

## Statistical Analysis of Malnutrition and Tuberculosis Cases in High Burden Districts of Madhya Pradesh

Bhavna Goswami\* and Sushma Jain

Department of Statistics,  
Govt Motilal Vigyan Mahavidyalaya, Bhopal (Madhya Pradesh), India.

(Corresponding author: Bhavna Goswami\*)

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**ABSTRACT:** This statistical study investigates the relationship between malnutrition and tuberculosis (TB) incidence in high-burden districts of Madhya Pradesh, utilizing secondary data from relevant government sources. Tuberculosis remains a significant public health challenge globally, particularly in India, which carries the highest burden of TB cases. One of the primary challenges of the study was the availability and quality of data from government sources, which may have inconsistencies and gaps that could affect the reliability of the analysis. Despite these challenges, statistical analysis revealed a strong positive correlation between malnutrition and TB incidence, as indicated by a Pearson correlation coefficient of 0.817 ( $p = 0.007$ ) and a Spearman's rank correlation coefficient of 0.867 ( $p = 0.005$ ). The findings suggest that higher levels of malnutrition correspond to increased TB prevalence, reinforcing the urgent need for integrated health strategies that simultaneously address nutritional deficiencies and TB management. With significant numbers of anemic and underweight individuals in districts such as Bhopal and Rewa, enhancing nutrition appears essential for improving the population's overall health and mitigating TB incidence. These results advocate for comprehensive public health interventions focusing on nutritional improvements as a means to reduce TB prevalence. Furthermore, the study contributes to the understanding of how nutritional status impacts TB outcomes in Madhya Pradesh, providing valuable insights for policymakers and health practitioners in designing targeted interventions that enhance community health outcomes across the region.

**Keywords:** Tuberculosis, Malnutrition, Madhya Pradesh, Public Health, Correlation Analysis, Nutritional Deficiencies, Environmental Health.

### INTRODUCTION

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis* that poses a significant public health challenge globally. In 1993, the World Health Organization (WHO) declared TB a global emergency (Daley, 2019), yet millions of deaths continue to occur annually due to this disease. The highest incidence of TB is found in Asia, accounting for 58% of cases, followed by Africa (27%), the Eastern Mediterranean Region (8%), Europe (4%), and the Americas (3%) (Turk-Adawi *et al.*, 2018). Notably, only about 10% of individuals infected with the bacterium develop active TB, while the remaining 90% manage to contain or suppress the bacillus. India bears the highest burden of TB in the world, representing approximately one-fifth of all new cases globally, with around 24% of the world's total TB cases reported each year (WHO, 2017). The country also faces a significant challenge with multidrug-resistant TB (MDR-TB), estimating around 130,000 new cases annually (WHO, 2017). Epidemiology plays a crucial role in identifying geographic regions and vulnerable populations at higher risk for TB morbidity and mortality (Kharwadkar *et al.*, 2022). By mapping the geographic distribution of TB, we

can target interventions more effectively to reduce the associated risk factors. Madhya Pradesh, a state in India, also exhibits a high prevalence of TB, necessitating a closer examination of the factors contributing to the heightened infection rates within its borders (Selvaraj *et al.*, 2022).

This study aims to conduct a statistical analysis to explore the potential links between malnutrition and TB cases in the high-burden districts of Madhya Pradesh. Utilizing available TB data alongside advanced statistical, we will investigate the underlying variables contributing to the increased rates of TB infection in this region. Our findings are intended to inform local health strategies and public health initiatives aimed at mitigating the impact of TB. In this study, we utilized primary data to examine the correlation between tuberculosis (TB) cases and environmental malnutrition in high-burden districts of Madhya Pradesh though it was reported high in other some district of other States of India (Verma and Gupta 2021). By analyzing existing datasets that encompass TB incidence rates and malnutrition indicators, we aim to identify potential associations and patterns that may illuminate the factors contributing to the elevated prevalence of TB in these regions (Feleke *et al.*, 2019). Our statistical analysis

seeks to provide insights into how environmental malnutrition may influence TB vulnerability, thereby informing targeted public health interventions and strategies that address both nutritional deficiencies and disease prevention.

## MATERIALS AND METHODS

### Methodology Overview

This study investigates the correlation between tuberculosis (TB) cases and environmental malnutrition in high-burden districts of Madhya Pradesh using secondary data from various official sources.

