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High Prevalence of Diabetes Mellitus and Its Associated Factors in Patients with Tuberculosis Comorbidity: A Cross-Sectional Study in Kinshasa, DRC

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Abstract

Introduction: Tuberculosis (TB) and diabetes mellitus (DM) are two major public health challenges, particularly in developing countries where their prevalence continues to rise. Diabetes is a recognized risk factor for TB, contributing to more severe disease forms and increased complications. This study aimed to assess the prevalence of diabetes among TB patients in Kinshasa and to identify associated factors. **Methodology:** A cross-sectional analytical study was conducted among 336 TB patients receiving treatment at several health centers in Kinshasa. Sociodemographic, clinical, and paraclinical data were collected and analyzed using statistical tests to identify factors associated with diabetes. Univariate and multivariate logistic regression analyses were performed. **Results:** Among the 336 TB patients, 38 had diabetes, corresponding to a prevalence of 11.3% [95%CI 8.1 - 15.3]. The study population showed a male predominance (62.5%) with a median age of 34 years. Factors significantly associated with diabetes included age ≥ 34 years (Adjusted Odds Ratio [AOR] = 4.9, $p < 0.0001$), hypertension (AOR = 2.6, $p = 0.048$), and the presence of cavitary lung lesions (70.8% in diabetics vs. 29.8% in non-diabetics, $p = 0.0129$). **Conclusion:** This study highlights a high prevalence of diabetes mellitus among tuberculosis patients in Kinshasa and demonstrates a significant

association between the two conditions. These findings emphasize the need for integrated management strategies, including systematic diabetes screening in TB patients and close metabolic monitoring, to reduce comorbidity and improve treatment outcomes.

Keywords

Tuberculosis, Diabetes Mellitus, Comorbidity, Risk Factors, Kinshasa

1. Introduction

Tuberculosis (TB) remains a major public health issue, particularly in developing countries where its prevalence remains high. In 2022, the World Health Organization (WHO) estimated that nearly 10.6 million people developed tuberculosis, with the majority of cases concentrated in sub-Saharan Africa [1] [2]. In Kinshasa, the capital of Democratic Republic of the Congo (DRC), unfavorable socioeconomic conditions, a fragile health system, and frequent comorbidity with other diseases, such as HIV/AIDS, exacerbate the burden of this disease. At the same time, DM is emerging as a silent epidemic, with increasing prevalence even in regions previously considered low-risk [3] as described for DRC in the past and recently [4] [5].

In DRC, tuberculosis carries a heavy economic and social burden; with more than 100,000 cases reported each year, the DRC is among the 30 countries that bear 80% of the global burden of TB and among the 27 countries that account for 85% of the global burden of multidrug-resistant tuberculosis [6]. Diabetes, a metabolic disease characterized by chronic hyperglycemia, is a major risk factor for the development of various infections, including tuberculosis. Diabetic patients are three times more likely to contract tuberculosis than the general population. Tuberculosis associated with diabetes is generally asymptomatic, more contagious, multi-resistant, and is significantly associated with an increased risk of treatment failure, relapse, and even death [7] [8].

This complex interaction between TB and diabetes presents specific challenges in terms of diagnosis, treatment, and clinical management. The association between TB and diabetes is not only a clinical concern but also a major public health issue. The simultaneous presence of these two diseases leads to increased morbidity and mortality, thus complicating patient management [9].

DM is known to significantly alter the immune system, increasing patients' susceptibility to various infections, including tuberculosis. The interactions between TB and DM create a vicious cycle: diabetes worsens the progression of tuberculosis, while tuberculosis can disrupt glycemic balance, complicating diabetes management. This double burden represents a major challenge for health systems, especially in low-resource settings [10]-[12]. In the context of Kinshasa, the coexistence of these two diseases is a cause for concern. However, specific data on the

frequency and factors associated with tuberculosis in diabetic patients are limited. A better understanding of these interactions is essential.

