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Prevalence of Pulmonary Tuberculosis and Associated Factors among Patients Admitted to the Amissa Bongo University Hospital Center in Franceville, Gabon

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Abstract

Background: In Gabon, the epidemiology of tuberculosis has been considerably reshaped by the AIDS virus. It is in this context that the present study was conducted to assess the prevalence of pulmonary tuberculosis and associated factors among patients at the Amissa Bongo Regional Hospital in Franceville, Gabon. **Patients and Methods:** This prospective, cross-sectional study was conducted in the biomedical analysis laboratory of the Amissa Bongo Regional University Hospital in Franceville from 19 June 2021 to 22 January 2022. After agreeing to take part in the study, participants were asked to fill in a questionnaire to collect their socio-demographic data and habits. Clinical signs were also observed. Sputum and gastric fluid samples were collected and examined using the Xpert MTB/RIF test and BAAR smear microscopy. Data were analysed using R software version 3.6.1. The results of the univariate and multivariate analyses were considered significant for $p \leq 0.05$. **Results:** A total of 309 patients were included in this study, 50.81% (n = 157) men and 49.19% (n = 152) women. Of these, 98 had a positive diagnosis of pulmonary tuberculosis, giving an overall prevalence rate of 31.72%. There were 40 women or 40.82% (95% CI: [0.30 - 0.51]) and 58 men or 59.18% (95% CI: [0.48 - 0.69]). A univariate analysis of the prevalence of tuberculosis according to risk factors and clinical signs indicated a certain association between certain variables. However, an in-depth multivariate logistic regression

analysis of this prevalence, according to the risk factors and clinical signs observed in the patients in the study, indicated that the age group 15 and 49 years (Adjusted OR = 47.77; 95% CI: [4.4; 519.7] p = 0.001*), fever (Adjusted OR = 4.83; 95% CI: [1.16, 20.12] p = 0.031*), alcohol consumption (Adjusted OR = 12.2; 95% CI: 12.2 [2.5; 5.9] p = 0. 002*), smoking (Adjusted OR = 9.83; 95% CI: [1.78; 54.24] p = 0.037), HIV infection (Adjusted OR = 4.63; 95% CI: [1.25; 17.1] p = 0.022), cough (Adjusted OR = 4.31; 95% CI: [1.21, 15.4] p = 0. 025*), chest pain (Adjusted OR = 103.6; 95% CI: [19.4; 55.2] p = 0.000), night sweating cough (Adjusted OR = 10.84; 95% CI: [3.18; 36.98] p = 0.000*) were significant risk factors for pulmonary tuberculosis. **Conclusion:** The results of the present study showed that the prevalence of pulmonary tuberculosis was greatest among males in Franceville and the surrounding area. The 15 - 49 age group, fever, alcohol consumption, smoking, HIV infection, chest pain, night sweats and cough were significant risk factors for pulmonary tuberculosis. Consequently, screening for tuberculosis in HIV-positive patients, public awareness and community mobilisation should be encouraged.

Keywords

Prevalence, Pulmonary Tuberculosis, Ziehl-Neelsen Rapid Acid Staining, GeneXpert, CHURAB, Franceville, Gabon

1. Introduction

Caused by *Mycobacterium tuberculosis*, tuberculosis (TB) is a serious bacterial disease that mainly affects the lungs (pulmonary TB), but can also affect other organs (extra-pulmonary TB) [1]. The disease is transmitted when a person with tuberculosis coughs, speedés, sings or talks. The germs of Mycobacterium tuberculosis are spread through the air and can be inhaled by other people. An estimated 10.6 million people fell ill with tuberculosis (TB) in 2021, an increase of 4.5% on 2020, and 1.6 million people died from TB (including 187,000 HIV-positive people), according to the World Health Organization's Global TB Report 2022 [2]. However, tuberculosis is a very common opportunistic disease that kills infected people, but can be cured if people go to hospital early for screening and follow the advice of healthcare staff until treatment is complete [3]. The WHO recently reported that 12% of the 9.6 million new cases of tuberculosis were HIV-positive [4]. In HIV-positive patients, active tuberculosis is due to the reactivation of endogenous latent disease and reinfection with a new strain [5]. Epidemiological studies have shown that co-infection with HIV can increase the risk of reactivation of latent tuberculosis by a factor of 20, and is the strongest known risk factor for the progression of M. tuberculosis infection to active disease [6]. Furthermore, the WHO has indicated that tuberculosis, along with HIV, is the most deadly infectious disease in the world, with both diseases estimated to be responsible for approximately 1.5 million deaths in 2022 [4]. Because of the HIV pandemic, poverty, the movement of displaced people and the