#### A. Data Collection

Data for this study will be sourced from the Central TB Division (CTD), Ministry of Health and Family Welfare, Government of India, specifically the NIKSHAY database, detailing reported TB cases from 2015 to 2022. Furthermore, additional secondary data will be obtained from the National Family Health Survey (NFHS) reports ([https://www.niti.gov.in/sites/default/files/2022-07/SNP\\_Madhyap%20Pradesh\\_Final.pdf](https://www.niti.gov.in/sites/default/files/2022-07/SNP_Madhyap%20Pradesh_Final.pdf)). This data includes information on malnutrition indicators, such as the number of anemic women (ages 15-49 years) from 2019 to 2021, as well as data on anemic and stunted children (under 5 years) and underweight women and children for the same time period. The analysis will specifically focus on the following districts in Madhya Pradesh: Bhopal, Shivpur, Jabalpur, Rewa, Sagar, Satna, Betul, Mandla, Chhindwara, and Ujjain.

#### B. Tabulation of Collected Data

The initial step in the analysis involves classifying and tabulating the collected data. If published statistics are employed, they will be rearranged into new groups to facilitate our analysis. The classification and tabulation processes aim to clarify the significance of the gathered data. In some cases, this organization may provide sufficient insights that negate the need for additional statistical analysis.

#### C. Statistical Tools

Statistical and bioinformatics software will be employed to analyze the collected data, focusing on

the relationship between TB incidence rates and environmental parameters, including malnutrition.

The following statistical methods will be applied:

**Descriptive Statistics:** Means plots and scatter plots will be used to visually examine the data distribution and relationships.

**Correlation Analysis:** Pearson and Spearman's rank correlation coefficients will evaluate the strength and direction of associations between TB incidence and malnutrition parameters. The statistical analyses will be performed using software packages such as SPSS and online tool "statskingdom.com" to ensure robust and reliable findings.

By combining these methodologies, the study aims to elucidate the intricate relationships between malnutrition and TB cases, which may guide public health interventions targeted at reducing TB prevalence in Madhya Pradesh.

## RESULTS AND DISCUSSION

The statistical analysis conducted in this study highlights significant correlations between malnutrition and tuberculosis (TB) cases in the high-burden districts of Madhya Pradesh. Detailed examination of the collected data is presented in Tables (1, 2) and (Fig. 1, 2). Table 1 illustrates the nutritional status and prevalence of anemia among women and children across selected districts from 2019 to 2021. The data reveals alarmingly high rates of anemia, stunting, and underweight conditions, which are critical markers of malnutrition. For instance, Bhopal reports 431,000 anemic women and 159,000 anemic children, along with a malnutrition value of 172,200. Similarly, Rewa and Sagar reflect high malnutrition indices, indicating a substantial burden of nutritional deficiencies. In Table 2, the linkage between malnutrition and TB incidence is further emphasized. Districts such as Bhopal not only demonstrate high malnutrition rates but also report significant TB cases, with Bhopal recording 9,154.875 TB patients. This pattern is consistent across other districts, highlighting a trend whereby elevated malnutrition correlates with higher TB rates, a phenomenon also reported in some studies (Alene, 2019; Ogbo *et al.*, 2018).

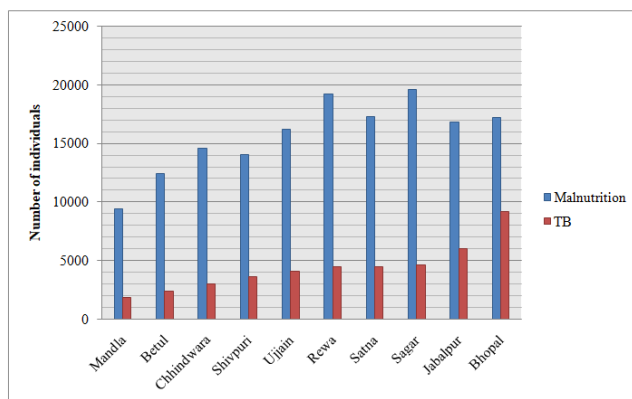
**Table 1: Nutritional Status and Prevalence of Anaemia in Women and Children Across Selected Districts during 2019 to 2021 from Madhya Pradesh.**