Democratic Republic of the Congo as we said above, is one of the countries most affected by TB, with prevalence and incidence rates among the highest in the world. At the same time, the prevalence of diabetes is increasing, largely due to nutritional transition and rapid urbanization [1] [4] [6] [13]. These two diseases, although distinct, share important epidemiological and pathophysiological links. Thus, DM-TB comorbidity represents a threat to public health and requires the implementation of urgent measures to both prevent and manage both diseases [14] [15]. In view of the above, the national tuberculosis control program recommends active and systematic screening for tuberculosis in all diabetic patients at each contact with a health facility in order to treat them, improve tuberculosis treatment outcomes, and avoid relapses, which are common in these patients [10] [16]. In addition, TB can complicate diabetes management by exacerbating blood sugar fluctuations and increasing the risk of complications. Studying these interactions in Kinshasa is essential for developing appropriate prevention and treatment strategies aimed at reducing the burden of morbidity and mortality associated with these two diseases. This research aims to determine the frequency of diabetic among tuberculosis patients followed up in healthcare facilities in Kinshasa and to identify the factors associated with this comorbidity.

2. Methods

2.1. Type, Site and Period of the Study

This study was a cross-sectional analytical study conducted in eight (8) tuberculosis diagnosis and treatment centers (CDTs) selected from the four administrative division, in which we took 2 health district or zone) of the city-province of Kinshasa, capital of the DRC.

Selection of CDTs

Kinshasa comprises 35 health zones and a total of 105 CDTs from the official list of functional centers in Kinshasa, as provided by the National Tuberculosis Control Program (PNLT). For security reasons, the health zones located on the outskirts of the city, where insecurity was evident, were excluded from the sampling frame. Consequently, 32 health zones were retained for random selection. To ensure geographical representativeness, we selected two health zones per administrative division, making a total of eight health zones across the four administrative divisions of Kinshasa. In each selected zone, one CDT was considered for inclusion. A simple random sampling was performed using a random number generator in Microsoft Excel. Each CDT was assigned a unique identification number, and the corresponding numbers were randomly drawn until the required number of centers was obtained.

The study took place during the period from November 1, 2024, to January 31, 2025. It was done an equal distribution of tuberculosis patients with tuberculosis across the different health zones, *i.e.*, 12.5% per health zone (**Table 1**).

Table 1. Various tools of Tuberculosis diagnosis.

Variables	Fréquence (n)	%	IC 95 %
AFB			
+ (1 - 99/100)	100	42.4	(36.1 - 48.9)
++ (1 - 10/100)	95	40.25	(34.1 - 46.6)
+++ (>10/100)	2	0.85	(0.1 - 3.0)
0 (0 bacilles/100)	6	2.54	(0.9 - 5.5)
Negative (0 bacilles/100)	18	7.63	(4.6 - 11.7)
Scanty (1 - 9/100)	15	6.36	(3.6 - 10.2)
Xpert MTB/Rif			
Negative	15	5.54	(3.1 - 9.0)
Positive/RIF–	196	72.32	(66.2 - 77.9)
Positive/RIF+	58	21.40	(16.7 - 26.7)
Indeterminate	1	0.37	(0.0 - 2.1)
Error	1	0.37	(0.0 - 2.1)
Skin test			
Serum IGRA test positive	176	68.48	(62.1 - 74.3)
Analysis of other specimens (EPT)	15	6.17	(3.5 - 10.0)
Pleural fluid positive	6	54.55*	(25.1 - 81.0)
Suc from node positive	5	45.45*	(19.0 - 74.9)

AFB: acid fast bacilli. EPT: extrapulmonary TB. IGRA: Interferon-Gamma Release Assay.

2.2. Study Population

The target population consisted of patients who had previously been diagnosed with tuberculosis, had no history of diabetes, and were aged 18 years or older, in tuberculosis treatment and diagnosis centers in the city province of Kinshasa. Simple random sampling was used for this study. Tuberculosis diagnosis and treatment centers were randomly selected two in each administrative district of the city province of Kinshasa. Our sample size was calculated where n = 336 records to be included in all CDTs in the study.

