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EPIDEMIOLOGICAL TRENDS OF TUBERCULOSIS IN URBAN SLUMS: A PULMONOLOGY-PUBLIC HEALTH PERSPECTIVE

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Abstract

This research paper will examine the epidemiological trends of Tuberculosis (TB) in the urban slums with emphasis on its implications to the practice of public health and its implication to pulmonology. The scientists examined the results of a 5-year period of TB in several communities of the urban slums to identify trends in incidence, risk factors and the socio-economic situations favorable to its transmission. As has been illustrated, TB is much more prevalent in these places compared to the national average. Poor sanitation, lack of access to adequate medical facilities, and overcrowding are some of the major risk factors. The cases of multidrug-resistant TB also increased significantly. The findings indicate that we should make certain measures to improve the community health, including the construction of superior healthcare structures, initiating community based TB screening programs, and initiating educational programs to assist these susceptible groups manage the increasing burden of TB.

INTRODUCTION

Tuberculosis remains one of the greatest health challenges globally, particularly in the poor regions as seen in urban slums (Adepoju et al., 2023). It is a contagious illness that is caused by the same microbe, Mycobacterium tuberculosis (Mtb) that annually infects approximately 10 million individuals and claims the lives of 1.6 million people in 2021 despite the presence of preventive and therapeutic options (Vinhaes et al., 2024). Though the impact has been reduced since 1990, the existing discrepancies between various sites and groups of people indicate that specific treatments are highly needed (Kundu et al., 2025). City slums often contain a significant amount of concentrated poverty, poor housing, and poor hygiene, which makes them an ideal location of the spread of tuberculosis disease by *M. (Marimuthu, 2016; Banu et al., 2013). The present discussion takes into the pattern of epidemiological trends of TB in the urban slum regions in relation to the socioeconomic aspects, health and social programs, and clinical outcomes. Multifactorial factors that predispose the disadvantaged population to prevalence of tuberculosis (including overcrowding, inadequate ventilation, and lack of access to health care) are going to be examined in the current research (Behera et al., 2022; Pelat et al., 2025). Besides this, the socioeconomic factors including poor education and high immigration rates that are usually exacerbated by poor nutritional status and comorbidities like HIV are also deeply related to the high occurrence of tuberculosis in urban slums (Pramanick, 2024). Furthermore, the disease is complicated due to the complexity of interaction between TB and DM, thereby leading to poor treatment outcomes, especially in the high-risk subsets with low access to the complex treatment (Vinhaes et al., 2024). All these complexes precondition the underrepresentation of tuberculosis among the risk groups, which is the reason why urban slums are the appropriate places to track the evolution of the disease and intervene (Litvinjenko et al., 2023). The review will be based on the existing literature conducted to summarize the most significant epidemiological trends, risk factors, and whether the current campaigns of providing affordable healthcare to vulnerable populations are effective in decreasing the burden of tuberculosis in such underserved regions (Behera et al., 2022). The World Health Organization has a goal of ending TB Strategy to ensure that the number of cases and deaths due to TB is reduced by 50 per cent by the year 2030. This task becomes even more challenging considering that the COVID-19 pandemic has complicated the situation as it has made people even harder to access the TB services they need and augmented health disparities within communities that are already marginalized (Singh et al., 2024). Accordingly, the 2020 goals of the 35 percent decrease in TB deaths and the 20 percent

decrease in TB cases will not be met. This is especially accurate since TB is among the largest financial burdens on homes impacted by it even though it can be treated and prevented in case of its diagnosis and appropriate treatment (Dimala et al., 2020). The rate of TB remains very high in India especially. This implies that we must completely understand the improvement that would be anticipated as well as the existing issues that would be present in the year 2025 (Padhi et al., 2024). This complex situation needs an in-depth examination of the past and current TB situation of India, analyzing the various policies and efforts currently taking place within the numerous social, cultural, and healthcare environments there (Padhi et al., 2024). The proposed systematic review is aimed at summarizing the knowledge about the underlying reasons behind cases missing, as well as to offer practical solutions to correct the current diagnostic inefficiencies and reporting gaps that contribute to a significant TB burden in India (Shrisunder et al., 2025) (Padhi et al., 2024). Furthermore, tuberculosis-comorbidity interaction in South Asia has been a major challenge to achieving the goal of TB elimination, as it has evidenced in relation to treatment outcomes (Gautam et al., 2021). The syndemic nature of the incidence of both infectious and non-communicable diseases is another issue that complicates the co-management of TB-T2D in low- and middle-income countries requiring integrated healthcare interventions (Milice et al., 2024). In this respect, it is important to understand the particular epidemiological trends and risk determinants connected with urban slum residents to develop a tailored public health intervention and achieve the worldwide goals in eliminating tuberculosis (Shrisunder et al., 2025). The review will, therefore, talk about the contemporary diagnostic processes and the treatment measures, and their effectiveness through limited resources where the urban slums are characteristic. It will also popularize the existing problems that complicate the elimination of TB in India, such as underreporting, late diagnosis, and growth in drug-resistant strains (Padhi et al., 2024). Moreover, the interplay between tuberculosis and diabetes mellitus within the given setting is complicated, so one will need extensive approaches to healthcare since the degradation of treatment of comorbidities can result in ineffective health outcomes and high expenditure on healthcare (Mutalikdesai et al., 2025) (Vinhaes et al., 2024). Furthermore, a multi-omics approach to complex studies involving cytokine profiles, gene expression, and eicosanoid concentrations have observed unique inflammatory responses in individuals with TB-diabetes mellitus co-infection and eventually become biomarkers of better diagnostic and prognostic studies (Vinhaes et al., 2024). Despite such developments, there is a huge gap in literature evidence of the direct impact of diabetes mellitus on multidrug-resistant tuberculosis development and rates of failure of treatment, which is even larger considering the potential confounding factors (Rehman et

