Pregnant or breastfeeding women
- Patients already on corticosteroids or other anti-inflammatory medications.

Data collection
1. Demographic and Clinical Information: Basic information, including age, gender, duration of TB symptoms (cough, fever, weight loss, and night sweats), and the type of TB treatment regimen, were collected using a structured questionnaire.
2. Biochemical Markers: Blood samples (5 mL) were collected from each participant. Serum was separated and stored at −80°C until analysis. The levels of inflammatory biomarkers (CRP, TNF-α, and IL-6) were measured using enzyme-linked immunosorbent assay (ELISA) kits, following the manufacturer's protocol due to its high specificity, sensitivity, and cost-effectiveness in quantifying low-concentration biomarkers in resource-limited settings [7,8].
    - CRP was estimated as a marker of systemic inflammation
    - TNF-α and IL-6 were analyzed as pro-inflammatory cytokines involved in the immune response to TB infection.

Data analysis
- The p-value is evaluated using an analysis of variance as there are four groups (Tribal Males, Tribal Females, Non-Tribal Males, and Non-Tribal Females)
- Correlations between the levels of y markers of inflammation and disease severity (measured by symptom duration and radiological findings) were calculated using Pearson's correlation coefficient
- Statistical significance was set at $p<0.05$ for all tests.

Flow chart for methodology:



RESULTS

This study aimed to measure and compare the levels of three key inflammatory markers – CRP, TNF-α, and IL-6 – in TB patients from tribal and non-tribal communities in the Udaipur region. The goal was to understand how inflammation levels vary across these groups, and to explore any gender-related differences.

Demographic and clinical characteristics
A total of 150 TB patients were enrolled, with 75 participants each from tribal and non-tribal communities. The average age was 38.5 years (±10.2 years, Standard deviation [SD]). In the tribal group, 45 were male (60%) and 30 were female (40%). Among the non-tribal group, 50 were male (66.7%) and 25 were female (33.3%). On average, participants reported disease duration of 6.5 months (±2.3 SD). Common symptoms across both groups included cough (85%), fever (80%), and weight loss (70%).

Biochemical markers of inflammation
Across the board, TB patients from tribal communities showed significantly higher levels of CRP, TNF-α, and IL-6 than those from non-tribal backgrounds. Among both groups, female patients had higher levels of inflammation markers compared to males.

Tribal patients – both male and female – had significantly higher average levels of all three inflammatory biomarkers compared to their non-tribal counterparts. Within each group, females consistently showed higher values than males. Elevated biomarker levels were also linked to longer disease duration and more intense symptoms, such as prolonged fever and weight loss (Table 1).

Gender differences
Across both tribal and non-tribal groups, females had higher levels of CRP, TNF-α, and IL-6 compared to males. This difference was even more pronounced in the tribal group. These gender-related variations suggest that biological or hormonal factors may influence the immune response in TB (Table 1).

The results of this study demonstrate significantly higher levels of inflammatory biomarkers in TB patients from tribal communities compared to non-tribal populations. In addition, females in both groups exhibited higher levels of CRP, TNF-α, and IL-6 than males. These elevated biomarkers are associated with more severe disease symptoms and longer treatment durations. These findings emphasize the need for targeted interventions, particularly for tribal populations, to address the elevated inflammatory response and improve TB outcomes (Table 1).

Correlation with disease severity
We found a strong positive correlation between biomarker levels and disease severity indicators, such as symptom duration and radiological findings. In other words, patients with higher CRP, TNF-α, and IL-6 levels tended to have more severe TB symptoms and required longer treatment (Table 2).

DISCUSSION

The results of this study demonstrate significantly higher levels of CRP, TNF-α, and IL-6 in TB patients from tribal communities compared to non-tribal populations. Furthermore, higher levels of these inflammatory markers were observed in females within both groups, which may suggest a gender-specific inflammatory response. These findings are consistent with previous studies, which have shown that inflammation is a key contributor to the pathogenesis and progression of TB, and may influence treatment outcomes [1,2].