emergence of multi-drug resistant strains, tuberculosis remains an enormous public health problem in developing countries [7]. Moreover, a previous study showed that in most developing countries, HIV pandemics, diabetes, malnutrition, alcoholism, smoking, contact with active TB, extreme poverty and homelessness are common risk factors identified in relation to TB [8]. Tuberculosis has been identified as an important cause of morbidity and mortality in Gabon. [9]. Considered a developing country in Central Africa, economic imbalances are widespread, the literacy rate is borderline average and basic health services are not only under-equipped but sometimes scarce. In Gabon, according to the World Health Atlas, the incidence of tuberculosis was estimated at 521/100,000 in 2019 [10]. According to the National Tuberculosis Control Programme (PNLT), the WHO ranks Gabon 4th among African countries and territories for the incidence of tuberculosis, and with a high morbidity rate [11]. Another problem facing the country is the simultaneous prevalence of TB and HIV. In a study conducted in the south of the country in 2021, 73 patients (6.4%) were co-infected with HIV+/TB+ [12]. The mortality rate for people infected with both TB and HIV was 25% [13]. Faced with this situation, since 4 May 2021, at a workshop to validate its national strategic plan 2021-2025, the Gabonese government has made the fight against tuberculosis one of the priorities of the country's health sector development programme [10]. However, a review of the literature indicates that there is a paucity of studies on the prevalence of TB in patients in south-eastern Gabon. For this reason, the aim of the present study was to determine the prevalence of pulmonary tuberculosis and associated factors among patients attending the Centre Hospitalier Universitaire Régional Amissa Bongo in Franceville.

2. Patients and Methods

2.1. Study Design, Period and Description of the Study Area

This is a prospective, cross-sectional study designed and conducted from 19 June 2021 to 22 January 2022 at the biomedical analysis laboratory of the Centre Hospitalier Universitaire Amissa Bongo in Franceville, the provincial capital of Haut Ogooué, Gabon.

2.2. Study Population

Determination of Sample Size and Sampling Technique

To estimate the prevalence and risk factors associated with pulmonary TB in the city of Franceville and surrounding departments, the study sample size was determined using the single proportion population formula as used elsewhere, positing the formula:

$$n = \left(Z\alpha/2\right)^2 \times \left(P,\ \left(1-P\right)^2 \middle/ d^2\right) \quad [14]$$

In this, n represents the sample size, $Z\alpha/2$ is the standard normal deviation (1.96), corresponding to a 95% confidence interval (CI), P is the prevalence of

pulmonary tuberculosis. In the absence of *P* values obtained elsewhere, or in a previous study in the town of Franceville and surrounding departments, this *P* value was taken to be 50%. *d* is considered to be the precision/marginal error (*d* = 0.05) or 5%. Initially, the sample size determined for the study was 281. As applied in two studies elsewhere, errors resulting from the probability of non-compliance or drop-out were minimised. As the sample size was increased by 10% [15] [16], the sample size finally used in this study was 309 participants.

2.3. Data Collection, Sampling Procedure and Sample Processing

The data used for this study were collected from people who came for diagnosis to the biomedical analysis laboratory of the Centre Hospitalier Universitaire Régional Amissa Bongo in Franceville as part of the national tuberculosis control programme.

2.3.1. Study Inclusion and Exclusion Criteria

Only people who had consented to participate in the study by correctly answering the survey questionnaire, and whose results of the two diagnoses were usable, were included in the present study. People who did not wish to take part in the study or whose test results could not be used were excluded.

2.3.2. Sociodemographic Data

Data on patients' socio-demographic characteristics were obtained by means of a face-to-face interview in the laboratory with the patient using a pre-tested semi-structured questionnaire on 10% of the subjects, who were not included in the study. The questionnaire took into account the patient's date of diagnosis, age, sex, marital status, professional status, level of education, family size, place of residence and monthly income.

2.3.3. Laboratory Diagnoses

The diagnosis of tuberculosis was made on the basis of clinical evidence, *i.e.* sputum was collected in leak-proof sterile plastic containers, decontaminated with sodium hypochlorite and concentrated by centrifugation to release the bacteria ready for staining. Sputum samples from adults or gastric fluid from children were examined by the Xpert MTB/RIF test, using the standard protocol. This is a rapid diagnostic tool for multidrug-resistant tuberculosis recommended by the WHO, which stipulates that once the sputum has been collected, it is mixed in the cartridge supplied with the sample reagent buffer in a volume ratio of 1:2 (sample: sample reagent buffer). The cartridge is then hermetically sealed, vortexed for 15 seconds and left to stand at room temperature for 10 min. After this, the cartridge is vortexed again after 10 minutes and left to stand for 5 minutes. Using the Pasteur pipette supplied with the kit, just over 2 ml of the treated sample is placed in the cartridge, which is then loaded into the Xpert machine and the results collected via an Xpert computer after 2 hours. The results are then collected using an Xpert computer [17]. Secondly, by smears prepared, fixed and stained using Ziehl-Neelsen staining methods as described elsewhere

[18]. To confirm the presence of acid-fast bacilli, the smears were then carefully inspected using a zoom stereomicroscope. When two or more smears showed acid-base staining, the sample was defined as positive. In addition, the questionnaire submitted to the patients also included the risk factors for tuberculosis to which they were exposed, *i.e.* smoking, patients who had already received anti-tuberculosis treatment, HIV infection, asthma, nutritional status, and alcohol consumption.

2.3.4. Clinical Symptoms of Tuberculosis

Clinical symptoms of tuberculosis such as chest pain, fever, cough, duration of cough, and night sweats were observed in some patients in the study.