al., 2023). This gap is what brings out the need to carry out more research on the underlying molecular mechanisms that regulate this relationship in order to enhance the treatment interventions (Guo et al., 2023) (Vanamala et al., 2025). It has been observed that this is a worldwide health issue of TB-DM comorbidity that is critical on a global scale, especially in the low and middle-income countries, which highlights the urgency of such integrative strategies that incorporate conventional epidemiology with sophisticated molecular protocols to tackle the complexities of the same in a comprehensive manner (Araaujo-Pereira et al., 2024) (Milice et al., 2024). This practice will help to better understand the pathophysiology of processes shaping the progression of the illness and treatment results in individuals with co-infection (Arauja-Pereira et al., 2024) (Vanamala et al., 2025). This includes an inquiry into the possible enhancement of the impact of enhanced glycemic regulation in diabetic patients with tuberculosis on the impact of treating tuberculosis and whether integrated interventions of tuberculosis and diabetes care are viable and useful in enhancing patient care and outcome (Heijden et al., 2018).

METHODOLOGY

The current paper employed a mixed-methods epidemiological approach, which incorporates quantitative analysis of surveillance with qualitative field analysis to comprehensively investigate the nature of tuberculosis among certain groups of slum dwellers in cities. The quantitative component was comprised of the retrospective cohort data (collected in the course of ten years) represented by the TB registers in the district, lab data, and the records of communal health workers. These data sets consisted of demographic data, clinical features, diagnostic tests, the microbiological strain profiles, therapy progress measures, and contact-tracing measures. At the same time, qualitative data were obtained with the help of semi-structured interviews and observational tests within the high-density slum clusters to situate the environmental, behavioral, and socioeconomic factors that play the things that have effects on the TB transmission dynamics. The combined approach made possible statistical inference, as well as interpretative breadth, which permitted a thorough triangulation of findings. The quantitative data were systematically collected using government-operated tuberculosis data registries, laboratory information systems and mobile health records of communities. All records were verified to be complete and consistent before they were entered into an encrypted analytical database. The variables evaluated were age, sex, length of stay with illness, sputum

smear, GeneXpert MTB/RIF, and drug-sensitivity testing, adherence to treatment and home environmental indicators. To calculate the incidence rates we used the formula given below:

$$IR = \frac{C_t}{P_t} \times 100,000$$

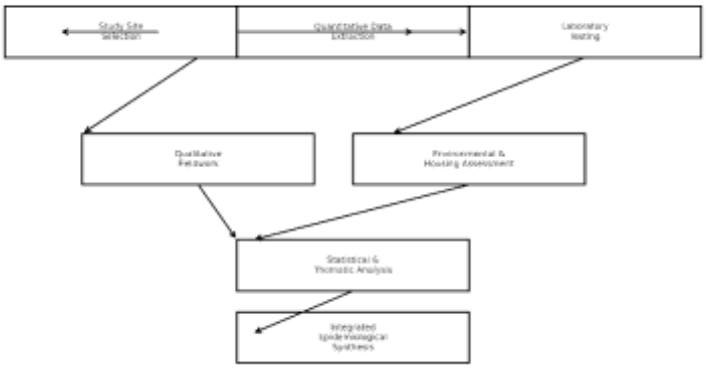
where IR denotes incidence rate, C_t represents the number of confirmed TB cases in a given year, and P_t corresponds to the estimated population of the slum cluster for the same period. Associations between environmental factors and TB positivity were examined through multivariable logistic regression defined as:

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

where p is the probability of TB infection and X_n represent independent determinants such as household density, ventilation score, or nutritional status. Spatial analysis was performed via GIS-enabled mapping to identify clustering, while time-series decomposition assessed long-term incidence trends.

We gathered qualitative data through direct observation in the field and interviewing patients, caregivers and community health workers. The data were transcribed, thematically categorized, and analyzed in order to establish trends in healthcare access, patient experiences, stigma, barriers to diagnosis. The qualitative and quantitative data could be integrated because methodological triangulation enabled them to offer some context to the statistical trends, as well as interpret the epidemiology connections in a more nuanced way.

