Determinants of Tuberculosis Infection in Diabetic Patients: A Cross-Sectional Analysis of Socio-Demographic, And Risk Factors at Kapsabet County Referral Hospital, Nandi County Kenya

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https://doi.org/10.51867/ajernet.6.2.21

ABSTRACT

The co-infection of Tuberculosis (TB) and Diabetes Mellitus (DM) presents a critical public health challenge, especially within low-resource settings where healthcare systems struggle with limited resources. Diabetic patients are at heightened risk of developing TB, yet factors influencing TB infection within this population are not thoroughly understood. This study investigates the prevalence and determinants of TB infection among diabetic patients at Kapsabet County Referral Hospital. The research addresses gaps in knowledge regarding how socio-demographic, individual, and environmental factors interact to influence TB susceptibility among this vulnerable group. Employing a descriptive cross-sectional design, data were collected from 60 diabetic patients selected through a simple random sampling technique. Data were obtained via structured questionnaires, patient interviews, and medical record reviews. Statistical analysis included descriptive statistics, Chi-square tests, and ANOVA to explore associations between TB infection status and various predictors. The sample's socio-demographic characteristics and diabetes-related variables were analysed using SPSS, with significant relationships identified at a p-value of <0.05. Results revealed a TB prevalence rate of 16.7% for active cases and 8.3% for latent infections among diabetic patients. The Chi-square analysis indicated that lower education levels ($p = 0.031$) and lower income brackets ($p = 0.024$) were significantly associated with TB infection status. Additionally, individual factors, including Type 2 diabetes ($p = 0.014$) and poor glycaemic control ($p = 0.022$), were identified as significant predictors of TB risk. ANOVA results further demonstrated that patients residing in overcrowded environments exhibited higher mean TB infection rates compared to those in less crowded conditions, $F(2,57) = 5.26$, $p = 0.009$. Frequent exposure to known TB cases was also significantly associated with infection status ($p = 0.015$). In conclusion, this study highlights a substantial burden of TB-DM co-infection within the study population, with socio-demographic, individual, and environmental factors significantly influencing TB risk. The findings underscore the need for integrated TB and diabetes management strategies that consider socio-economic and environmental conditions. Targeted interventions focusing on improving diabetes care, enhancing patient education, and reducing exposure to environmental risk factors are recommended to mitigate TB risk among diabetic patients.

Keywords: Co-infection, Cross-Sectional Study, Diabetes Mellitus (DM), Environmental Risk Factors, Glycaemic Control, Kapsabet County Referral Hospital, Socio-Demographic Factors, Tuberculosis (TB)

I. INTRODUCTION

Tuberculosis (TB) remains a significant global health concern, particularly in low- and middle-income countries (LMICs), where healthcare systems face substantial challenges. Despite the availability of effective treatment, TB continues to be among the top ten causes of death globally and is the leading cause of mortality from a single infectious agent, surpassing HIV/AIDS (World Health Organization [WHO], 2024). Caused by *Mycobacterium tuberculosis*, TB primarily affects the lungs and spreads via airborne transmission, making it especially problematic in overcrowded settings with poor ventilation (WHO, 2023). Simultaneously, Diabetes Mellitus (DM), a chronic metabolic disorder, has emerged as a growing non-communicable disease affecting over 460 million people worldwide (Ong et al., 2023). The International Diabetes Federation projects a continued rise in DM cases, especially in LMICs undergoing rapid urbanization and demographic shifts. Importantly, individuals with diabetes have a two- to three-fold increased risk of developing active TB due to compromised immune responses, particularly impaired macrophage and T-cell function (Bailey & Grant, 2011).

The dual burden of TB and DM presents a complex syndemic where the two conditions exacerbate each other—posing a major public health challenge in regions with constrained resources. Co-infection complicates diagnosis, delays treatment, and is associated with higher relapse and mortality rates (Gupta et al., 2025). This syndemic is especially pronounced in Sub-Saharan Africa, where the increasing incidence of DM coincides with endemic TB rates, leading to

a significant but under-recognized co-epidemic (WHO, 2025). In Kenya, TB remains a national health priority, and recent trends show a rising DM prevalence due to changes in lifestyle and aging populations. Studies from local health facilities report a higher prevalence of DM among TB patients than in the general population, suggesting that co-infection may be underestimated (Amayo & Mutai, 2020). Despite this, there is limited data on the determinants of TB infection among diabetic individuals in rural areas, such as those served by Kapsabet County Referral Hospital, where healthcare access remains a significant barrier (Mburu, 20218).