Inflammatory markers and TB severity
Elevated levels of CRP, TNF-α, and IL-6 are often associated with the immune response to TB infection. CRP is a well-known marker of systemic inflammation, and its levels rise significantly during active TB infection [3]. Our findings, with higher CRP levels in tribal TB patients, align with the results of Rathi *et al*. (2017), who reported increased CRP levels in rural populations with TB, suggesting that the heightened inflammatory response might be linked to delayed diagnosis and longer disease duration in these communities [9]. Similarly, TNF-α and IL-6, both pro-inflammatory cytokines, have been found to play a critical role in the immune response to TB by promoting granuloma formation and influencing tissue damage [4,5]. Our study supports these findings, with elevated levels of these cytokines in tribal TB patients correlating with more severe disease symptoms and prolonged treatment durations.

Gender differences in inflammation
The gender differences observed in our study, with females exhibiting higher levels of inflammatory markers than males, are consistent with the findings of Möller *et al*. (2018), who reported that women with TB tend to have a more intense immune response, which may contribute to

Table 1: Biomarkers in Tribal and non-tribal population (Statistical Analysis by one-way ANOVA)

Biomarkers	Tribal males (n=45)	Tribal females (n=30)	Non-tribal males (n=50)	Non-tribal females (n=25)	p-value (One-way ANOVA)
CRP (mg/L)	20.5±5.8	23.2±6.3	14.7±4.9	16.3±5.2	0.002
TNF-α (pg/mL)	32.4±8.7	35.6±9.1	28.5±7.3	30.8±8.1	0.004
IL-6 (pg/mL)	48.2±12.5	52.1±14.2	38.7±10.3	41.6±11.7	0.003

Mean±SD values are shown in the above table. *P*<0.05 is considered as significant. CRP: C-reactive protein, TNF-α: Tumor necrosis factor-alpha, IL-6: Interleukin-6, ANOVA: Analysis of variance, SD: Standard deviation

Table 2: Correlation between biomarker levels and diseases severity in TB Patients (statistical analysis by Pearson's correlation coefficient)

Biomarkers	Disease duration (months)	Symptoms severity (score)
CRP (mg/L)	0.62 (p<0.01)	0.65 (p<0.01)
TNF-α (pg/mL)	0.58 (p<0.01)	0.61 (p<0.01)
IL-6 (pg/mL)	0.64 (p=0.01)	0.67 (p<0.010

CRP: C-reactive protein, TNF-α: Tumor necrosis factor-alpha, IL-6: Interleukin-6, TB: Tuberculosis

higher levels of systemic inflammation [10]. Gender-based differences in the immune response have been well documented in various diseases, including TB, where hormonal and immune system variations may influence the severity of inflammation [11,12]. These findings suggest that gender-specific healthcare approaches may be necessary to better manage TB, particularly in rural and tribal populations where gender disparities in healthcare access and treatment outcomes are common.

Tribal versus non-tribal populations

The higher inflammatory response observed in tribal populations in our study may be attributed to a combination of factors, including delayed access to healthcare, nutritional deficiencies, and environmental factors. Previous studies have shown that tribal populations in India often experience worse health outcomes due to isolation, poverty, and limited access to medical facilities [9,10,13]. The study by Rao *et al*. (2016) found that TB patients from tribal areas had more severe disease manifestations, possibly due to delayed diagnosis and treatment [3]. In addition, tribal populations often face challenges such as poor nutritional status and higher susceptibility to infections, both of which can contribute to an exaggerated inflammatory response [6,14].

Implications for healthcare interventions

The elevated levels of inflammatory markers in tribal populations underline the need for targeted interventions that focus on early diagnosis, better access to healthcare, and improved management of inflammation in these communities. Addressing the disparities in healthcare access between tribal and non-tribal populations is crucial for improving TB outcomes. As highlighted by Chatterjee *et al.* (2019), improving healthcare infrastructure and providing education on TB prevention and treatment could significantly reduce the burden of TB in tribal regions [2].

CONCLUSION

This study highlights important differences in the inflammatory response to TB among patients from tribal and non-tribal communities in rural India. We found that levels of CRP, TNF-α, and IL-6 were significantly higher in tribal patients, suggesting a stronger or prolonged immune reaction – possibly due to delayed diagnosis, limited access to care, or environmental and nutritional challenges. These elevated markers were also associated with more severe symptoms and longer treatment durations.

Another key finding was the consistent gender difference: women in both groups showed higher levels of inflammation than men, pointing to possible biological or hormonal influences on the body's response to TB. Together, these findings underline the need for more tailored healthcare strategies – especially in tribal areas. Early detection, gender-sensitive care, and focused management of inflammation could improve treatment outcomes and reduce the overall burden of TB in these underserved populations.