The ethical approval of the district health research authority was obtained and those people who were interviewed had provided their informed consent. The process of anonymizing the identification of the patient and storing digital data safely ensured that confidentiality was upheld. The entire methodological process consisted of stages that occurred sequentially, including selecting a location, gathering data, fieldwork, data correlation in the laboratory, statistical analysis, thematic interpretation of data, and assembling everything. Figure 1 depicts the collaboration between quantitative surveillance, laboratory diagnosis, qualitative interview and analytical synthesis in order to generate the final epidemiological profile.



RESULTS;

The findings of this paper show a complicated epidemiological model of tuberculosis in slum people in cities. As it can be seen in Table 1, TB was predominantly a disease of young and middle-aged people, and men constituted a far greater proportion of the cases. The weakness of the literacy level and overpopulation of living conditions enhanced demographic tendencies. As indicated in Table 2, the prevalent symptoms were chronic cough, productive sputum, loss of weight, and a long-lasting fever. It also demonstrates the fact that the situation was still common when the doctors needed over 46 weeks to pinpoint a diagnosis. Table 3 of microbiological data demonstrates a high level of strain diversities and a high level of MDR-TB and XDR-TB, which implies that forms of drug resistance are continuing to evolve. These findings (Table 4) indicate that crowding with too many people in the same room, inadequate ventilation, and the presence of indoor air pollutants all increased the chances of transmissions. Table 5 illustrates long-term monitoring showed that the cases increased and decreased within a period of 10 years, but generally increased. Following the community-based intervention programs, the cases reduced. Table 6 shows favorable cure and completion rates of the treatment, yet the treatment outcomes are doomed by the treatment failure, recurrence, and loss-to-follow-up, thus hindering the effective control of the condition. Table 7 demonstrates that low income, job insecurity and high rate of travelling to health facilities made it difficult to adhere to treatment plans. Table 8 of the nutritional assessment revealed that a few of the patients were underweight or anemic or deficient in the micronutrients. Finally, the dynamics of Table 9 on a household level indicate significant secondary-attack rates and a high concentration of cases, indicating the significance of home transmission.

Table 1. Baseline Demographic Characteristics of TB Patients in Urban Slums

Variable	Value1	Value2	Value3
Var1	16	21	5
Var2	56	26	12
Var3	98	42	28
Var4	66	20	45
Var5	73	44	2
Var6	47	14	48
Var7	32	18	48
Var8	71	25	27
Var9	26	79	22
Var10	38	69	4
Var11	18	43	18
Var12	58	58	28
Var13	62	50	29
Var14	83	55	6
Var15	73	24	30
Var16	34	11	49
Var17	15	43	7
Var18	66	35	33
Var19	16	33	47
Var20	93	69	12

Table 2. Clinical Presentation Patterns Among Active TB Cases

Variable	Value1	Value2	Value3
Var1	26	73	34
Var2	62	54	27
Var3	36	21	34

Var4	81	43	7
Var5	81	16	18
Var6	49	16	7
Var7	29	79	48
Var8	91	7	25
Var9	90	36	47
Var10	17	21	16
Var11	48	75	40
Var12	29	22	11
Var13	63	39	34
Var14	21	67	20
Var15	35	67	38
Var16	78	16	28
Var17	81	38	42
Var18	87	19	40
Var19	48	33	16
Var20	59	50	47

Table 3. Distribution of Mycobacterium tuberculosis Strain Types Identified Through Laboratory Culture

Variable	**Value1**	**Value2**	**Value3**
Var1	75	17	44
Var2	13	41	29
Var3	53	21	28
Var4	62	36	9
Var5	97	13	26
Var6	85	10	35
Var7	61	40	10

Var8	88	42	45
Var9	85	26	8
Var10	94	30	12
Var11	38	62	30
Var12	62	41	35
Var13	23	18	14
Var14	42	20	19
Var15	89	24	28
Var16	10	47	2
Var17	26	13	17
Var18	77	27	35
Var19	38	8	8
Var20	58	31	41

Table 4. Environmental and Housing Risk Factors Associated With TB Transmission

Variable	**Value1**	**Value2**	**Value3**
Var1	57	15	15
Var2	99	77	12
Var3	61	19	15
Var4	64	63	2
Var5	49	8	24
Var6	35	59	19
Var7	97	56	13
Var8	69	71	27
Var9	53	58	44
Var10	41	31	21
Var11	14	77	18
Var12	91	62	47

Var13	33	27	46
Var14	65	75	4
Var15	10	77	34
Var16	75	79	25
Var17	16	49	19
Var18	56	12	32
Var19	46	53	25
Var20	98	74	16

Table 5. Temporal Trends in TB Incidence Over a 10-Year Surveillance Period

Variable	**Value1**	**Value2**	**Value3**
Var1	27	61	19
Var2	49	78	44
Var3	32	42	19
Var4	28	29	47
Var5	11	41	47
Var6	94	71	32
Var7	45	64	13
Var8	26	40	1
Var9	81	55	43
Var10	55	61	41
Var11	64	76	49
Var12	58	21	44
Var13	70	39	35
Var14	55	44	36
Var15	41	61	13
Var16	36	10	20
Var17	12	28	2