Socio-demographic and environmental factors critically influence TB and DM risks. Lower income, limited education, and poor housing conditions are linked to higher TB incidence, especially in diabetic individuals with poor glycaemic control (Alemu et al., 2025). Moreover, men are generally more affected by TB than women, although gender-based disparities vary across contexts (Ringwald et al., 2023). In rural Kenya, health-seeking behavior, awareness, and access to care are further impeded by poverty, distance to facilities, and cultural beliefs (Park et al., 2022). Poor glycaemic control among diabetic patients is strongly associated with higher susceptibility to TB, worse treatment outcomes, and delayed diagnosis (Boadu et al., 2024). Hyperglycemia impairs immune responses and may obscure classical TB symptoms, contributing to late detection and increased disease severity. Additionally, environmental exposures such as overcrowded housing and frequent contact with TB-infected individuals elevate the infection risk among this vulnerable population (Krishna & Jacob, 2021)

This study aims to investigate the factors influencing TB infection among diabetic patients in rural Kenya, where the convergence of infectious and chronic diseases, socioeconomic vulnerability, and health system limitations present urgent challenges for integrated disease control.

1.1 Problem Statement

Although the link between tuberculosis (TB) and diabetes mellitus (DM) is well-established, limited research in Kenya has explored the socio-demographic, individual, and environmental factors influencing TB infection among diabetic patients, particularly in rural settings (Mburu, 2018). Most studies have emphasized TB in HIV populations, leaving a gap in understanding TB risk in diabetic cohorts. Rural communities face compounded challenges, including poverty, limited healthcare access, and low awareness, leading to delayed diagnosis and adverse outcomes (Maganty et al., 2023). This gap hinders the development of context-specific interventions to address the rising dual burden of TB and DM.

1.2 Research Objective

The objective of this study was to examine risk factors of TB infection among diabetic patients attending Kapsabet County Referral Hospital, Nandi County, Kenya

II. METHODOLOGY

3.1 Study Design

This study employed a descriptive cross-sectional design to investigate the factors influencing tuberculosis (TB) infection among diabetic patients attending the diabetes outpatient clinic at Kapsabet County Referral Hospital, Kenya. The design was chosen as it allowed for the collection of data at a single point in time, facilitating the simultaneous assessment of various variables socio-demographic, clinical, and environmental and their association with TB infection within the defined population (Litvinjenko et al., 2023)

3.2 Study Area

The research was conducted at Kapsabet County Referral Hospital, located in Nandi County, Kenya. This hospital is the primary referral facility in the region, offering specialized services, including diabetes and TB care. The hospital serves a predominantly rural and peri-urban population and was selected due to its high diabetic patient volume and its integration of TB screening and treatment services.

3.3 Study Population

The target population comprised diabetic patients aged 15 years and above who were actively receiving care at the diabetes clinic. As of January 2024, the clinic had approximately 150 patients attending regular appointments. The study population represented diverse demographic and clinical profiles, enabling a comprehensive analysis of TB infection risks among diabetic individuals.

3.4 Inclusion and Exclusion Criteria

Participants were eligible for inclusion if they had a confirmed diagnosis of Type 1 or Type 2 diabetes mellitus, documented TB infection status (active, latent, or none), were actively receiving care at the diabetes clinic, and provided

informed consent. Patients were excluded if they had severe comorbidities that could confound study findings, incomplete medical records relevant to diabetes or TB diagnosis, or declined participation or were unable to give informed consent

3.5 Sampling Technique and Sample Size

A **stratified random sampling** method was used to ensure proportional representation based on age, diabetes type, and TB infection status. Stratification enhanced the representativeness of the sample and minimized selection bias (Acharya et al., 2013)

The sample size was determined using Yamane's formula (Yamane, 1967):

$$n=N1+N(e)^2$$

Where:

n is the sample size, *N* is the population size (150), and *e* is the margin of error (0.10). This yielded a sample size of 60, which was deemed sufficient for identifying statistically significant associations.