The number was evenly distributed across districts and CDTs.

1) Inclusion criteria: patients aged of 18 years and older with pulmonary and extrapulmonary tuberculosis who were registered, monitored, and undergoing treatment; having given informed consent.

2) Exclusion criteria: to be known to have diabetes prior to the tuberculosis episode.

2.3. Definition of Concepts

Tuberculosis patients pulmonary and EPTB were defined according to national guidelines [16].

Diabetes mellitus was defined operationally, by a fasting venous plasma glucose level of 126 mg/dl or higher on two occasions or a casual blood glucose level of 200 mg/dl or higher, in both cases in individuals previously free of glycemic problems reported in the past.

For patient a Chest X-ray was available at the time of TB diagnosis.

2.4. Variables of Interest and Data Analysis

The dependent variable is patients with tuberculosis and diabetes;

The independent variables selected in this study for the various models to be adjusted were anthropometric and sociodemographic status, site of residence, Household income/day, Clinical signs including history of hypertension, diabetes mellitus in the family, alcohol abused, tobacco), tuberculosis screening and other assessment.

For Pre-testing of the data collection tool, the pre-established questionnaire was pre-tested in a CDT on a small sample of 25 files from our study population. Any problems identified were corrected in advance.

The data collected on the electronic data collection tool (Kobocollect) were extracted from the kobotoolbox server. After cleaning and checking for consistency and completeness, they were recorded in an Excel 2019 spreadsheet and then exported to the R version 4.4.1 data analysis software.

Appropriate statistical analyses were performed regarding to type of data. The median and interquartile range were used to summarize continuous variables, Frequency and proportion tables for categorical variables. The chi-square test to test associations between the dependent variable and independent variables and also to compare proportions, the Mann-Whitney test was used to compare continuous variables. Univariate and multivariate analyses using binary logistic regression were used to identify factors associated with diabetes in patients with tuberculosis. A 95% confidence (CI) level was used with a significance threshold of $\alpha < 0.05$ considered significant.

2.5. Ethical Considerations

The protocol was approved by the National Health Ethics Committee under No. 651/CNES/BN/PMMF/2024 on May 16, 2024, and by the various staff and medical officers on the field where the CDTs were selected. The study was conducted in strict compliance with the World Medical Association's Declaration of Helsinki, revised in 2013. Written informed consent was obtained in advance from all study participants.

3. Results

3.1. Tuberculosis Diagnostic and General Characteristics and Profile of Patients

The various tools used to diagnose TB and the distribution of results are shown in the following Table 2.

Bacteriological examination of sputum staining showed that highly positive forms (++ and +) accounted for the majority of cases (82.6%), reflecting a high bacillary load and therefore high contagiousness. Scanty and negative results represented only 6.36% and 7.63%, respectively, indicating that the majority of patients were at the active bacilliferous stage.

The more sensitive Xpert MTB/Rif test detected Mycobacterium tuberculosis in 93.7% of cases, 21.4% of which were rifampicin-resistant (RIF+). This high resistance rate suggests a worrying circulation of MDR-TB (multidrug-resistant) strains, requiring increased early screening and therapeutic monitoring.

3.2. Calculation of Rate of Diabetes Mellitus

The overall rate of diabetes mellitus among TB patients across all centers in Kinshasa was 11.3% (95% CI: 8.1 - 15.3). However, a notable variation was observed between health zones. The highest prevalence was found in Gombe (34.2%), followed by Lingwala (16.7%) and Masina (14.3%), suggesting possible urban lifestyle or socioeconomic influences in these areas. Conversely, N'djili (0%), Kalamu 1 (4.8%), and Kalamu 2 (2.4%) recorded very low rates, possibly reflecting differences in population profiles, diagnostic capacity, or case detection. The Mont-Amba division (Limete and Matete) presented intermediate rates around 10% - 12%.