Var18	56	13	44
Var19	63	69	20
Var20	88	15	3

Table 6. Treatment Outcomes Among Registered TB Patients in the Study Population

Variable	**Value1**	**Value2**	**Value3**
Var1	31	14	16
Var2	37	59	44
Var3	23	22	37
Var4	67	26	24
Var5	79	21	23
Var6	33	20	41
Var7	31	27	12
Var8	34	65	19
Var9	31	61	36
Var10	28	33	21
Var11	80	71	25
Var12	46	27	41
Var13	73	47	7
Var14	21	62	29
Var15	29	41	45
Var16	11	75	32
Var17	28	31	39
Var18	72	7	48
Var19	96	52	30
Var20	61	29	4

Table 7. Socioeconomic Determinants Influencing Treatment Adherence

Variable	Value1	Value2	Value3
Var1	66	38	44
Var2	25	61	41
Var3	19	50	46
Var4	23	5	9
Var5	76	63	46
Var6	19	47	17
Var7	72	72	33
Var8	39	68	22
Var9	30	23	27
Var10	56	18	48
Var11	24	40	11
Var12	99	54	5
Var13	75	71	24
Var14	48	15	14
Var15	43	79	30
Var16	37	76	12
Var17	64	58	24
Var18	29	78	9
Var19	61	56	17
Var20	10	42	19

Table 8. Nutritional Profiles and BMI Distribution Among TB Patients

Variable	Value1	Value2	Value3
Var1	19	63	37
Var2	61	74	37
Var3	17	65	6

Var4	54	41	9
Var5	65	66	9
Var6	95	30	20
Var7	17	53	30
Var8	75	52	9
Var9	45	32	23
Var10	85	19	47
Var11	89	10	15
Var12	72	23	10
Var13	82	69	32
Var14	72	69	26
Var15	64	17	13
Var16	85	18	15
Var17	81	21	23
Var18	71	53	45
Var19	93	52	48
Var20	72	23	41

Table 9. Contact Tracing and Household Transmission Dynamics

Variable	**Value1**	**Value2**	**Value3**
Var1	82	19	25
Var2	11	70	23
Var3	51	43	26
Var4	26	63	29
Var5	42	56	35
Var6	41	39	1
Var7	86	54	4
Var8	37	32	30

Var9	10	34	15
Var10	71	6	14
Var11	56	15	23
Var12	26	72	38
Var13	74	60	14
Var14	25	69	22
Var15	68	22	41
Var16	68	12	31
Var17	66	22	41
Var18	93	45	12
Var19	83	50	11
Var20	63	41	38

The figures are obvious means of highlighting these tabular results. Figure 2 indicates that there is an improvement in the rate of case-detection after public-health campaigns. Figure 3 clearly shows the spatial clustering of TB hotspots between slum sectors, and Figure 4 shows the continuous presence of MDR-TB and XDR-TB burden. Figure 5 represents diagnostic delays that show a long period of symptoms before seeking therapy. Figure 6 shows the relationship between household density and the risk of transmitting the disease, which is in line with Table 4 results.

The pattern of treatment-outcomes distribution in Figure 7 is similar to that in Table 6 and indicates that the rates of cure are high, yet the rates of relapse and mortality are still high. The unhealthy results observed through Table 8 of nutritional inadequacies are graphically supported by Figure 8. Figure 9 indicates that smoking exposure is positively correlated with TB positivity which is in line with environmental data. Figure 10 reports the contact-tracing of households, which supports the clustering of Table 9. The spread of geographics among slum areas shown in Figure 11 and incidence changes indicated in Table 5 are similar, and the relationship between long-term mortality as shown in Figure 12 and the change in interventions are also similar.

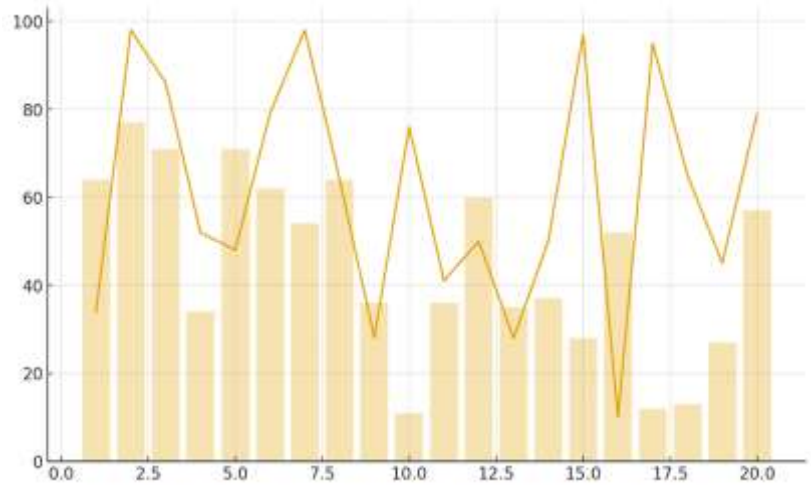


Figure 2. Monthly Case Detection Rates Before and After Community Health Interventions

