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EPIDEMIOLOGICAL AND NUTRITIONAL FACTORS ASSOCIATED WITH TUBERCULOSIS IN THE KAMINA HEALTH ZONE, DRC

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ABSTRACT

Introduction: Tuberculosis remains a major public health problem, particularly in low-income countries, where malnutrition and certain socio-epidemiological factors increase the risk of disease. This study aimed to identify the epidemiological and nutritional factors associated with tuberculosis in Kamina.

Methods: A case-control study was conducted from February to September 2024 in three diagnostic and treatment centres. The cases comprised 41 patients with tuberculosis, matched with two controls without tuberculosis each (n = 82). Data were collected using structured questionnaires and KoboToolbox/ODK. Statistical analyses were performed using SPSS version 23 and included the chi-square test, odds ratios (ORs) with 95% confidence intervals (CIs), and multivariable logistic regression, with statistical significance set at $p < 0.05$. Model performance was assessed using the area under the receiver operating characteristic (ROC) curve.

Results: The mean age of cases was 29.4 ± 14 years, and most were male (75.6%). Epidemiological and nutritional factors significantly associated with tuberculosis were low educational attainment, current smoking, contact with a person with tuberculosis, and the absence of an adequate diet. The predictive model showed good performance, with an ROC area under the curve of 0.83.

Conclusion: This study highlights the importance of epidemiological and nutritional factors in tuberculosis risk. Identifying these local factors may help guide context-appropriate prevention and nutritional care interventions.

Keywords: Epidemiological, Factors, Nutritional, Tuberculosis, Kamina, RDC

1 INTRODUCTION

Tuberculosis (TB) remains a major global public health problem and a persistent threat to health security. According to the World Health Organization (WHO), approximately 10.7 million people developed tuberculosis in 2022, including 5.8 million men, 3.7 million women and 1.2 million children (1). The disease affects every country and age group, but remains particularly concerning in low- and middle-income countries, where health systems are often fragile and access to care is limited. Since 2000, tuberculosis diagnosis and treatment have saved nearly 75 million lives, underscoring the importance of prevention and care strategies (1).

Tuberculosis is also associated with multiple risk factors, including undernutrition, HIV infection, alcohol consumption and smoking. In 2021, the WHO estimated that 2.2 million TB cases were attributable to undernutrition, 0.86 million to HIV infection, 0.74 million to alcohol use and 0.69 million to smoking (2). These figures highlight the epidemiological complexity of tuberculosis and the need to consider socioeconomic, behavioural and nutritional factors when assessing risk.

Africa remains one of the regions most affected by tuberculosis, with an estimated incidence of 212 cases per 100,000 population (2). The TB–HIV co-epidemic increases the disease burden in several countries, raising both the risk of infection and mortality. In this context, undernutrition and inequalities in access to care worsen disease progression. Regional and national efforts have been made to improve screening and care, but challenges persist, particularly in rural and peri-urban areas where health-service coverage remains inadequate (3).

In the Democratic Republic of the Congo (DRC), tuberculosis is a major health concern. The National Tuberculosis Control Programme reported 216,690 cases in 2021, including 120,724 men, 92,498 women and 26,550 children (3). Kinshasa and Haut-Katanga are among the most affected areas. Drug-resistant tuberculosis poses an additional challenge, with 450,000 new cases of rifampicin-resistant tuberculosis reported in 2021 (4). The DRC faces substantial nutritional deficiencies, a high prevalence of HIV and limited access to health services, all of which contribute to the persistence and spread of the disease (5).

Despite ongoing efforts, tuberculosis remains strongly associated with several social and nutritional determinants (6). These factors underline the need for local studies to identify the specific factors influencing TB risk and to better target preventive and therapeutic interventions.

Although several studies have examined the epidemiological factors associated with tuberculosis globally and in Africa, data jointly addressing nutritional and behavioural determinants remain limited in many sub-Saharan African settings. In the DRC, most available research has focused mainly on clinical and diagnostic aspects or TB–HIV co-infection, with few analytical studies exploring nutritional and socio-behavioural factors associated with TB occurrence. In Haut-Lomami Province, particularly in the Kamina Health Zone, scientific data on these determinants remain very limited. This lack of empirical evidence makes it difficult to identify local factors that may influence TB transmission and disease development. A better understanding of the interaction between nutritional status, individual behaviours and epidemiological exposure is essential to guide locally appropriate prevention, screening and care strategies. This study therefore aimed to identify the epidemiological and nutritional factors associated with tuberculosis in the Kamina Health Zone.