Table 2. Distribution of diabetes mellitus among TB patients by health zones in Kinshasa.

Administrative Division	Health Zone	CDT	Non-Diabetic (n)	Diabetic (n)	% (rate)	95% CI
FUNA	Kalamu 1	BONDEKO	40	2	4.8%	(0.6 - 16.2)
	Kalamu 2	HPRKA	41	1	2.4%	(0.1 - 12.6)
LUKUNGA	Lingwala	KABINDA	35	7	16.7%	(7.0 - 31.4)
	Gombe	BOYAMBI	25	13	34.2%	(18.6 - 53.2)
MONT-AMBA	Limete	II^{e} Rue	38	4	9.5%	(2.7 - 22.6)
	Matete	SAINT ALPHONSE	37	5	11.9%	(4.0 - 25.6)
TSHANGU	N'djili	BOMOI	46	0	0.0%	(0.0 - 7.7)
	Masina	ELONGA	36	6	14.3%	(5.4 - 28.5)
	TOTAL		298	38	11.3%	(8.1 - 15.3)

3.3. General Characteristics of the Population Study

Sociodemographic characteristics of the study population are described in Table 3. Gender distribution revealed no significant difference ($p = 0.533$), with males predominating in both diabetic and non-diabetic groups. The median age of diabetic TB patients (51.5 years) was significantly higher than that of non-diabetic patients (32 years), indicating that older age strongly correlates with diabetes occurrence.

This Table 3 shows a statistically significant relationship between age ≥ 34 years

and the presence of diabetes ($p < 0.00001$). Similarly, marital status in union is associated with diabetes ($p < 0.0001$). The sample was dominated by single individuals (53%) and unemployed individuals (41.7%). Just over half of the patients had completed primary education, and 45% of patients spent less than US$3 per day. A history of alcohol consumption (48.2%) and smoking (31.6%) was common.

Table 3. Sociodemographic characteristics of TB patients by diabetes status.

Variables	Total n = 336 (%)	Diabetes mellitus		p-value
		Yes n = 38 (%)	No n = 298 (%)	
Gender				0.533
Female	126 (37.5)	16 (42.1)	110 (36.9)	
Male	210 (62.5)	22 (57.9)	188 (63.1)	
Age group (years) Median	Médiane:	51.5 (22 - 75)	32 (18 - 83)	<0.00001
<34	163 (48.5)	6 (16)	157 (53)	
≥34	173 (51.5)	32 (84)	141 (47.3)	
Marital status				<0.00001
Single	177 (52.7)	4 (10.5)	173 (58.1)	
Married	145 (43.2)	30 (79)	115 (38.6)	
Divorced	3 (01)	00 (00)	03 (1.01)	
Widowed	11 (3.3)	04 (10.5)	07 (2.4)	
Occupation				0.316
Unemployed	140 (41.7)	13 (34.2)	127 (42.6)	
Private employee	136 (40.5)	15 (39.5)	121 (40.6)	
Public employee	60 (17.9)	10 (26.3)	50 (16.8)	
Level of education				0.709
None	2 (0.6)	0 (00)	2 (0.7)	
Primary	172 (51.2)	17 (44.7)	155 (52)	
Secondary	160 (47.6)	21 (55.3)	139 (46.6)	
Higher/university	2 (0.6)	0 (00)	02 (0.7)	
Household income/day (in US dollars)	*n* = 128	*n* = 21	*n* = 107	0.161
<1	38 (29.7)	3 (14.3)	35 (32.7)	
1 - 2	57 (44.5)	12 (57.1)	45 (42.1)	
3 - 5	19 (14.8)	5 (23.8)	14 (13.1)	
>5	14 (11)	1 (4.8)	13 (12.2)	

Legend: USD = US dollars.