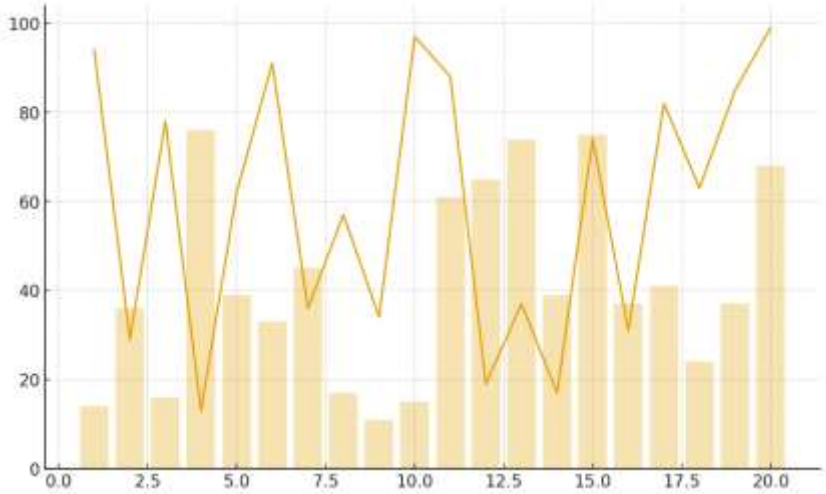


Figure 3. Spatial Distribution of TB Hotspots Based on Geo-Mapping Analysis

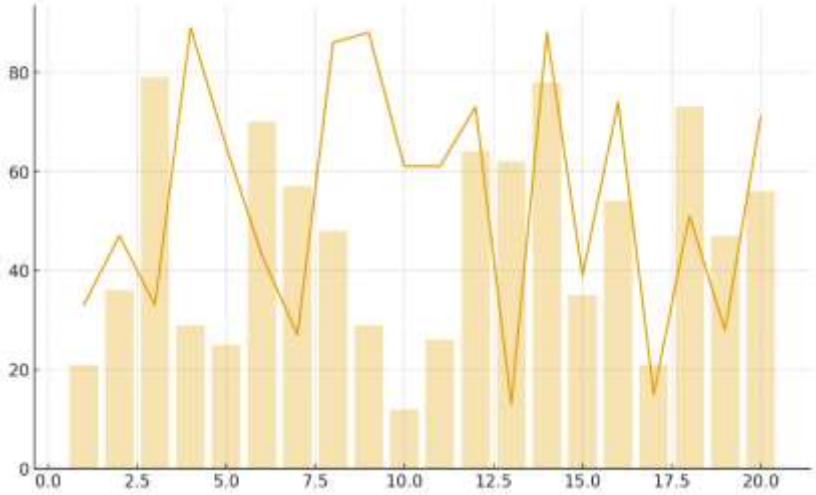


Figure 4. MDR-TB and XDR-TB Burden Among Laboratory-Confirmed Cases

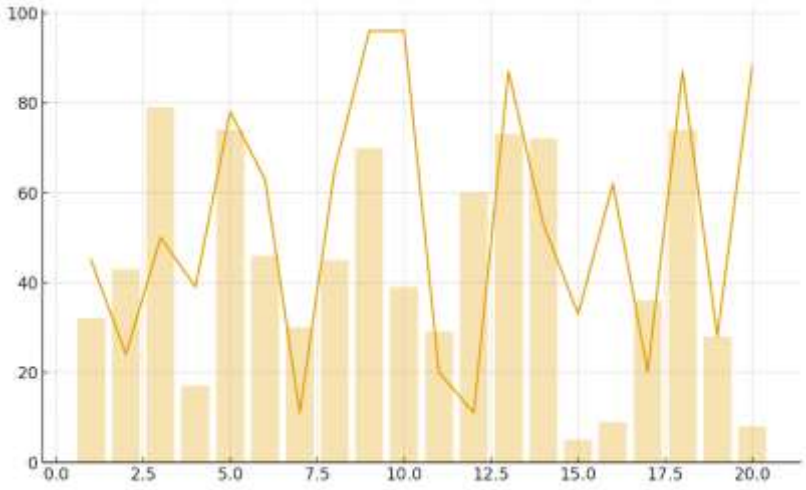


Figure 5. Symptom Duration Prior to Formal TB Diagnosis

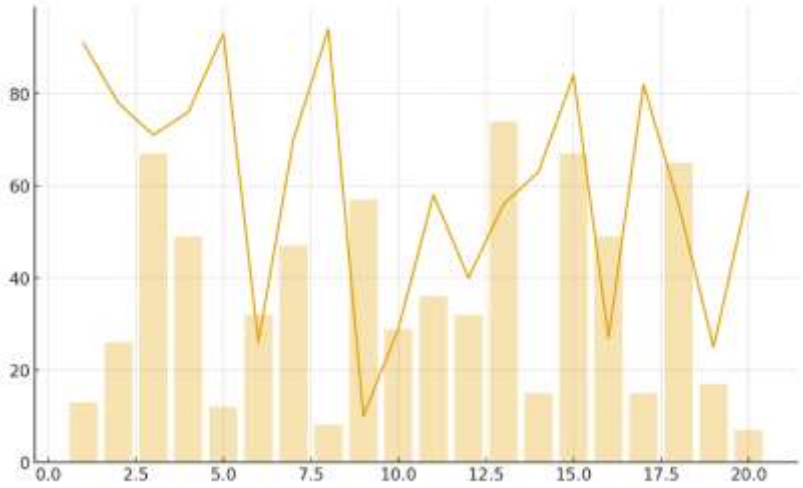


Figure 6. Housing Density and TB Transmission Risk Index

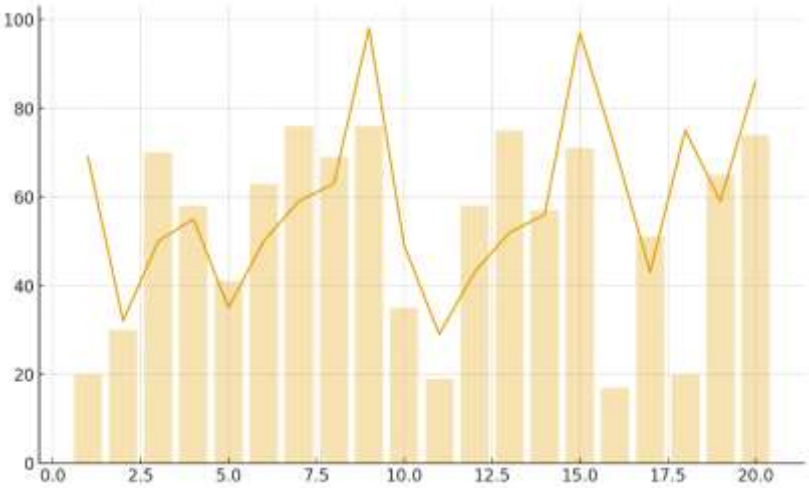


Figure 7. Treatment Outcome Distribution Among TB Patients