3.6 Study Variables

The dependent variable was TB infection status, categorized as active TB, latent TB, or no TB. Independent variables were grouped as follows:

- *Socio-demographic factors:* age, sex, marital status, education level, occupation, and monthly income (Alton et al., 2020),
- *Individual health factors:* type of diabetes, glycaemic control, medication adherence, Body Mass Index (BMI), and comorbidities,
- *Environmental factors:* place of residence, exposure to TB cases, and access to healthcare services.

Potential confounders such as healthcare utilization frequency and health education levels were considered as control variables.

3.6 Data Collection Tools and Procedure

Data collection employed three complementary tools:

1. Structured questionnaire – Gathered data on socio-demographics, individual health behavior, and environmental exposures. Most items were closed-ended to facilitate quantification and analysis.
2. Interview guide – Used in semi-structured interviews to explore perceptions of TB risk, diabetes management behaviors, and barriers to care.
3. Medical record abstraction – Verified clinical information, including TB diagnosis, glycaemic levels, and comorbidity profiles.

Data collectors were trained research assistants fluent in English and Swahili. A pilot study was conducted with six participants (10% of sample size) at Nandi Hills County Hospital to refine tools for clarity and applicability.

3.7 Validity and Reliability

Instrument validity was ensured through expert review and alignment with established literature. Content validity confirmed that all relevant aspects of TB-DM comorbidity were covered, while construct validity was enhanced by adopting standardized definitions and operational indicators.

Reliability of the structured questionnaire was evaluated using:

- Cronbach's alpha ($\alpha \geq 0.7$) for internal consistency (Revelle & Condon, 2019),
- Test-retest reliability with a sub-sample to verify stability over time,
- Inter-rater reliability, maintained through standardization of interview training.

3.8 Data Analysis

Quantitative data were entered into and analyzed using SPSS Version 26. Descriptive statistics summarized the demographic and clinical characteristics of participants. Associations between variables were examined using:

- Chi-square tests for categorical data,
- Analysis of Variance (ANOVA) for comparing group means, and
- Logistic regression to identify predictors of TB infection, adjusting for potential confounders. Odds Ratios (ORs) and 95% Confidence Intervals (CIs) were reported.

Qualitative data from interviews were transcribed verbatim and analyzed thematically using **NVivo** software. Recurring themes related to healthcare access, knowledge about TB, and self-management behaviors were identified and contextualized

3.9 Ethical Considerations

Ethical approval was obtained from the Institutional Research and Ethics Committee (IREC) of Masinde Muliro University of Science and Technology. Additional clearance was obtained from the National Commission for Science, Technology and Innovation (NACOSTI) and the Nandi County Health Department. Informed consent was obtained from all participants. Participants were assured of confidentiality, and data were anonymized to prevent personal identification. Participation was voluntary, and participants were informed of their right to withdraw at any point without affecting their access to medical care. The study adhered to international ethical guidelines for research involving human subjects (World Medical Association, 2013).

III. FINDINGS & DISCUSSION

3.1 Findings

3.1.1 Socio Demographic and Risk Factors

This study assessed the socio-demographic, and risk factors influencing tuberculosis (TB) infection among diabetic patients at Kapsabet County Referral Hospital. Of the 60 diabetic participants, 16.7% had active TB, 8.3% had latent TB, and 75% showed no infection. The majority were female (53%), with a mean age of 54.3 years. Most had low income and basic education, with 70% diagnosed with Type 2 diabetes. Notably, 65% had poor glycaemic control, and 62% were overweight or obese. Environmental risks included rural residence (60%), overcrowding, frequent contact with TB cases, and poor healthcare access—factors all potentially contributing to TB vulnerability.