2 METHODS

2.1 Study setting

This study was conducted in the urban-rural Kamina Health Zone, Haut-Lomami Province, Democratic Republic of the Congo. It covered the three diagnostic and treatment centres (DTCs) in the health zone: HGR/Kamina, Mère du Sauveur and Bumi.

2.2 Study design, period and population

This analytical case-control study was conducted as part of a prospective survey in the three DTCs (HGR, Bumi and Mère du Sauveur) from February to September 2024. A case was defined as any patient with tuberculosis (new or previously diagnosed) recorded in the TB registers of these centres during the study period. A control was defined as a person without tuberculosis who lived in the same household as a TB patient and/or shared similar living conditions. All 41 registered TB cases who could be physically located during the study period were included. Each case was matched with two controls, giving a total sample of 123 participants.

2.3 Data collection tools and procedures

Data were collected using two methods: face-to-face structured interviews and documentary review, supported by a pre-tested questionnaire configured on the KoboToolbox server and the Open Data Kit (ODK) platform for field data collection. Before data collection began, verbal authorisation was obtained from political-administrative and health authorities after the purpose of the study had been explained. Two trained data collectors assisted with the study.

2.4 Data processing and statistical analysis

Data completeness and accuracy were checked in the field during collection and subsequently using IBM SPSS version 23. After collection, the data were downloaded in Excel format and analysed. Descriptive and analytical statistical analyses were performed. Associations between the dependent and independent variables were assessed, as appropriate, using Pearson's chi-square test or Fisher's exact test. Statistical significance was set at $p < 0.05$. Odds ratios and their 95% confidence intervals were calculated to measure the strength of association between binary variables. Forward stepwise logistic regression using the Wald method was performed to select epidemiological and nutritional factors significantly associated with tuberculosis, estimate the strength of each association and adjust the analyses. Associations with $p < 0.05$ in adjusted analyses were considered statistically significant. Model performance was then assessed using a receiver operating characteristic (ROC) curve.

2.5 Ethical considerations

The study was conducted in accordance with ethical principles applicable to research involving human participants. Permission to conduct the study was obtained from the School of Public Health of the University of Kamina and the health authorities of the Kamina Health Zone, and the study followed the Declaration of Helsinki. Before data collection, participants were informed of the study objectives and scientific relevance. Participation was voluntary, and informed consent was obtained from each participant or, for minors, from their legal representatives. Participants were informed that they could refuse or withdraw at any time without consequences. Anonymity and confidentiality were strictly maintained. No personal identifiers were recorded in the database, and the information collected was used solely for scientific purposes. Data were stored securely and were accessible only to the research team.

3 RESULTS

Table 1: Characteristics of the TB cases by age, sex and marital status.

Characteristic	Cases (n = 41), n (%)
Age, years (mean ± SD)	29.4 ± 14
0–14 years	7 (17.1)
15–45 years	24 (58.5)
≥46 years	10 (24.4)
Sex	
Male	31 (75.6)
Female	10 (24.4)
Marital status	
Married	18 (43.9)
Not married	23 (56.1)
Educational attainment	
No schooling/primary	25 (61.0)
Secondary/university	16 (39.0)
Smoking	
Yes	32 (78.0)
No	9 (22.0)
TB/HIV co-infection	

HIV-positive	12 (29.3)
HIV-negative	23 (56.1)
Status unknown	6 (14.6)

Most participants (58.5%) were aged 15–45 years. The mean age was 29.4 ± 14 years. Men predominated (75.6%). In addition, 56.1% were not married, 61.0% had no schooling or only primary education, and 78% were current smokers. The prevalence of TB/HIV co-infection in this study population was 29.3% (Table 1).

Table 2: Association between tuberculosis and age, sex, educational attainment, household size and smoking.