3.4. Clinical Characteristics of the Study Population

Table 4 shows that Diabetic patients had a significantly higher prevalence of hy-

pertension (26%) compared to non-diabetic patients (8.1%, p = 0.0004). Conversely, alcohol consumption (23.7% vs 51.3%, p = 0.0013), tobacco use (2.6% vs 35.2%, p < 0.00001), and reported allergies (0% vs 32.9%, p < 0.00001) were significantly lower among diabetics than non-diabetics.

Table 4. History and clinical characteristics of the study population according to diabetes mellitus status.

Variables	Total n = 336 (%)	Diabetes mellitus		p-value
		Yes n = 38 (%)	No n = 298 (%)	
History				
HTN	34 (10)	10 (26)	24 (8.1)	0.0004
Alcohol	162 (48.2)	09 (23.7)	153 (51.3)	0.0013
Tobacco	106 (31.6)	01 (2.6)	105 (35.2)	<0.00001
Allergy	98 (29.2)	00 (00)	98 (32.9)	<0.00001
Dyspnea according to the MRC scale				0.2289
No shortness of breath during strenuous exercise	112 (51.1)	15 (48.4)	97 (51.6)	
Stopping while walking	16 (7.3)	00 (00)	16 (8.5)	
Stopping after a few minutes of walking	14 (6.4)	03 (9.7)	11 (5.9)	
Shortness of breath just from getting dressed	02 (0.9)	01 (3.2)	01 (0.5)	
Shortness of breath when climbing a slight slope	75 (34.3)	12 (38.7)	63 (33.5)	
Clinical				
Cough	334 (99.4)	37 (97.4)	297 (99.7)	0.083
Fever	283 (85.8)	31 (81.6)	252 (86.3)	0.433
Chest pain	257 (81)	22 (59.5)	235 (83.6)	0.0004
Hemoptysis	82 (26.03)	10 (28.6)	72 (25.7)	0.716
Signs of pulmonary localization				0.185
Yes	240 (72)	30 (81.1)	210 (70.7)	
No	96 (28)	8 (21.1)	88 (29.5)	
Extrapulmonary sign	23 (07)	1 (2.7)	22 (7.5)	0.281
Lymph node	13 (56.5)	0 (00)	13 (59.1)	
Pleural	10 (43.5)	1 (100)	9 (40.9)	

Regarding dyspnea assessed by the MRC scale, no statistically significant differences were observed between diabetics and non-diabetics (p = 0.2289). The majority of patients in both groups did not experience shortness of breath during strenuous exercise, and severe dyspnea was rare.

Clinically, nearly all patients presented with a cough (97.4% vs 99.7%, p = 0.083) and fever (81.6% vs 86.3%, p = 0.433), without significant differences between groups. Chest pain was significantly less frequent in diabetic patients (59.5% vs 83.6%, p = 0.0004), while hemoptysis showed no significant variation (28.6% vs 25.7%, p = 0.716). Signs of pulmonary localization were slightly more common in

diabetics (81.1% vs 70.7%, p = 0.185), but this difference was not statistically significant. Extrapulmonary manifestations were uncommon (2.7% vs 7.5%, p = 0.281); lymph node involvement occurred only in non-diabetic patients, whereas pleural involvement was observed in both groups.

Table 5. Chest X-ray profile of patients according to diabetes status.

Variables	Total (n = 336)	DM Yes (n = 38)	DM No (n = 298)	p-value
Chest X-ray performed	183 (55.3%)	25 (65.8%)	158 (53.9%)	0.16
Radiographic syndrome				
• Alveolar	38 (21.7%)	1 (4.2%)	37 (24.5%)	0.01
• Cavitary	62 (35.4%)	17 (70.8%)	45 (29.8%)	<0.001
• Interstitial	30 (17.1%)	3 (12.5%)	27 (17.9%)	0.54
• Mediastinal	1 (0.6%)	0 (0.0%)	1 (0.7%)	0.68
• Mixed	12 (6.9%)	1 (4.2%)	11 (7.3%)	0.59
• Pleural	30 (17.1%)	2 (8.3%)	28 (18.5%)	0.19
• Retractile	2 (1.1%)	0 (0.0%)	2 (1.3%)	0.64
Topography of lesions				
• Right upper lobe	29 (17%)	3 (14%)	26 (18%)	0.64
• Left upper lobe	38 (23%)	6 (27%)	32 (22%)	0.61
• Right lower lobe	38 (23%)	6 (27%)	32 (22%)	0.61
• Left lower lobe	45 (27%)	6 (27%)	39 (27%)	0.99
• Right middle lobe	18 (11%)	1 (5%)	17 (12%)	0.29