2.4. Data Analysis

Entered in a Microsoft Excel 2016 format, the data were then analysed using R software version 3.6.1, including the measurement of rates to determine risk factors associated with TB prevalence. A 95% confidence interval was estimated and a $p \leq 0.05$ value was considered statistically significant. Crude odds ratios (ORs), and adjusted odds ratios (AORs) to a 95% confidence interval (95% CI), were calculated for each risk factor variable. A p-value ≤ 0.05 was considered statistically significant.

2.5. Ethical Considerations

The study obtained authorisation from the South-East Regional Director of Health, by letter No. 0345/PHO/SG/DRSSE/SGP/D, and endorsement from the managers of the University Hospital Centre of Franceville (CHUF). The data collected did not include patient identities or personal information. Patients' anonymity was guaranteed, to avoid any stigmatization.

3. Results

3.1. Sociodemographic Characteristics of Study Patients

A total of 309 patients were included in this study. Of these, 50.81% (n = 157) were men and 49.19% (n = 152) were women. It was found that 55.66% (n = 172) were aged between 15 and 49 years, followed by the ≥50 years age group with 26.53% (n = 82). The remainder (n = 55, *i.e.* 17.08%) were in the 1 to 4 years and 0 to 11 months age groups. The mean age of the respondents in this study was 43.31 years (mean standard deviation = 20.21). Regarding the marital status of the study population, 44.01% (n = 136) of respondents were single and 22.65% (n = 70) were divorced. The majority (n = 189; 61.17%) of respondents lived in urban areas (in Franceville) and 38.84% (n = 120) lived in rural areas in the surrounding departments. 27.51% (n = 85) were unemployed, followed by 23.95% (n = 74) civil servants, 18.77% (n = 58) pensioners and 18.12% (n = 56) housewives. Only 45.31% (n = 140) of the patients were illiterate, but 29.13% (n = 90) had completed secondary school and 8.41% university. 138 patients (44.66%)

lived in large families of 6 or more people. Monthly income was high for only 13.26% of patients (Table 1).

3.2. Prevalence of Tuberculosis in Study Patients

Of 309 sputum samples from adults or gastric fluid samples from children in the

Table 1. Socio-demographic characteristics of study patients.

Characteristics		Frequencies	Percentages (%)
Age	0 - 11 months	5	1.62
	1 - 4 years	22	7.12
	5 - 14 years	28	9.07
	15 - 49 years	172	55.66
	≥ 50 years	82	26.53
Gender	Male	157	50.81
	Female	152	49.19
Marital status	Married	58	18.77
	Single	136	44.01
	Divorced	70	22.65
	Widowed	45	14.57
Professional status	Civil servant	74	23.95
	Unemployed	85	27.51
	blue-collar worker	36	11.65
	Housewife	56	18.12
	Retired	58	18.77
Educational level	Illiterate	140	45.31
	Primary	53	17.15
	Secondary	90	29.13
	University	26	8.41
Residence place	Urbain	189	61.17
	Rural	120	38.84
Number of people living in the family	1 - 3	75	24.28
	4 - 5	96	31.06
	≥6	138	44.66
Monthly income	≤50,000 CFA Francs	203	65.7
	≤100,000 Francs CFA	65	21.04
	≥200,000 CFA Francs	41	13.26

CFA = African Financial Community; 1 US Dollar = 607.74 CFA Franc.

study, 98 samples, giving an overall prevalence rate of 31.72% (95% CI: [0.26 - 0.26]), were positive for both diagnoses of pulmonary tuberculosis. There were 40 females or 40.82% (95% CI: [0.30 - 0.51]) and 58 males or 59.18% (95% CI: [0.48 - 0.69]). The most infected age group was between 15 and 49, with 38 patients or 19.74% (95% CI: [0.29 - 0.49]).

3.3. Prevalence of Tuberculosis According to Risk Factors and Clinical Signs Observed in Study Patients

A univariate analysis of tuberculosis prevalence according to risk factors and clinical signs observed in study patients indicated that, patients in the 5 - 14 age group (OR = 3. 24; 95% CI: [1.47, 7.15] p = 0.002*), 15 and 49 years (OR = 0.36; 95% CI: [0.22; 0.59] p < 0.001*), male (OR = 1.64; 95% CI: [1.01, 2.66] p = 0.045*), who smoked (OR = 1. 75; 95% CI: [1.03; 2.91] p = 0.03*), who consumed alcohol (OR = 3.62; 95% CI: [2.11; 6.22] p = 0.001*), with asthma history (OR = 5.71; 95% CI: [2.39, 13. 66] p < 0.001), having previously received anti-tuberculosis treatment (OR = 2.57; 95% CI: [[1.24, 5.33] p = 0.006*) and being HIV-infected (OR = 3.2; 95% CI: [1.87, 5.51] p < 0.001) had a very high probability of being tuberculosis patients. Similarly, patients with clinical symptoms such as cough (OR = 7.53; 95% CI: [4.19, 13.54]) p < 0.001, chest pain (OR = 62.81; 95% CI: [29.07: 135. 72] p < 0.001), fever (OR = 21.1; 95% CI: [10.62, 42.2] p < 0.001), and night sweats (OR = 13.24; 95% CI: [7.36: 23.82] p < 0.001), were at high risk of tuberculosis infection (**Table 2**).