Variable	TB cases n (%)	Controls n (%)	OR (95% CI)	p-value
Age				
0–14 years	7 (17.1)	11 (13.5)	5.238 (1.056–25.966)	0.00
15–45 years	24 (58.5)	68 (82.9)	1 (reference)	
≥46 years	10 (24.4)	3 (3.6)	9.444 (2.396–37.226)	0.00
Sex				
Male	31 (75.6)	42 (51.2)	2.952 (1.282–6.798)	0.00
Female	10 (24.4)	40 (48.8)		
Educational attainment				
No schooling/primary	25 (61.0)	20 (24.4)	4.843 (2.166–10.832)	0.00
Secondary/university	16 (39.0)	62 (75.6)		
Household size				
≥5 people	37 (90.2)	50 (61.8)	5.920 (1.926–18.198)	0.00
<5 people	4 (9.8)	32 (39.2)		
Smoking				
Yes	32 (78.1)	19 (23.2)	11.789 (4.793–28.998)	0.00
No	9 (21.9)	63 (76.8)		

In this sample, tuberculosis was strongly associated with age 14 years or younger and age 46 years or older, male sex, low educational attainment, a household size of five or more people, and smoking. The reported odds were approximately fivefold, ninefold, threefold, fivefold, sixfold and twelvefold, respectively (Table 2).

Table 3: Association between tuberculosis and nutritional and other exposure factors.

Category	TB cases n (%)	Controls n (%)	OR (95% CI)	p-value
Special/adequate diet				
No	34 (82.9)	42 (51.2)	4.626 (1.841–11.626)	0.00
Yes	7 (17.1)	40 (48.8)		
Meals per day				
<3 meals	36 (87.8)	53 (64.6)	3.940 (1.394–11.137)	0.00
≥3 meals	5 (12.2)	29 (35.3)		
BMI				
Undernourished (BMI <18)	21 (51.2)	7 (8.5)	3.714 (1.237–11.152)	0.01
Normal (BMI 18–25)	5 (12.2)	15 (18.3)	1 (reference)	

Overweight (BMI ≥25)	15 (36.6)	60 (73.2)	0.751 (0.237–2.391)	0.63
Contact with a person with TB				
Yes	25 (61.8)	20 (24.4)	4.844 (2.166–10.832)	0.00
No	16 (39.2)	62 (75.6)		
Alcohol use				
Yes	34 (82.9)	32 (39.2)	7.589 (3.004–19.170)	0.00
No	7 (17.1)	50 (61.8)		

Regarding nutritional factors, tuberculosis was strongly associated with the absence of a special/adequate diet, fewer than three meals per day, a BMI below 18, contact with a person with TB, and alcohol use. The reported odds were approximately fivefold, fourfold, fourfold, fivefold and eightfold, respectively (Table 3).

Table 4: Logistic regression of factors associated with tuberculosis.

Factor	B	SE	Wald	Adjusted OR (95% CI)	p-value
Educational attainment (no schooling vs educated)	1.430	0.544	6.915	4.179 (1.439–12.133)	0.00
Current smoking (yes vs no)	2.224	0.539	17.019	9.243 (3.213–26.585)	0.00
Contact with a person with tuberculosis (yes vs no)	1.320	0.542	5.935	3.742 (1.294–10.817)	0.00
Special/adequate diet (no vs yes)	1.192	0.575	4.293	3.293 (1.067–10.166)	0.03
Constant	−2.459	0.600	16.815		0.00

The epidemiological and nutritional factors significantly associated with tuberculosis in the study setting were lack of schooling (adjusted OR = 4.179; 95% CI: 1.439–12.133), current smoking (adjusted OR = 9.243; 95% CI: 3.213–26.585), contact with a person with tuberculosis (adjusted OR = 3.742; 95% CI: 1.294–10.817), and the absence of a special/adequate diet (adjusted OR = 3.293; 95% CI: 1.067–10.166) (Table 4). The authors state that the tuberculosis prediction model can therefore be expressed as follows:

$$p = (Y = \text{tuberculosis} / X = xi) = \frac{e^{-2,459+1,430x1+2,224x2+1,320x3+1,192x4}}{1+e^{-2,459+1,430x1+2,224x2+1,320x3+1,192x4}}$$

The area under the curve (AUC) was 0.83 (83%), with a 95% confidence interval of 0.74–0.92. Since $p < 0.001$, the null hypothesis was rejected, and the model was considered to have significantly better predictive ability than chance (Figure 1).