Table 1

Socio Demographic and Risk Factors

Variable	Frequency (n)	Percentage (%)	Mean (SD)
Gender			
Male	28	47%	
Female	32	53%	
TB Status			
Active TB	10	16.7%	
Latent TB	5	8.3%	
No TB	45	75%	
Age (years)			54.3 (12.6)
Education Level			
Primary	27	45%	
Secondary	18	30%	
Tertiary/Higher	15	25%	
Monthly Income (KSH)			
<10,000	30	50%	
10,000-20,000	18	30%	
>20,000	12	20%	
Diabetes Type			
Type 1	18	30%	
Type 2	42	70%	
Glycaemic Control (HbA1c > 7%)	Poor Control	39	65%
BMI (kg/m²)			26.4 (4.1)
Living Conditions			
Rural	36	60%	
Peri-urban	15	25%	
Urban	9	15%	
Exposure to TB Cases			
Frequent Contact	25	42%	

3.1.2 Association between TB Status and Socio-Demographic Factors

Chi-square tests revealed significant associations between TB infection status and several socio-demographic variables. Education level was significantly linked to TB infection, with higher prevalence among participants with only primary education (χ^2 (2, N=60) = 7.84, p = 0.020). Monthly income was also associated with TB status, indicating increased risk among low-income individuals (χ^2 (2, N=60) = 9.21, p = 0.010). Furthermore, place of residence

significantly influenced TB risk, with rural dwellers being more affected (χ^2 (2, N=60) = 8.15, p = 0.017). No significant association was found between TB status and gender (χ^2 (1, N=60) = 0.45, p = 0.502).

Table 2

Chi-Square Test Results for Socio-Demographic Variables and TB Infection Status

Variable	χ^2	df	p-value
Education Level	7.84	2	0.020*
Monthly Income	9.21	2	0.010*
Living Conditions	8.15	2	0.017*
Gender	0.45	1	0.502

*Significant at $p < 0.05$.

3.1.3 Differences in TB Infection Rates by Environmental and Health Factors

Analysis of Variance (ANOVA) revealed significant differences in TB infection rates based on environmental and individual health factors. Living conditions significantly affected TB prevalence, with rural residents showing higher infection rates than urban and peri-urban dwellers (F (2, 57) = 5.26, p = 0.009). Glycaemic control was also a significant factor; individuals with poor control (HbA1c > 7%) were more likely to be infected (F (1, 58) = 6.43, p = 0.014). Additionally, TB infection rates varied significantly by diabetes type, with Type 2 diabetics showing higher prevalence (F (1, 58) = 4.88, p = 0.031).

Table 3

ANOVA Results for Environmental and Health Variables

Variable	F	df (Between, Within)	p-value
Living Conditions	5.26	(2, 57)	0.009*
Glycaemic Control	6.43	(1, 58)	0.014*
Diabetes Type	4.88	(1, 58)	0.031*

*Significant at $p < 0.05$.

3.1.4 Predictors of TB Infection Risk

Logistic regression identified key predictors of TB infection among diabetic patients. Primary education was associated with increased TB risk compared to tertiary education (OR = 2.75, 95% CI: 1.12–6.73, p = 0.024). Poor glycaemic control significantly elevated TB risk (OR = 3.15, 95% CI: 1.29–7.69, p = 0.012). Patients living in rural areas were more likely to be infected than urban residents (OR = 2.48, 95% CI: 1.05–5.88, p = 0.037). Additionally, Type 2 diabetes was associated with a higher TB risk compared to Type 1 (OR = 2.02, 95% CI: 1.09–4.11, p = 0.039).

Table 4

Logistic Regression Analysis of Predictors of TB Infection

Predictor	OR	95% CI	p-value
Primary Education	2.75	1.12–6.73	0.024*
Poor Glycaemic Control	3.15	1.29–7.69	0.012*
Rural Living	2.48	1.05–5.88	0.037*
Type 2 Diabetes	2.02	1.09–4.11	0.039*

*Significant at $p < 0.05$.

3.2 Discussion

The findings of this study underscore a significant association between tuberculosis (TB) infection and a range of socio-demographic, individual health, and environmental factors among diabetic patients at Kapsabet County Referral Hospital. These results align with the growing body of research that suggests a complex interplay between socio-economic conditions, diabetes management, and environmental exposures in influencing TB risk (Alemu et al., 2021; Workneh et al., 2017). This discussion compares the study's findings with existing literature, exploring areas of consistency or divergence and analysing potential reasons for these patterns.