3.4. Multivariate Analysis of the Prevalence of Tuberculosis, According to the Risk Factors and Clinics Observed in the Study Patients

An in-depth analysis of the prevalence of tuberculosis, according to the risk factors and clinics observed in the patients in the study, indicated that the age group 15 and 49 years (Adjusted OR = 47.77; 95% CI: [4. 4; 519.7] p = 0.001*), fever (Adjusted OR = 4.83; 95% CI: [1.16, 20.12] p = 0.031*), alcohol consumption (Adjusted OR = 12.2; 95% CI: 12.2 [2.5; 5.9] p = 0. 002*), smoking (Adjusted OR = 9.83; 95% CI: [1.78; 54.24] p = 0.037), HIV infection (Adjusted OR = 4.63; 95% CI: [1.25; 17.1] p = 0.022), cough (Adjusted OR = 4.31; 95% CI: [1.21, 15.4] p = 0. 025*), chest pain (Adjusted OR = 103.6; 95% CI: [19.4; 55.2] p = 0.000), night sweating cough (Adjusted OR = 10.84; 95% CI: [3.18; 36.98] p = 0.000*) were potential risk factors for tuberculosis in the present study (**Table 3**).

4. Discussion

Although the recent WHO report on tuberculosis indicated that the prevalence of this disease has declined worldwide, we are far from achieving a world without tuberculosis, even by 2050 [19]. The present study indicated a global prevalence of 31.72%. Confirming Gabon's position in the zone of 300 or more cases of tuberculosis per 100,000 inhabitants worldwide [20], this result is comparable to that of an earlier study carried out in Ethiopia, which found a prevalence of

Table 2. Univariate analysis of tuberculosis prevalence according to risk factors and clinical signs observed in study patients.

Risk factors and clinical signs		Status of pulmonary tuberculosis		Univariate analysis	
		Positive [N (%)]	Negative [N (%)]	OR [IC95%]	p-value
Age	0 - 11 months	1 (20)	4 (80)	Ref	
	1 - 4 years	10 (45.45)	12 (54.55)	1.88 [0.78; 4.51]	0.15
	5 - 14 years	16 (57.14)	12 (42.86)	3.24 [1.47; 7.15]	0.002*
	15 - 49 years ans	38 (22.1)	134 (77.9)	0.36 [0.22; 0.59]	<0.001*
	≥50 years	33 (40.24)	49 (59.76)	1.68 [0.99; 2.85]	0.053
Gender	Male	58 (36.94)	99 (63,06)	1.64 [1.01; 2.66]	0.045*
	Masculin	40 (26.32)	112(73,68)	Ref	
Smoking	Yes	38 (40,43)	56 (59.57)	1.75 [1.03; 2.91]	0.03*
	No	60(27,91))	155 (72.09)	Ref	
Alcohol consumption	Yes	41 (53.95)	35 (46.05)	3.62 [2.11; 6.22]	0.001*
	No	57 (24.46)	176 (75.54)	Ref	
History of asthma	Yes	18 (69.23)	8 (30.77)	5.71 [2.39; 13.66]	<0.001*
	No	80 (28.27)	203 (71.73)	Ref	
Nutritional status	Très bon	21 (30)	49 (70)	Ref	
	Bon	47 (31.54)	102 (68.46)	0.98 [0.61; 1.58]	0.95
	Pas bon	30 (33.33)	60 (66.67)	0.74 [0.41; 1.32]	0.69
Patient previously treated with anti-tuberculosis drugs	Yes	17 (53.12)	15(46.88)	2.57 [1.24; 5.33]	0.006*
	No	81(29.24)	196 (70.76)	Ref	-
Presence of tuberculosis in the family	Yes	22 (41.51)	31 (58.49)	1.68 [0.91; 3.09]	0.092
	No	31 (31.31)	68 (68.69)	Ref	
	inconnu	45 (28.66)	112 (71.34)	0.75 [0.46; 1.21]	0.241
HIV infection	Yes	39 (52)	36 (48)	3.2 [1.87; 5.51]	<0.001*
	No	59 (25.21)	175 (74.79)	Ref	-
Cough	Yes	47 (67.14)	23 (28.86)	7.53 [4.19; 13.54]	<0.001*
	No	51 (21.34)	188 (78.66)	Ref	
Duration of cough	1 week	26 (31.33)	57 (68.67)	0.98 [0.57; 1.68]	0.605
	≥2 weeks	72 (31.86)	154 (68.14)	Ref	
Chest pain	Yes	76 (87.36)	11 (12.64)	62.81 [29.07; 135.72]	<0.001*
	No	22 (9.91)	200 (90.09)	Ref	
Fever	Yes	57 (81.84)	13 (18.18)	21.1 [10.62; 42.2]	<0.001*
	No	41(17.15)	198 (82.85)	Ref	
Nocturnal sweating	Yes	78 (61.90)	48 (38.1)	13.24 [7.36; 23.82]	<0.001*
	No	20 (10.93)	163 (89.07)	Ref	

OR = odds ratio; CI = confidence interval; * = significant test.