Sr. No.	District	No. of anaemic women	No. of Anaemic children	No. of stunted children	No. of underweight women	No. of underweight children	Malnutrition
1.	Bhopal	431000	159000	51000	145000	75000	172200
2.	Betul	288000	94000	55000	127000	57000	124200
3.	Chhindwara	288000	105000	55000	196000	87000	146200
4.	Shivpur	249000	152000	94000	131000	76000	140400
5.	Jabalpur	402000	85000	45000	230000	79000	168200
6.	Rewa	441000	203000	107000	118000	91000	192000
7.	Sagar	351000	228000	130000	161000	109000	195800
8.	Satna	391000	203000	41000	145000	86000	173200
9.	Mandla	212000	81000	41000	94000	42000	94000
10.	Ujjain	347000	168000	80000	134000	83000	162400
11.	Above 10 districts of mp	340000	147800	79500	148100	78500	158780
12.	Madhya Pradesh (52 districts av.)	248387	118857	64122	104346	60775	119298

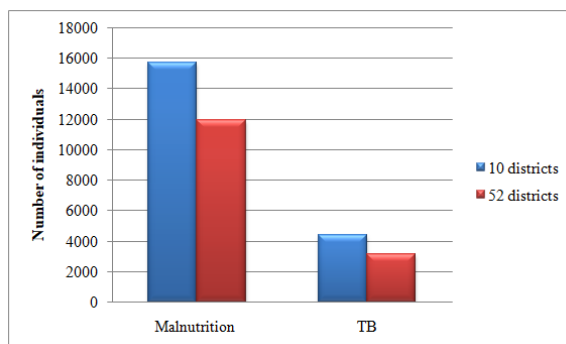
**Note :** Malnutrition value were calculated adding the values of No. of anaemic women, No. of Anaemic children, No. of stunted children, No. of underweight women, No. of underweight children, malnutrition and the Average of selected 10 districts and 52 district of MP give in Table 1

**Table 2: Prevalence of Malnutrition and Tuberculosis (TB) in Selected Districts of Madhya Pradesh.**

Sr. No.	District	Malnutrition	TB (Average (mean) taken from the available 8 years data from 2015)
1.	Mandla	94000	1845.625
2.	Betul	124200	2417.375
3.	Chhindwara	146200	3032.75
4.	Shivpuri	140400	3629.625
5.	Ujjain	162400	4115.75
6.	Rewa	192000	4440.625
7.	Satna	173200	4498.625
8.	Sagar	195800	4634.75
9.	Jabalpur	168200	6055.75
10.	Bhopal	172200	9154.875
11.	10 districts	158780	4382.575
12.	52 districts	119298	3143.074



**Fig. 1.** Present figure showing the distribution malnutrition (values  $\times 10^4$ ) and recorded TB patients in selected districts of Madhya Pradesh.



**Fig. 2.** Present figure showing the distribution malnutrition (values  $\times 10^4$ ) and recorded TB patients in selected 10 districts average and 52 district (average of 52 district data) of Madhya Pradesh.

**Results of Correlation Analysis:** The statistical analysis performed in this study reveals a robust and significant correlation between malnutrition and tuberculosis (TB) incidence in high-burden districts of Madhya Pradesh.

**Pearson Correlation Analysis:** The Pearson correlation coefficient was calculated to be 0.817 ( $p = 0.007$ ), demonstrating a strong positive relationship between malnutrition and TB incidence. This indicates that as malnutrition levels increase, the incidence of TB cases also significantly rises. The high value of  $r^2 = 0.6674$  suggests that approximately 66.74% of the variance in TB cases can be explained by malnutrition levels, highlighting the critical impact of nutritional status on TB prevalence. The covariance of 34,194,512.8472 reinforces the positive relationship, indicating how changes in malnutrition levels correlate with changes in TB incidence across the sampled districts. The sample

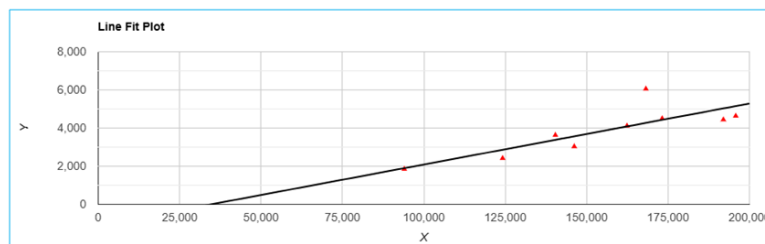
size of 9 indicates that the data points came from nine high-burden districts, making the results particularly relevant for those areas.