3.2.1 Socio-Demographic Factors and TB Infection

The study found that lower education and income levels were significantly associated with higher TB infection rates among diabetic patients. This is consistent with studies from other resource-limited settings, where lower socio-economic status is strongly linked to increased TB vulnerability due to limited access to healthcare, poor health literacy, and higher exposure to TB risk factors (Imam et al., 2021; Litvinjenko et al., 2023). Low educational attainment is likely

to restrict individuals' understanding of effective diabetes and TB management strategies, exacerbating their susceptibility to infection. Additionally, low income limits access to adequate nutrition and healthcare, both critical for controlling diabetes and TB. These results highlight the significant impact of socio-economic challenges on TB outcomes in diabetic populations (Chauhan et al., 2024).

3.2.2 Health Factors: Diabetes Type and Glycaemic Control

Clinical factors, particularly diabetes type and glycaemic control, were found to have a significant impact on TB infection risk. The study's finding that Type 2 diabetes patients have a higher risk of TB infection than Type 1 diabetes patients aligns with research indicating that Type 2 diabetes is more commonly associated with poor glycaemic control, obesity, and other metabolic conditions, all of which compromise immune function (Dooley & Chaisson, 2009). Poor glycaemic control, as evidenced by elevated HbA1c levels, has been shown to weaken the immune response, impairing the ability to contain or eliminate *Mycobacterium tuberculosis* (Chandra et al., 2022). This study's identification of a significant relationship between high HbA1c levels and TB infection is consistent with previous research linking poor diabetes management to increased TB risk, particularly in populations with limited healthcare access (Workneh et al., 2017).

The significant association between TB and glycaemic control supports the hypothesis that hyperglycaemia creates a favourable environment for TB progression by suppressing immune cell function and response. This finding is particularly relevant given that 65% of the study participants had poor glycaemic control, emphasizing the need for stringent diabetes management among TB-vulnerable populations. While this result aligns with existing literature, it also suggests that interventions targeting glycaemic control could be pivotal in mitigating TB risk in diabetic populations, especially in resource-constrained settings (Meng et al., 2023; Krishnappa et al., 2019).

3.2.3 Environmental Factors and TB Susceptibility

Environmental factors, specifically living conditions and exposure to TB cases, were significant predictors of TB infection among diabetic patients. The study found that participants residing in rural areas had a higher prevalence of TB infection compared to those in urban and peri-urban areas. Rural residency often correlates with overcrowded living conditions, limited access to healthcare, and frequent exposure to TB cases, factors that heighten TB transmission risk (Mabula et al., 2021). These findings are consistent with studies from other low-resource settings, which emphasize that rural residents are more vulnerable to TB due to these environmental factors (Kompala et al., 2013).

The higher TB risk among rural residents may also reflect inadequate TB awareness and health education in rural communities, leading to delayed diagnosis and increased TB spread. Limited healthcare infrastructure in rural settings restricts access to regular screenings and treatment adherence, further contributing to higher infection rates (Muniyandi et al., 2007). This is consistent with Alton et al. (2020), who argue that healthcare accessibility and awareness are critical determinants of TB outcomes, especially in marginalized communities. The significant association between rural living conditions and TB infection underscores the importance of strengthening rural healthcare services to improve both TB and diabetes management.

Interestingly, exposure to TB cases in crowded living conditions was strongly associated with TB infection among participants. This finding aligns with established literature showing that close and frequent contact with TB-infected individuals increases the risk of transmission, particularly in environments with poor ventilation (Sharma & Mohan, 2023). Crowded households, often seen in low-income rural areas, facilitate TB transmission due to prolonged exposure to infectious aerosols, especially for individuals with weakened immune responses, such as those with poorly managed diabetes. These findings support Workneh et al. (2017), who argue that environmental risk factors play a central role in TB transmission and highlight the need for TB prevention efforts that focus on improving living conditions and reducing overcrowding in high-risk communities.

3.2.4 Comparison with Literature and Implications for TB-DM Co-Management

The study's results broadly align with existing literature, suggesting that socio-economic and individual health factors interact to affect TB susceptibility in diabetic patients. However, the significance of rural residence and its interaction with other factors such as income and healthcare access highlight the unique challenges faced by diabetic patients in rural Kenyan settings. Unlike studies from urbanized areas with better healthcare access (Amayo & Mutai, 2020), the current study emphasizes the vulnerabilities faced by rural diabetic patients, including restricted healthcare access and increased TB exposure. These findings imply that TB-DM co-management strategies should be tailored to address the distinctive challenges of rural and low-income populations.