Table 3. Multivariate logistic regression analysis of tuberculosis prevalence as a function of risk factors associated with tuberculosis and clinical symptoms observed in study patients.

Risk factors and clinical signs observed in study patients		Prevalence of pulmonary tuberculosis		Multivariate analysis	
		Positive [N (%)]	Negative [N (%)]	Adjusted OR [IC95%]	p-value
Age	5 - 14 years	16 (57.14)	12 (42.86)	-	-
	15 - 49 years	38 (22.1)	134 (77.9)	47.77 [4.4; 519.7]	0.001*
Gender	Male	58 (36.94)	99 (63.06)	1.04 [0.33; 3.4]	0.94
	Female	40 (26.32)	112(73.68)	1	-
Fever	Yes	57 (81.84)	13 (18.16)	4.83 [1.16; 20.12]	0.031*
	No	41 (17.15)	198 (82.85)	1	-
Alcohol consumption	Yes	41 (53.96)	35 (46.05)	12.2 [2.5; 5.9]	0.002*
	No	57 (24.46)	176 (75.54)	1	-
History of asthma	Oui	18 (69.23)	8 (30.77)	1.21 [0.16; 16.6]	0.85
	Non	80 (28.27)	203 (71.73)	1	-
Patient previously treated with anti-tuberculosis drugs	Oui	17 (29.77)	15	2.2 [0.3; 17]	0.45
	Non	81(33.33)	196 (66.67)	1	-
HIV infection	Oui	89 (72.36)	36 (27.64)	4.63 [1.25; 17.1]	0.022*
	Non	9 (4.91)	175 (95.09)	1	-
Cough	Oui	47 (67.14)	23 (28.86)	4.31 [1.21; 15.4]	0.025*
	Non	51 (21.34	188 (78.66)	1	-
Chest pain	Oui	76 (87.36)	11 (12.64)	103.6 [19.4; 55.2]	0.000*
	Non	22 (9.91)	200 (90.09)	-	
Smoking	Oui	38 (40.43)	56 (59.57)	9.83 [1.78; 54.24]	0.009*
	Non	60 (27.91)	155 (72.09)	1	-
Nocturnal sweating	Oui	78 (61.90)	48 (38.1)	10.84 [3.18; 36.98]	0.000*
	Non	20 (10.93)	163 (9.07)	1	-

OR = odds ratio; CI = confidence interval; * = significant test.

33% [21]. It is well above those found in Central African Republic 10.99%, East Amhara, Ethiopia: 2015-2019 which was 11%, South Africa 13% [22] [23] [24].. However, it is well below those obtained in other studies, carried out in other African countries such as Congo, 79.1% [25], Togo, 57% [26]. The variability of these results could be due not only to the different diagnostic methods used in each study, but also to the quality of the participants in the different studies, the study period, the sample size, the geographical location and the differences in the methods and practices put in place for tuberculosis control in each region or country. The high prevalence of tuberculosis in the present study could be due to the multiple screening awareness campaigns promoted by the PNLT. As a result, the majority of study participants (33.33%) were newly infected patients (who

had never taken anti-tuberculosis treatment). Contrary to the results obtained in studies which indicated that the age groups most affected by pulmonary tuberculosis were those aged 21 - 30 (28.24%) and 31 - 40 (26.55%) [27], a univariate and then multivariate analysis indicated that the prevalence of pulmonary tuberculosis was statistically associated with patients in the 15 - 49 age group. In line with studies carried out in many countries that have shown a predominance of tuberculosis in young adults [28], this result can be justified by the fact that, with a mean age of 43.31 ± 20.21 years, the patients in the present study were relatively young adults. Socially and economically active, they represent a period of life that is unfortunately often conducive to numerous infections, including that caused by Koch's *bacillus*, the causative agent of tuberculosis [29]. Just as fever was reported in 60% - 85% of patients with pulmonary tuberculosis in a study elsewhere [30], the present study indicated that fever was statistically associated with the disease. This corroborates well with the fact that generally, every case of active pulmonary tuberculosis presents some degree of pyrexia, which is one of the important signs of tuberculosis activity [31]. In contrast to studies such as Arnould, which denied the etiological influence of alcoholism on tuberculosis [32], alcohol consumption was shown to be significantly associated with tuberculosis in the present study. This is in line with a study carried out in France, in which it was stated that most tuberculosis sufferers were alcoholics, and that tuberculosis and alcoholism constituted a serious morbid couple [33]. In addition, in vivo and in vitro studies have shown that alcohol consumption considerably disrupts the immune response, increasing susceptibility to respiratory diseases such as tuberculosis [34]. Despite the opinion of some systematic reviews and meta-analyses of observational studies that have shown an unfavourable association between global epidemics of tuberculosis and smoking [35], smoking was associated with pulmonary tuberculosis in the present study. This finding corroborates the fact that both passive and active exposure to cigarette smoke are associated with an increased risk of developing active tuberculosis and with mortality from this disease [9]. In line with the literature according to which HIV infection is accompanied by an immune deficiency, which favors the occurrence of numerous opportunistic infections including tuberculosis, it was indicated in the present study that HIV infection was significantly associated with tuberculosis and presented an increased risk of active tuberculosis [36]. This may also be justified by the fact that in Gabon, Koula-Moutou is a town with a high rate of HIV cases [37]. Cough and chest pain were significantly associated with the prevalence of pulmonary tuberculosis in this study. This result is similar to that found in a study in the Central African Republic, where the most frequent functional signs were chronic cough (71.81%) and chest pain in 127 cases (57.73%) [38]. This could be explained by the fact that our patients came to the clinic very late. As in a study which reported that TB patients present with symptoms, in particular weight loss, fever, dyspnoea and night sweats [38], night sweats were significantly associated with pulmonary TB in the present study. This may be justified by the fact that TB symptoms can vary from patient to pa-