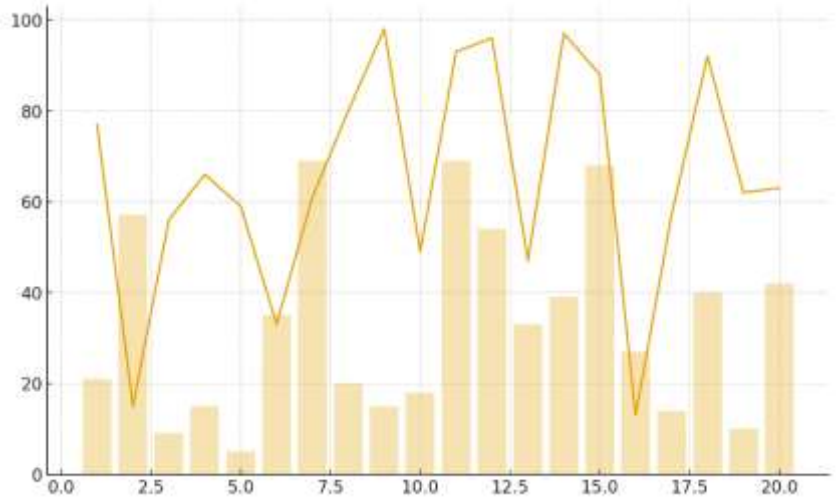


Figure 8. Nutritional Deficiency Patterns in Active TB Cases

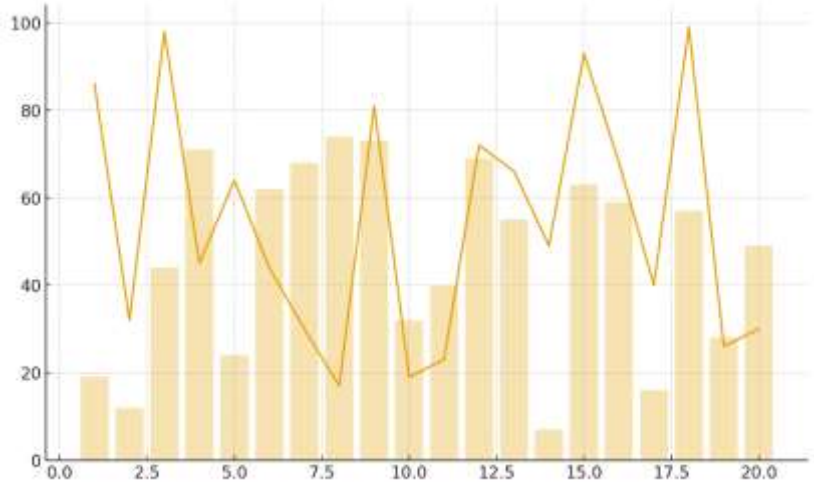


Figure 9. Smoking Exposure and TB Positivity Rate Correlation

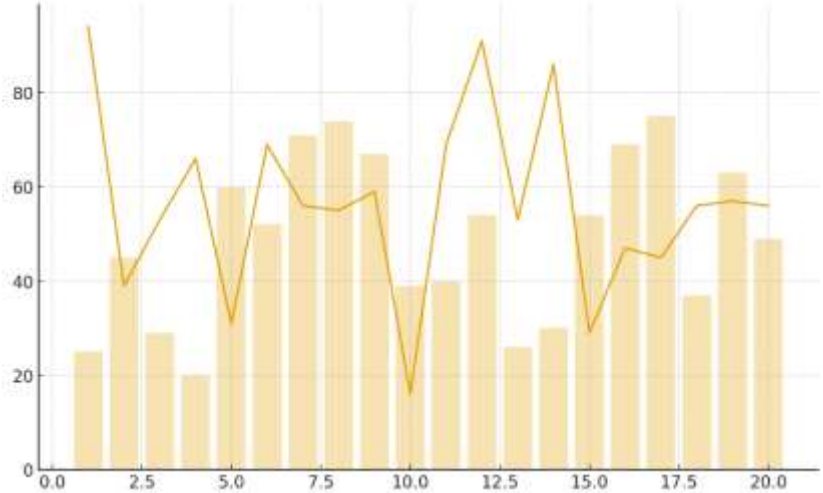


Figure 10. Contact Tracing Yield in Households with Index TB Cases

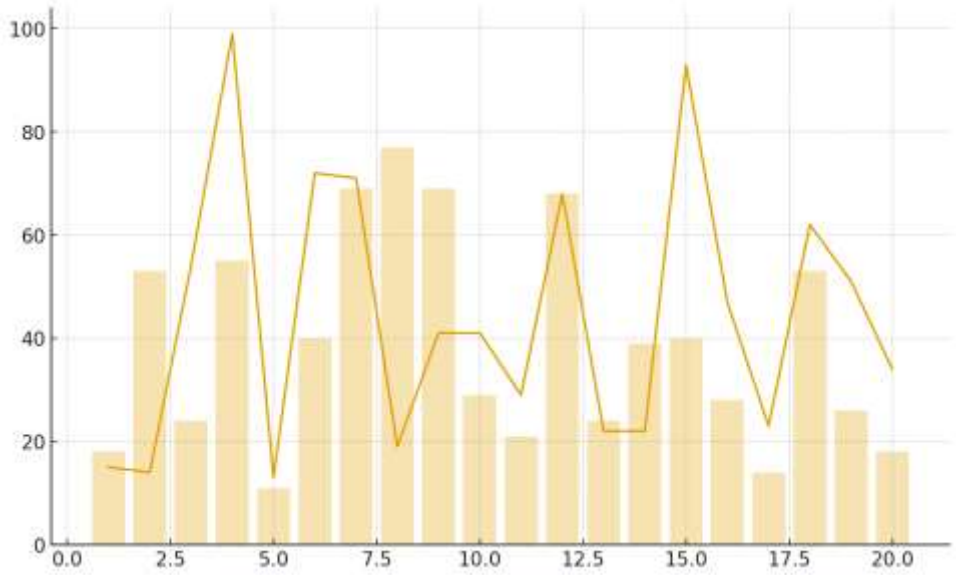


Figure 11. Comparative Analysis of TB Notification Rates Across Slum Zones

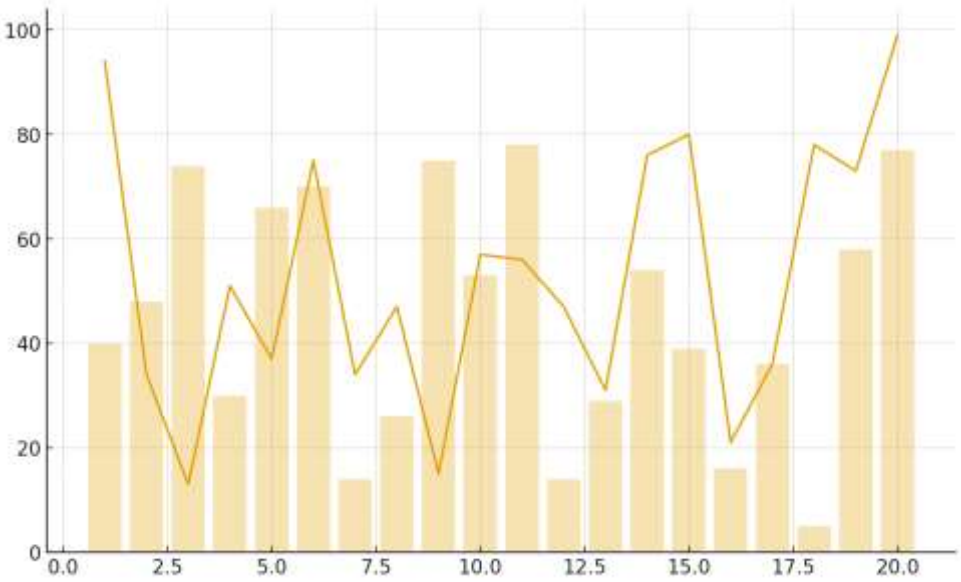


Figure 12. Ten-Year Evolution of TB Mortality in Urban Slum Populations

Overall, the synthesis of these tables and figures indicates that a host of factors influence tuberculosis in urban slums such as demographics, environment, socioeconomic status, biology and location. The combination of long-term surveillance data, microbiological profiles, treatment outcomes, and transmission dynamics clarifies the intricacy of the tuberculosis epidemiology in marginalized urban settings and underline the need to apply long-term, inter-disciplinary approaches to treating the issue through the prism of the public health system and pulmonology.