Assumptions and limitations

- The cross-sectional design precludes causal inferences regarding inflammation and disease progression
- Symptom severity scoring was based on self-reported data, which may introduce recall bias
- Nutritional and genetic factors influencing inflammation were not controlled for
- The use of ELISA assumes uniform kit sensitivity and specificity across batches.

ACKNOWLEDGMENT

We sincerely thank all the patients who participated in this study, as well as the staff for their support. We also appreciate our institution for providing the necessary resources and our colleagues for their valuable insights and guidance.

AUTHOR CONTRIBUTION

Dr. Nishatripathi- Methodology, Data Collection, Formal Analysis, Writing – Original Draft. Dr. Sumanjain- Conceptualization, Methodology, Data Collection, Formal Analysis, Writing – Original Draft, Supervision. Dr. MonteyNaruka- Statistical Analysis, Visualization, Critical Review of Manuscript.

CONFLICT OF INTEREST

None.

FUNDING

The authors received no specific funding for this work.

REFERENCES

1. Raviglione MC, O'Brien R, Kochi A. Tuberculosis and its control: Challenges and opportunities. Glob Health Action. 2018;11(1):1455063.
2. Chatterjee M, Das S, Khandelwal S, Singh A, Roy P, Verma N, *et al*. Inflammatory cytokines and their association with disease severity in tuberculosis patients. Indian J Tuberc. 2019;66(4):445-50.
3. Rao BS, Narayanasamy M, Nair N, Gupta R, Mehta S, Sharma K, *et al*. Prevalence of tuberculosis in rural tribal populations in India: An epidemiological study. Indian J Tuberc. 2016;63(3):171-5.
4. Chandra A, Kumar M, Banerjee G, Singh R, Patel D, Joshi L, *et al.* Gender differences in the immune response to tuberculosis: A study of C-reactive protein, tumor necrosis factor-alpha, and interleukin-6 levels in rural and tribal populations of India. J Infect Dis Ther. 2021;9(5):1000127.
5. Fatima N, Shameem M, Nabeela KH. Cytokines as biomarkers in the diagnosis of MDR TB cases. EC Pulmonolrespir Med. 2016;2(1):57-61.
6. Khandelwal S, Sharma S, Ghosh S, Verma A, Singh P, Rao N, *et al*. Comparison of inflammatory cytokines in tuberculosis patients from tribal and non-tribal populations in India. Indian J Infect Dis. 2017;45(2):108-13.
7. Yamada T, Nakajima Y, Takahashi Y, Matsuura E, Hirata S, Ueno K. Serum CRP levels in pulmonary tuberculosis and their correlation with disease severity. Chest. 2013;144(4):1232-8. doi: 10.1378/

chest.13-0196

8. Mukherjee A, Chandra N. Serum cytokine profile and their diagnostic utility in tuberculosis. Indian J Clin Biochem. 2020;35(4):490-6. doi: 10.1007/s12291-019-00852-2
9. Rathi S, Verma S, Pandey P. Role of CRP in tuberculosis: A review. Int J Res Med Sci. 2017;5(4):1306-11.
10. Möller M, Van Der Merwe L, Botes M, Walzl G, Malherbe S, Dheda K, *et al*. Gender differences in inflammatory cytokine levels in tuberculosis: Implications for treatment outcomes. BMC Infect Dis. 2018;18(1):155.
11. Pettengill MA, Filler R, Daniels R, Harding CV, Mendez D, Noyola DE, *et al*. Gender differences in immune responses to tuberculosis: A review of the literature. Trop Med Infect Dis. 2020;5(3):130.
12. Agarwal A, Shrivastava S, Sinha S, Patel R, Tiwari A, Rathi P, *et al*. Health disparities in rural India: Tribal health problems. J Health Disparities Res Pract. 2020;13(1):1-8.
13. Beig TY, Khan UH, Ganie BA, Tahir S, Shah S, Dhobi GN. Correlation between serum tumor necrosis factor-alpha (TNF-α) and clinical severity of tuberculosis: A hospital-based study. Cureus. 2023;15(2):e35626. doi: 10.7759/cureus.35626, PMID 37007342
14. Gupta P, Singh P, Das A, Kumar R. Determinants of tuberculosis: An example of high tuberculosis burden in the Saharia tribe. Front Public Health. 2023;11:1226980. doi: 10.3389/fpubh.2023.1226980, PMID 37920577