tient, but a few key signs are generally associated with the disease. Sweating profusely at night is one of them, and often indicates that the body's infection levels are potentially very high.

5. Study Limitations

Stemming solely from a hospital-based analysis of patients infected with pulmonary tuberculosis, the results of the present study may not be generalizable. Having used only Ziehl-Neelsen smear microscopy and the Xpert MTB/RIF test, the use of a chest X-ray, as a complementary diagnostic tool for all HIV-infected individuals, would have avoided missing certain cases of tuberculosis. In addition, the culture technique and CD4 assay were not performed due to limited laboratory facilities.

6. Conclusion

The present study has established that the prevalence of tuberculosis is predominant among males in the 15 to 49 age group in Franceville and surrounding departments. Many risk factors and clinical signs were significantly associated with tuberculosis in the present study. This suggests possible gaps in symptom-based case-finding that may need to be addressed in similar settings. Therefore, TB screening of HIV-positive patients, public awareness and community mobilization should be encouraged. In addition, large-scale studies on trends in TB/HIV co-infection and associated factors should also be implemented throughout the country.

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Authors' Contributions

All authors contributed equally to this work. They have read and appreciated the final version of this manuscript.

Informed Consent

Informed verbal consent was obtained from each study participant.

Conflicts of Interest

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

References

[1] Baykan, A.H., Sayiner, H.S., Aydin, E., Koc, M., Inan, I. and Erturk, S.M. (2022) Extrapulmonary Tuberculosıs: An Old but Resurgent Problem. *Insights into Imag-*

ing, **13**, Article No. 39. https://doi.org/10.1186/s13244-022-01172-0

[2] WHO (2022) How Tuberculosis Infections and Deaths Increased during the COVID-19 Africa Renewal Pandemic.

[3] Bloom, B.R., Atun, R., Cohen, T., *et al.* (2017) Tuberculosis. In: Holmes, K.K., Bertozzi, S., Bloom, B.R., *et al.*, Eds., *Major Infectious Diseases*, 3rd Edition, Chapter 11, The International Bank for Reconstruction and Development/The World Bank, Washington DC. https://www.ncbi.nlm.nih.gov/books/NBK525174/

[4] Alemu, A., Wubie Aycheh, M. and Dilnessa, T. (2021) Tuberculosis and Human Immunodeficiency Virus Co-Infection and Associated Factors at Debre Markos Comprehensive Specialized Hospital, Northwest Ethiopia: A Four-Year Retrospective Study. *HIV/AIDS—Research and Palliative Care*, **13**, 293-299. https://doi.org/10.2147/HIV.S284034

[5] Knight, G.M., McQuaid, C.F., Dodd, P.J. and Houben, R.M.G.J. (2019) Global Burden of Latent Multidrug-Resistant Tuberculosis: Trends and Estimates Based on Mathematical Modelling. *The Lancet Infectious Diseases*, **19**, 903-912. https://doi.org/10.1016/S1473-3099(19)30307-X

[6] Chen, Q., Yu, S., Rui, J., Guo, Y., Yang, S., Abudurusuli, G., Yang, Z., Liu, C., Luo, L., Wang, M., Lei, Z., Zhao, Q., Gavotte, L., Niu, Y., Frutos, R. and Chen, T. (2022) Transmissibility of Tuberculosis among Students and Non-Students: An Occupational-Specific Mathematical Modelling. *Infectious Diseases of Poverty*, **11**, Article No. 117. https://doi.org/10.1186/s40249-022-01046-z

[7] Abubakar, I., Zignol, M., Falzon, D., Raviglione, M., Ditiu, L., Masham, S., Adetifa, I., Ford, N., Cox, H., Lawn, S.D., Marais, B.J., McHugh, T.D., Mwaba, P., Bates, M., Lipman, M., Zijenah, L., Logan, S., McChesney, R., Zumla, A., Sarda, K., Nahid, P., Hoelscher, M., Pletschette, M., Memish, Z.A., Kim, P., Hafner, R., Cole, S., Migliori, G.B., Maeurer, M., Schito, M. and Zumla, A. (2013) Drug-Resistant Tuberculosis: Time for Visionary Political Leadership. *The Lancet Infectious Diseases*, **13**, 529-539. https://doi.org/10.1016/S1473-3099(13)70030-6