Table 5 displays that a higher proportion of diabetic tuberculosis patients underwent chest X-ray (65.8%) compared with non-diabetics (53.9%), although this difference was not statistically significant (p = 0.16). Cavitary lesions were markedly more common among diabetics (70.8% vs 29.8%, p < 0.001), indicating a more destructive radiological pattern typical of immunometabolic impairment in diabetes. Conversely, alveolar infiltrates were less frequent among diabetics (4.2% vs 24.5%, p = 0.01). Other patterns (interstitial, pleural, mixed) did not differ significantly. The topography of lesions did not vary significantly (p > 0.05), suggesting that diabetes influences disease severity rather than anatomical distribution. These results underscore the need for systematic radiographic monitoring in diabetic TB patients.

3.5. Factors Associated with Diabetes Mellitus

As shown in Table 6, the univariate analysis identified several factors significantly associated with diabetes mellitus. Age ≥ 34 years was strongly associated with diabetes, with an unadjusted odds ratio (UOR) of 5.9 (95% CI: 2.41 - 14.52, p < 0.0001). In multivariate analysis, age ≥ 34 years remained an independent predictor (AOR = 4.9; 95% CI: 1.97 - 12.51, p < 0.001).

Table 6. Factors associated of diabetes mellitus among the study population (Univariate and Multivariate Analysis).

Variables	Total n = 336	Univariate			Multivariate		
		UOR	IC 95%	p-value	AOR	IC 95%	p-value
<34		1			1		
≥34	32	5.9	(2.408 - 14.524)	<0.0001	4.9	(1.968 - 12.511)	<0.001*
Marital status							
Living alone		1			1		
In a relationship	30	5.8	(2.585 - 13.078)	0.001	2.6	(0.792 - 8.448)	0.11
Hypertension							
No		1			1		
Yes	10	3.9	(1.755 - 9.0917)	<0.0001	2.6	(1.009 - 6.606)	0.04
Alcohol							
No		1			1		
Yes	09	0.3	(0.137 - 0.648)	0.002	0.6	(0.245 - 1.442)	0.25
Tobacco							
No		1			1		
Yes	01	0.05	(0.068 - 0.371)	0.003	0.6	(0.007 - 0.439)	0.006**
Chest pain							
No		1			1		
Yes	22	0.3	(151 - 0.637)	0.001	0.4	(0.156 - 0.815)	0.014**

UOR: unadjusted Odd Ratio. AOR: Adjusted Odd Ratio.

Hypertension was significantly associated with diabetes in both univariate (COR = 3.9; 95% CI: 1.76 - 9.09; $p < 0.0001$) and multivariate analysis (AOR = 2.6; 95% CI: 1.01 - 6.61; $p = 0.04$), indicating that hypertensive individuals were more than twice as likely to have diabetes compared to normotensive participants.

Marital status was significant in univariate analysis, with individuals in a relationship having higher odds of diabetes (UOR = 5.8; 95% CI: 2.59 - 13.08; $p = 0.001$), but this association lost significance after adjustment in multivariate analysis (AOR = 2.6; 95% CI: 0.79 - 8.45; $p = 0.11$).

Alcohol and tobacco use were inversely associated with diabetes in univariate analysis (UOR = 0.3 and 0.05, respectively), suggesting lower prevalence among users; however, after adjustment, only tobacco use remained significant (AOR = 0.6; 95% CI: 0.007 - 0.44; $p = 0.006$), indicating a complex relationship that may involve confounding factors.