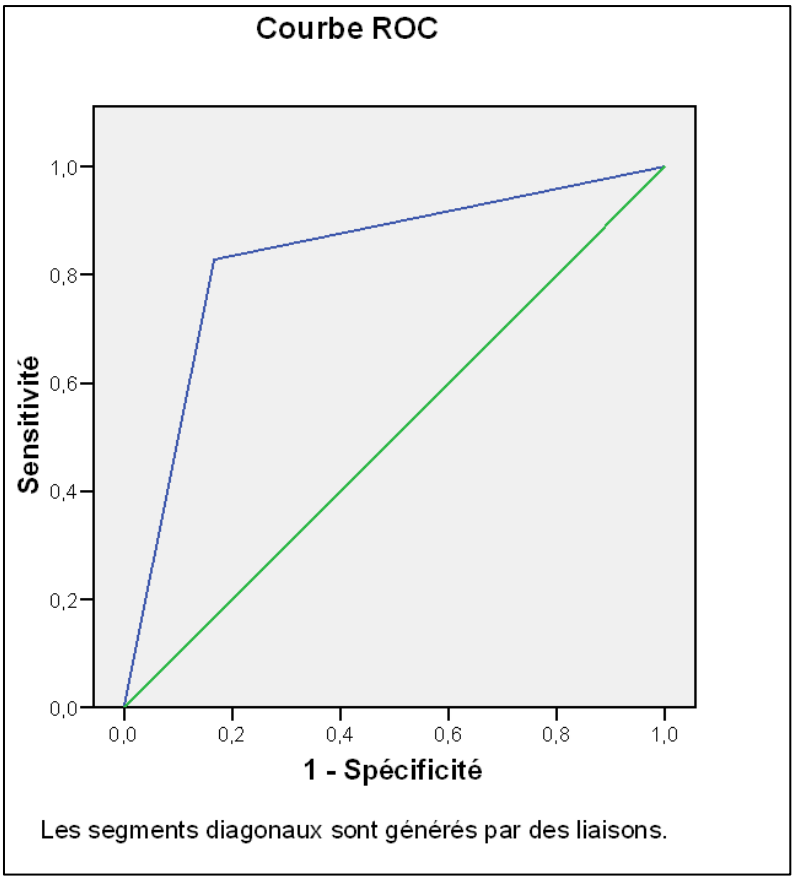


Figure 1: ROC curve for epidemiological and nutritional factors associated with tuberculosis in the prediction model.

4 DISCUSSION

In our study, men were more frequently affected by tuberculosis than women. Our findings are consistent with studies conducted in several countries, where lifestyles shaped by difficult working conditions in a context of widespread poverty may partly explain this pattern (7). Domestic work, which may involve less exposure to difficult conditions outside the home, has been suggested as a protective factor for women. These findings are similar to those reported by Ngombe et al. in the Kamina Health Zone and by Chahboune et al. in Morocco (5, 7). Risk-related behaviours more common among men, such as smoking, may also explain this male predominance. However, women's vulnerability to tuberculosis has also been discussed in relation to exposure to cooking smoke and substantial dust during housework or yard maintenance (8). Other studies have found no significant sex difference (9), so this issue remains debated.

Previous reports indicate that 20%–60% of tuberculosis cases occur among people with little or no formal education (10). In our study, tuberculosis was significantly associated with having no schooling or only primary education. The association between literacy and tuberculosis may be explained by the fact that literacy facilitates reading and understanding health-awareness messages. Illiteracy has been associated with tuberculosis in Ghana, Burkina Faso, Côte d'Ivoire and Guinea; people who were illiterate were at greater risk of testing positive for tuberculosis than those with education (11). Randriatsarafara et al. also found a significant association between low educational attainment and drug-susceptible tuberculosis (OR = 3.8; 95% CI: 2.71–7.43) (9). In contrast, Mazza-Stalder et al. found no statistically significant association between tuberculosis and low educational attainment (p = 0.91) (12).