[8] Meumann, E.M., Horan, K., Ralph, A.P., Farmer, B., Globan, M., Stephenson, E., Popple, T., Boyd, R., Kaestli, M., Seemann, T., Vandelannoote, K., Lowbridge, C., Baird, R.W., Stinear, T.P., Williamson, D.A., Currie, B.J. and Krause, V.L. (2021) Tuberculosis in Australia's Tropical North: A Population-Based Genomic Epidemiological Study. *The Lancet Regional Health—Western Pacific*, **15**, Article ID: 100229. https://doi.org/10.1016/j.lanwpc.2021.100229

[9] Silva, D.R., Muñoz-Torrico, M., Duarte, R., Galvão, T., Bonini, E.H., Arbex, F.F., Arbex, M.A., Augusto, V.M., Rabahi, M.F. and Mello, F.C.Q. (2018) Risk Factors for Tuberculosis: Diabetes, Smoking, Alcohol Use, and the Use of Other Drugs. *Jornal Brasileiro de Pneumologia*, **44**, 145-152. https://doi.org/10.1590/s1806-37562017000000443

[10] Adegbite, B.R., Edoa, J.R., Agbo Achimi Abdul, J., Epola, M., Mevyann, C., Dejon-Agobé, J.C., Zinsou, J.F., Honkpehedji, Y.J., Mpagama, S.G., Alabi, A.S., Kremsner, P.G., Klipstein-Grobusch, K., Adegnika, A.A. and Grobusch, M.P. (2022) Non-Communicable Disease CO-Morbidity and Associated Factors in Tuberculosis Patients: A Cross-Sectional Study in Gabon. *EClinicalMedicine*, **45**, Article ID: 101316. https://doi.org/10.1016/j.eclinm.2022.101316

[11] Ranking of States by Incidence of Tuberculosis (per 100,000 Inhabitants). https://atlasocio.com/classements/sante/maladies/classement-etats-par-incidence-tuberculose-monde.php

[12] Mussavu, A.-I. (2021) Gabon Fine-Tunes Its 2021-2025 Strategic Plan According to

Gabon Review Time Journalist.
https://www.gabonreview.com/tuberculose-le-gabon-peaufine-son-plan-strategique-2021-2025/

[13] Mba, T.N., Obiang, C.S., Moundounga, H.K., N'Nang, E.O., Meye, B., Mba, I., *et al.* (2021) Epidemiological and Clinical Profile of HIV/TB Co-Infected Patients in Two Departments of the Ngounié Province in South of Gabon. *International Journal of Innovation Scientific Research and Review*, **3**, 1489-1493.

[14] Daniel, W.W. (2009) Biostatistics a Foundation for Analysis in the Health Science. 9th Edition, John Willey and Sons Inc., New York.

[15] Tadesse, G. (2005) The Prevalence of Intestinal Helminthic Infections and Associated Risk Factors Among School Children in Babile Town, Eastern Ethiopia. *The Ethiopian Journal of Health Development*, **19**, 140-147.
https://doi.org/10.4314/ejhd.v19i2.9983

[16] Sitotaw, B., Mekuriaw, H. and Damtie, D. (2019) Prevalence of Intestinal Parasitic Infections and Associated Risk Factors among Jawi Primary School Children, Jawi Town, North-West Ethiopia. *BMC Infectious Diseases*, **19**, Article No. 341.
https://doi.org/10.1186/s12879-019-3971-x

[17] Kombila, U.D., Ibinga, L.D., Mounguengui, D., Manomba Boulingui, C. and Boguikouma, J.B. (2012) Epidemiological and Evolutionary Profile of Tuberculosis under the Influence Og HIV. *Revue des Maladies Respiratoires*, **39**, 1-7.
https://doi.org/10.1016/j.rmr.2021.10.003

[18] Cepheid (2012) GeneXpert Dx System. Users' Manual.

[19] Geleta, D.A., Megerssa, Y.C., Gudeta, A.N., Akalu, G.T., Debele, M.T. and Tulu, K.D. (2015) Xpert MTB/RIF Assay for Diagnosis of Pulmonary Tuberculosis in Sputum Specimens in Remote Health Care Facility. *BMC Microbiology*, **15**, Article No. 220. https://doi.org/10.1186/s12866-015-0566-6

[20] Yu, S., Ma, J. and Jia, Z. (2020) Estimating the Incidence of Tuberculosis—Shanghai, China, 2025-2050. *China CDC Weekly*, **2**, 995-998.
https://doi.org/10.46234/ccdcw2020.266

[21] Ravigliore, M.C. and O'Brien, R.J. (2008) Harrison's Principles of Internal Medicine. 17th Edition, McGraw-Hill Societies, New York.