Chest pain was associated with lower odds of diabetes in both univariate (COR = 0.3; 95% CI: 0.15 - 0.64; $p = 0.001$) and multivariate analysis (AOR = 0.4; 95% CI: 0.16 - 0.82; $p = 0.014$), suggesting that patients presenting with chest pain were less likely to have diabetes.

Overall, after adjustment, age ≥ 34 years, hypertension, tobacco use, and chest

pain remained significantly associated with diabetes mellitus in this population. These findings highlight the importance of age and comorbidity as risk factors, while behavioral factors such as alcohol and tobacco use show more complex, potentially confounded relationships.

4. Discussion

4.1. Sociodemographic Profile

The study showed a predominance of males (62.5%) among tuberculosis patients with diabetes mellitus, which is consistent with epidemiological trends observed in other studies on tuberculosis [6] [17] and diabetes. This male overrepresentation could be explained by more frequent risk behaviors (smoking, alcohol consumption) as well as later access to care [13].

The median age of participants was 34 years, with a predominance of patients aged 34 years and older in the diabetic group. This observation is consistent with studies showing an increased risk of diabetes with age, particularly in patients with tuberculosis [18] [19]. In addition, more than half of diabetic patients were married (79%), unlike non-diabetic patients, the majority of whom were single. One possible explanation is that married people have a more sedentary lifestyle, which is a risk factor for diabetes.

4.2. Frequency of Diabetes in Tuberculosis Patients

These findings indicate that the burden of diabetes among TB patients is not evenly distributed across Kinshasa's administrative divisions, as shown by metaanalysis [9] [20]. Urban and central health zones (particularly Gombe) appear to have a higher comorbidity burden, which may be linked to older patient profiles, lifestyle factors, or better diagnostic access. This geographic variability highlights the need for targeted screening and integrated management programs at the district level [2] [21]. The rate or prevalence of diabetes in tuberculosis patients was estimated at 11%. This prevalence is similar to that reported in other studies in sub-Saharan Africa, where the prevalence of diabetes in tuberculosis patients varies between 10% and 15% [4] [9] [10] [19]. This relatively high proportion suggests a significant link between the two conditions. Diabetes weakens the immune response, thereby promoting the reactivation of latent Mycobacterium tuberculosis [22] [23]. Conversely, tuberculosis can disrupt glycemic control, making diabetes more difficult to manage [10] [24].

4.3. Clinical Profile

Clinical analysis revealed that the majority of diabetic patients showed signs of advanced tuberculosis. In particular, 70.8% of diabetics had cavitary lesions, compared with 29.8% of non-diabetics ($p = 0.0129$). These results confirm the observations of Chiang *et al.* (2014) [11], which indicate that diabetic patients are more likely to develop severe forms of pulmonary tuberculosis.

A history of high blood pressure (HBP) was more common among diabetics

(26% vs. 8.1%, p = 0.0004). This finding reinforces the hypothesis that metabolic diseases such as diabetes and HTN often coexist and exacerbate associated complications even about TB patients (Leegaard *et al.*, 2011) [25].

Paraclinical analyses showed that 21.4% of patients were resistant to rifampicin. This high rate could be partly related to immune alterations induced by diabetes [23] [26]-[28].

4.4. Factors Associated with Diabetes in Tuberculosis Patients

Multivariate analysis identified several factors independently associated with diabetes among tuberculosis (TB) patients. Age ≥ 34 years (AOR = 4.9, p < 0.0001): The risk of diabetes increases with age, largely due to a progressive decline in insulin sensitivity and pancreatic β-cell function [18] [29]. Older TB patients are therefore more likely to present with comorbid diabetes, which may complicate disease management and treatment outcomes.

Hypertension (AOR = 2.6, p = 0.04) and diabetes share several pathophysiological mechanisms, including insulin resistance, chronic inflammation, and endothelial dysfunction [29] [30]. The coexistence of these conditions among TB patients highlights the need for integrated screening and management of cardiovascular and metabolic comorbidity.