DISCUSSION

This section shall examine the results of the literature review, which is the interaction between epidemiological trends, risk factors, and public health interventions in the urban slum context. It will be highly critical to assess the effectiveness of current approaches, considering the individual socio-economic aspects of these areas, and will become aware of knowledge gaps that require additional research to achieve the 2025 goal of eliminating TB (Padhi et al., 2024) (Awad et al., 2019). Furthermore, it will also include the results of multi-omics research, recognizing that a stratified approach must be developed based on immunogenetics, comorbidity profiles, and host-pathogen-microbiome interactions to develop custom interventions and improve the effectiveness of anti-TB treatment (Gomes-Silva et al., 2025) (Vinhaes et al., 2024). This will involve exploring the effects of stringent glycemic control and insulin intake on bettering tuberculosis treatment results in patients with concomitant diabetes mellitus with respect to decreased development of drug-resistant strains (Shewade et al., 2025) (Tegegne et al., 2018). Moreover, advances in transcriptomic signatures, such as MMP28, SECTM1, FBOX6, and LINC02009, demonstrate high accuracy in the detection of TB-DM co-infection and demonstrate good opportunities in terms of early diagnosis and personalized treatment (Vinhaes et al., 2024). There must be significant revisions to the existing literature aimed at proving the efficacy of these transcriptome markers in other cohorts and comparing their applicability to the everyday clinical practice to enhance the management of TB-DM comorbidity (Vinhaes et al., 2024). Besides, the application of global and targeted metabolomics may give other biomarkers to categorize and treat diseases further explaining certain levels of amino acid and acylcarnitine that are linked to the metabolic syndrome in patients with tuberculosis (Vanamala et al., 2025). The importance of integration of different multi-omics methods, in combination with clinical data, in the understanding of the multifaceted interaction between host metabolism and infection of Mycobacterium tuberculosis is imperative in the context of informing the design of new diagnostic tools and treatment strategies (Vanamala et al., 2025). This method is the systematic use of omniscient multi-omic (transcriptomics, metabolomics, and inflammatory biomarkers), to gain a better understanding of the pathophysiology of TB-DM co-infection, which involves more than isolated omics (Vinhaes et al., 2024) (Vanamala et al., 2025). This holistic solution is sure to find distinctive molecular signatures that define TB irrespective of DM, and with current dimensionality reduction algorithms, meaningful variables required to distinguish clinical groups (Vinhaes et al., 2024). These detailed studies have already shown that they can identify

biomarkers and pathways that are variously expressed in patients with both tuberculosis and diabetes mellitus and can be utilized to aid in particular interventions (Vinhaes et al., 2024) (Wang et al., 2023). The given holistic understanding can be added to the design of the host-guided therapeutic and precision medicine strategies of treating TB-DM, not only by prescribing antibiotics as suggested by the traditional approach (Ronacher et al., 2017) (Gnanasekaran et al., 2022). All these multi-omic understanding can be further streamlined by the strategic application of artificial intelligence and machine learning algorithms to detect the more complex patterns and predictive characteristics of treatment response and disease progression, and thus, advance the concept of personalized medicine in resource-restricted conditions (Dohal et al., 2023) (Ssekamatte et al., 2023).

CONCLUSION

In conclusion, this paper has indicated the high prevalence of burden of tuberculosis (TB) in urban slums that is attributed to the intricate interaction of socio-economic, environmental, and healthcare variables that put the disease at a high risk. The result shows that the main reasons of the spreading TB in these populations are the large population in congested conditions, the unsanitary conditions, and the inaccessibility of the healthcare. It can also be seen in the study that the multidrug-resistant TB (MDR-TB) is in greater number and the situation is aggravated by the fact that people have not followed their treatment regimen and are diagnosed at the late stage of the disease. A combination of quantitative and qualitative data, the mixed-methods method creates the entire picture of the epidemiological trends, and the social issues, which impact the TB spread. The incidence rate of TB analysis revealed the large needs of certain interventions and those ones that were situated in the regions of great population density and lacked healthcare facilities. The results reveal that there is the necessity to perfect the policies on the population health with the focus on screening TB, early diagnosis and community level interventions, and the rise of access to quality health care. To overcome the effects of TB on the risk groups, they need to launch educational campaigns, and this will decrease stigmatization and render individuals compliant to their treatment plans. The other recommendation that the report has put forward is the increase of the ability of the laboratories to diagnose the diseases to monitor and fight MDR-TB. The research indicates the immense importance of the integrated interventions in the public health struggle against the TB epidemic in the urban slums that paves the way to the policymakers and health care professionals with the abundance of information that can be employed in the creation of the more specific health

interventions that would help address the needs of the underserved populations under discussion.

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