[22] Mulisa, G., Workneh, T., Hordofa, N., Suaudi, M., Abebe, G. and Jarso, G. (2015) Multidrug-Resistant *Mycobacterium tuberculosis* and Associated Risk Factors in Oromia Region of Ethiopia. *International Journal of Infectious Diseases*, **39**, 57-61.
https://doi.org/10.1016/j.ijid.2015.08.013

[23] Tékpa, G., Fikouma, V., Téngothi, R.M.M., Longo, J.D., Woyengba, A.P.A. and Koffi, B. (2019) Epidemiological and Clinical Features of Tuberculosis at the Hôpital de l'Amitié in Bangui. *Pan African Medical Journal*, **33**, Article 31. (In French)
https://doi.org/10.11604/pamj.2019.33.31.13442

[24] Wasihun, A.G., Hailu, G.G. and Dejene, T.A. (2021) Prevalence of *Mycobacterium tuberculosis* (Rifampicin-Resistant MTB) and Associated Risk Actors among Pulmonary Presumptive TB Patients in Eastern Amhara, Ethiopia: 2015-2019. *Infectious Diseases and Therapy*, **10**, 1299-1308.
https://doi.org/10.1007/s40121-020-00368-5

[25] Nicol, M.P., Workman, L., Isaacs, W., Munro, J., Black, F., Eley, B., *et al.* (2014) Accuracy of the Xpert MTB/RIF Test for the Diagnosis of Pulmonary Tuberculosis in Children Admitted to Hospital in Cape Town, South Africa: A Descriptive Study. *The Lancet Infectious Diseases*, **11**, 819-824.
https://doi.org/10.1016/S1473-3099(11)70167-0

[26] Farra, A., Manirakiza, A., Yambiyo, B.M., Zandanga, G., Lokoti, B., Berlioz-Arthaud. A., *et al.* (2019) Surveillance of Rifampicin Resistance with GeneXpert MTB/RIF in the National Reference Laboratory for Tuberculosis at the Institut Pasteur in Bangui, 2015-2017. *Open Forum Infectious Diseases*, **6**, 2015-2017. https://doi.org/10.1093/ofid/ofz075

[27] Dagnra, A.Y., Mlaga, K.D., Adjoh, K., Kadanga, E., Disse, K. and Adekambi, T. (2015) Prevalence of Multidrug-Resistant Tuberculosis Cases Among HIV-Positive and HIV-Negative Patients Eligible for Retreatment Regimen in Togo Using GeneXpert MTB/RIF. *New Microbes and New Infections*, **8**, 24-27. https://doi.org/10.1016/j.nmni.2015.09.001

[28] Boulahbal, F. and Chaulet, P. (2004) Tuberculosis in Africa: Epidemiology and Control Measures. *Medecine Tropicale*, **64**, 224-288. (In French)

[29] Kinde-Gazard, D., Anagonou, Y.S., Gninafon, M., Tawo, L. and Josse, R. (1997) Cervical Adenopathies of Tuberculous Origin: Epidemiological, Diagnostic and Therapeutic Aspects at the National Hospital Center of Pneumo-Phtisiology of Cotonou. *Médecine d'Afrique Noire*, **44**, 90-94. (In French)

[30] Kiblawi, S.S.O., Say, S.J., Stondrill, R.B. and Norton, J. (1981) Fever Response of Patients on Therapy for Pulmonary Tuberculosis. *American Review of Respiratory Disease*, **123**, 20-24.

[31] Barnes, P.F., Chan, L.S. and Wong, S.F. (1987) The Course of Fever during Treatment of Pulmonary Tuberculosis. *Tubercle*, **68**, 255-260.

[32] Institut National d'Études Démographiques (1953) Publication of "Concours Medical".

[33] Ledermann, S. (1954) Alcoolisme et tuberculose pulmonaire [Alcoholism and Pulmonary Tuberculosis]. *Population*, **9**, 139-140. https://www.persee.fr/doc/pop_0032-4663_1954_num_9_1_3409 https://doi.org/10.2307/1525378

[34] Molina, P.E., Happel, K.I., Zhang, P., Kolls, J.K. and Nelson, S. (2010) Focus on: Alcohol and the Immune System. *Alcohol Research & Health*, **33**, 97-108.

[35] Bates, M.N., Khalakdina, A., Pai, M., Chang, L., Lessa, F. and Smith, K.R. (2007) Risk of Tuberculosis from Exposure to Tobacco Smoke: A Systematic Review and Meta-Analysis. *Archives of Internal Medicine*, **167**, 335-342. https://doi.org/10.1001/archinte.167.4.335

[36] Parashar, S., Collins, A.B., Montaner, J.S., Hogg, R.S. and Milloy, M.J. (2016) Reducing Rates of Preventable HIV/AIDS-Associated Mortality among People Living with HIV Who Inject Drugs. *Current Opinion in HIV and AIDS*, **11**, 507-513. https://doi.org/10.1097/COH.0000000000000297

[37] Biyang, Y.V.S., Parkouda, S., Bivigou-Mboumba, B., Iroungou, B.A., Ondeme, A.M. and Bisseye, C. (2022) Evaluation of HIV-1 Rapid Diagnostic Tests in the Context of Viral Genetic Diversity in Libreville (Gabon). *Pan African Medical Journal*, **42**, Article 194.

[38] Dooley, K.E. and Chaisson, R.E. (2009) Tuberculosis and Diabetes Mellitus: Convergence of Two Epidemics. *The Lancet Infectious Diseases*, **9**, 737-746. https://doi.org/10.1016/S1473-3099(09)70282-8