In Fig. 3, the linear fit analysis visually represents this correlation, illustrating how increases in malnutrition correspond to rising TB cases. The plotted line demonstrates a clear upward trend, further supporting the strong relationship highlighted in the statistical metrics.

**Spearman Rank Correlation Analysis.** Further corroborating this relationship is the Spearman's rank correlation coefficient, which was calculated at 0.867 ( $p = 0.005$ ). This coefficient reflects a significant positive association, indicating that higher malnutrition rates are closely tied to increased TB incidence, independent of the distribution of the data. Such findings suggest that even when the data does not follow a normal distribution, a strong rank-based relationship persists.

**Table 3: Statistical Analysis of Correlation and Regression Metrics**

Parameter	Value
Pearson correlation coefficient (r)	<b>0.817</b>
$r^2$	0.6674
P-value	0.007186
Covariance	34194512.8472
Sample size (n)	9
Statistic	3.748

**Fig. 3.** Evaluation of Pearson Correlation Coefficient and Linear Fit Analysis.**Table 4: Statistical Analysis of Correlation and Regression Metrics.**

Parameter	Value
Spearman's rank correlation coefficient ( $r_s$ )	<b>0.8667</b>
$r^2$	0.7511
P-value	0.005048
Covariance	6.5
Sample size (n)	9
Statistic	0.8667

The results of this study elucidate a significant relationship between malnutrition and tuberculosis (TB) in the high-burden districts of Madhya Pradesh. The Pearson correlation coefficient was calculated at 0.817 ( $p = 0.007$ ), indicating a strong positive relationship between malnutrition levels and TB incidence. This finding was further substantiated by the Spearman's rank correlation coefficient of 0.867 ( $p = 0.005$ ), which illustrated that as malnutrition increases, the number of TB cases also escalates.

These strong positive correlations underscore the urgent need for integrated health strategies that simultaneously address nutritional deficiencies and TB management. Both correlation coefficients clearly indicate that heightened levels of malnutrition are critical contributing factors to the incidence of TB in the districts studied (Padmapriyadarsini *et al.*, 2016).

Malnutrition is known to impair immune function, rendering individuals more susceptible to infections such as TB. This connection reinforces the necessity for public health interventions that focus on improving nutritional status as a means of reducing TB prevalence. Current literature supports these findings, showing that enhancing nutritional status can strengthen the immune response and decrease the incidence of TB. The World Health Organization (2017) has further indicated that undernourished individuals are significantly more likely to develop active TB when exposed to *Mycobacterium tuberculosis*, emphasizing the critical link between adequate nutrition and disease resistance. The high prevalence of anemia, stunting, and underweight conditions observed in districts such as Bhopal and Rewa aligns with previous studies highlighting the dual burden of malnutrition and infectious diseases in resource-constrained settings (Bose *et al.*, 2014). The considerable number of anemic women and children

reported points to systemic issues related to dietary deficiencies and access to healthcare, which are crucial determinants of nutritional status and susceptibility to TB.

Given the strong correlation coefficients, it follows that addressing malnutrition could serve as a viable public health intervention to reduce TB incidence in these districts. Nutritional supplementation and educational programs directed at vulnerable populations may pave the way for improved individual and community health outcomes (WHO, 2015). This assertion is supported by studies showing that nutritional interventions can significantly enhance TB treatment outcomes while reducing the associated morbidity. Furthermore, the persistent challenge of multidrug-resistant TB (MDR-TB) in India complicates treatment and public health efforts. Recent estimates suggest that approximately 130,000 cases of MDR-TB occur annually in the country (WHO, 2017). Since malnutrition is a contributing factor to poor treatment responses, integrated health strategies that address both nutritional deficiencies and TB management are essential for mitigating the disease's impact (). Given these findings, it is imperative for public health strategies in Madhya Pradesh to adopt a multifaceted approach that simultaneously tackles malnutrition and TB. Strengthening healthcare infrastructure to improve access to both nutritional and medical support is crucial, emphasizing the need for targeted interventions in high-burden districts.

## CONCLUSIONS

This study confirms the significant relationship between malnutrition and tuberculosis in the high-burden districts of Madhya Pradesh. The results advocate for comprehensive public health strategies that integrate

nutritional improvements with TB prevention and treatment efforts, ultimately aiming to reduce disease prevalence and enhance community health.

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**Conflict of Interest.** None.

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