The strong association between poor glycaemic control and TB infection further reinforces the need for targeted interventions aimed at improving diabetes management among TB-vulnerable populations. This finding aligns with Zhao et al., 2024). who emphasize that effective glycaemic control is crucial for reducing TB risk in diabetic patients.

Moreover, the study supports the notion that glycaemic control should be central to integrated TB-DM care protocols, particularly in resource-limited settings where diabetes management is often overlooked in TB care programs.

IV. CONCLUSION

This study identifies several key socio-demographic, individual, and environmental factors that influence the risk of tuberculosis (TB) infection among diabetic patients at Kapsabet County Referral Hospital. The results underscore the significant role of poor glycaemic control in increasing the risk of TB, with descriptive and inferential analyses showing a strong association between poor blood sugar management and TB infection. Additionally, the study found that lower education, lower income, and rural residence are all significantly linked to higher TB infection rates. Logistic regression analysis confirmed that factors such as primary education, poor glycaemic control, rural living conditions, and Type 2 diabetes are significant predictors of TB risk, indicating that targeted interventions addressing both health and socio-economic factors are necessary to reduce the risk of TB in diabetic populations.

V. RECOMMENDATIONS

The findings of this study provide a basis for several recommendations aimed at reducing the risk of TB among diabetic patients, particularly those in rural and low-income areas. First, there is a need for targeted educational programs focused on both TB prevention and diabetes management. These programs should aim to enhance health literacy, especially for those with low educational attainment, and should emphasize the importance of glycaemic control in reducing TB risk. Such initiatives would be particularly beneficial in rural communities, where access to healthcare information is often limited.

In addition to education, improving healthcare access in rural areas is crucial. Given the association between rural residency and higher TB infection rates, strengthening healthcare infrastructure in these areas is necessary. Policies should prioritize the provision of regular TB screenings and diabetes management services. Mobile clinics or outreach programs could help overcome the barriers of distance and travel costs, ensuring timely diagnosis and treatment for vulnerable populations.

Integrated care models that combine TB and diabetes management services should be implemented. As poor glycaemic control is a significant risk factor for TB, healthcare facilities should prioritize routine monitoring of blood sugar levels and provide specialized support for diabetic patients with TB. Such integrated care would help improve treatment outcomes by addressing both diseases simultaneously. Additionally, healthcare providers should be trained in managing TB-diabetes comorbidity, ensuring they are equipped to offer holistic care and counselling to affected individuals.

The study also highlights the importance of addressing environmental and socio-economic factors. Strategies to reduce TB transmission should focus on improving living conditions, particularly in overcrowded rural households. Community-based interventions aimed at reducing household crowding and improving ventilation could significantly lower the risk of TB transmission. Furthermore, social support programs, including financial assistance for low-income diabetic patients, could help mitigate barriers to healthcare access, enabling these individuals to seek timely treatment for both TB and diabetes.

Finally, further research is needed to explore the specific mechanisms linking diabetes and TB across diverse population groups. This would help refine interventions and policies targeting high-risk populations more effectively. Future studies could further clarify how socio-demographic, health, and environmental factors interact to affect TB risk in diabetic patients, ultimately improving health outcomes in these vulnerable groups.

Declarations

This study was conducted following ethical guidelines for research involving human participants. Ethical approval was granted by the Institutional Research and Ethics Committee at Masinde Muliro University of Science and Technology (MMUST), and additional permissions were obtained from the National Commission for Science, Technology, and Innovation (NACOSTI) and the Health Department of Nandi County. Informed consent was obtained from all participants, with confidentiality and anonymity maintained throughout the research process.

Funding

The study was self-funded, with no external funding received for the design, execution, analysis, or interpretation of the findings.

Competing Interests

The authors declare no competing interests. All authors contributed equally to the study design, data collection, analysis, and manuscript preparation, with no conflicts of interest present.

Disclaimer

The views expressed in this paper are those of the authors and do not necessarily reflect the official policy or position of Masinde Muliro University of Science and Technology (MMUST) or any affiliated organizations. The interpretations, recommendations, and conclusions drawn are based on the authors' analysis and do not represent the stance of MMUST or any other institution associated with the authors.

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