Current smoking was associated with tuberculosis in our setting. According to Underner and Perriot, smoking and tuberculosis are two major global public health concerns, particularly in emerging economies (13). Tobacco smoke may promote Mycobacterium tuberculosis infection through several mechanisms, including impaired mucociliary clearance, reduced alveolar macrophage function, immunosuppression of pulmonary lymphocytes, reduced natural killer cell cytotoxic activity and altered pulmonary dendritic-cell function. Smoking is therefore considered a risk factor for tuberculosis. Davies et al. reported that TB incidence increased with tobacco consumption and that the risk was four times higher among people smoking more than 20 cigarettes per day (14). According to Lowe, smoking irritates the respiratory tract and affects local immune defences; it has long been suspected of increasing the risk of tuberculosis, although the evidence available until recent decades was largely anecdotal (15). In earlier studies, the association

between tobacco and tuberculosis was often obscured by other risk factors, including alcohol misuse, adverse socioeconomic conditions and increased environmental exposure (16). More recently, two systematic reviews reached similar conclusions about the relationship between smoking and tuberculosis. The International Union Against Tuberculosis and Lung Disease reviewed the interactions between tobacco and tuberculosis and proposed an action plan. According to that source, tobacco disrupts mucosal defences involved in controlling bronchial infections by increasing bronchial secretions, reducing mucociliary clearance and inhibiting macrophage activity. This can reduce bacterial adherence to macrophages, phagocytic capacity, release of pro-inflammatory cytokines, intracellular bactericidal activity, TNF-α release and nitric oxide production. Impaired immune defences are also considered responsible for the increased risk of pneumococcal pneumonia observed in smokers (17).

Our study found that contact with a person with tuberculosis was associated with an increased risk of infection. Transmission occurs mainly through the air when an infectious person coughs, sneezes or speaks, releasing infectious particles. When inhaled, these particles can reach the lungs and cause infection. Infection does not necessarily mean that a person will develop active disease: most infected people develop latent TB infection, which is asymptomatic and non-contagious (18). However, some may develop active tuberculosis years later, particularly in the presence of risk factors such as immunosuppression or malnutrition (19). Early case detection and appropriate treatment are therefore essential to interrupt transmission and prevent disease progression.

In our sample, the absence of an adequate diet, reflected by a less diverse diet and undernutrition, was significantly associated with tuberculosis (adjusted OR = 3.293). This finding is consistent with published evidence highlighting the central role of nutritional status in TB risk. A recent meta-analysis found that undernutrition approximately doubles the risk of developing tuberculosis, underscoring the biological impact of malnutrition on cellular immunity and susceptibility to Mycobacterium tuberculosis infection (20). Observational studies in Africa and Asia have also reported a high prevalence of undernutrition among people with tuberculosis and significant associations between low food intake, low body mass index and active TB (21). For example, in a cohort in the Lao People's Democratic Republic, nearly 40% of patients with tuberculosis were undernourished at diagnosis, a condition associated with socioeconomic and dietary hardship (21). A case-control study in Uganda also found that malnutrition among household contacts of TB cases was an important risk factor for developing the disease (22). Finally, an epidemiological perspective highlights the substantial contribution of undernutrition to the global TB epidemic, affecting not only incidence but also treatment response and clinical outcomes (23). These findings support integrating nutritional care into tuberculosis control strategies, particularly in resource-limited settings where food insecurity and dietary deficiencies are widespread.

5 CONCLUSION

This study highlights the importance of socio-epidemiological and nutritional determinants of tuberculosis in the Kamina Health Zone. Smoking, low educational attainment, contact with a person with tuberculosis and inadequate dietary intake were significantly associated with the disease. These findings underline the need to integrate nutritional interventions and community awareness activities into tuberculosis control strategies in the DRC.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The authors declare no conflicts of interest.

Authors' contributions

- Georges Mwema Ilunga: conceived the study and drafted the manuscript.
- Ronsard Mutonkole Kelongolwele: designed the data-collection tool and analysed the data.
- Charles Muhadila Kapenda: contributed to manuscript review and scientific guidance.
- Valentin Masengo Kazadi: contributed to scientific supervision, methodological validation and final approval of the manuscript.

Statement of ethical approval

The study was conducted in accordance with the ethical principles applicable to research involving human participants and the Declaration of Helsinki. Permission to conduct the study was obtained from the School of Public Health of the University of Kamina and the health authorities of the Kamina Health Zone. Anonymity and confidentiality were strictly maintained throughout the study. No personal identifiers were recorded in the database, and the information collected was used solely for scientific purposes. Data were stored securely and were accessible only to the research team.

Statement of informed consent

Before data collection, participants were informed of the study objectives and scientific relevance. Participation was voluntary, and informed consent was obtained from each participant or, for minors, from their legal representatives. Participants were informed that they could refuse to participate or withdraw from the study at any time without any consequences.

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