Smoking (AOR = 0.6, p = 0.006) appeared as a protective factor in this study, a finding that contrasts with much of the literature. This unexpected inverse association may reflect confounding factors, such as underreporting, lifestyle differences, or selection bias. Further research is needed to clarify the relationship between smoking and diabetes among TB patients.

The inverse association between Chest pain (AOR = 0.4, p = 0.014) and diabetes suggests that diabetic patients may experience more atypical or "silent" forms of TB, which can delay diagnosis and reduce symptom-driven healthcare-seeking. This finding aligns with previous studies highlighting atypical TB presentations in patients with metabolic comorbidity [31].

The inverse association between chest pain and diabetes mellitus may be explained by the higher frequency of atypical or silent forms of tuberculosis observed in diabetic patients. A key mechanism involves diabetic neuropathy, particularly autonomic and sensory nerve dysfunction, which can alter the perception of thoracic pain. In long-standing or poorly controlled diabetes, damage to afferent sensory fibers may reduce the transmission of pain signals, thereby masking typical symptoms such as chest pain [32].

This phenomenon is well-established in cardiovascular disease, where diabetic patients frequently present silent ischemia or painless myocardial infarction due to impaired pain perception [33]. By analogy, a similar mechanism may occur in pulmonary or pleural tuberculosis, where irritation or inflammation that would normally generate pain becomes less perceptible. Additionally, diabetes-related immune dysfunction can contribute to less inflammatory and more insidious clinical presentations of tuberculosis, further reducing the occurrence of classical

symptoms. Therefore, diabetic patients with tuberculosis may be less likely to report chest pain, not because the disease is less severe, but because their sensory response to thoracic pathology is blunted. This supports the observed inverse association in our study.

Overall, these findings are consistent with the growing evidence that diabetes prevalence is increasing among TB patients [34]. However, variations exist across populations depending on socioeconomic conditions, TB screening practices, and healthcare access. The World Health Organization (WHO) recommends systematic screening for diabetes in all TB patients [7] [35] [36] Implementing such integrated approaches could improve early detection, optimize treatment outcomes, and reduce the morbidity and mortality associated with the dual burden of TB and diabetes.

Study Limitations and Strengths

This study has some limitations. Its cross-sectional design precludes causal inference between diabetes mellitus and tuberculosis, allowing only the identification of associations. Self-reported data on alcohol consumption, smoking, and medical history may have introduced recall bias. In addition, the analysis was restricted to a limited number of treatment centers in Kinshasa, which may reduce external validity. Missing biological and socioeconomic data could also have affected the precision of some estimates.

Nevertheless, the study has several strengths. It is among the few to investigate the dual burden of tuberculosis and diabetes in an urban African context. The random selection of treatment centers and the use of standardized clinical records strengthen its methodological rigor. The findings provide valuable public health evidence supporting integrated screening and management of diabetes among tuberculosis patients in Kinshasa.

5. Conclusions

This study highlights a high rate or prevalence of diabetes mellitus among tuberculosis patients in the city of Kinshasa and the significant association between diabetes and tuberculosis in Kinshasa. Diabetic patients are more likely to develop severe forms of tuberculosis, underscoring the need for integrated management of both conditions. This bidirectional interaction between diabetes and tuberculosis is a public health challenge requiring appropriate prevention and management strategies. Joint management of these two diseases would not only reduce associated mortality and morbidity, but also improve treatment outcomes by optimizing patient follow-up.

By integrating systematic diabetes screening into tuberculosis control programs and ensuring effective glycemic control, it would be possible to reduce the progression of complications and optimize the response to tuberculosis treatment.

Contributions of the Authors

ABB, SBF: principal investigator;

SBF, ABB, ZKM for the design of the study;

RL, SBF for data analysis;

ABB, RL, SBF, coordinated the collection of data;

SBF, DMK, IKM, RKY, JBKL, ZKM, JKN for proofreading and editing of the final form of article.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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