

Research



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Difficulties in eradicating tuberculosis in the central prison of Pointe Noire, Republic of Congo

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Abstract

Introduction: tuberculosis (TB) is a serious infectious disease, and its control is considered a challenge, particularly among vulnerable populations such as prisoners. The presence of TB in prisons is a persistent scourge. This article aims to describe the epidemiology of tuberculosis in Congolese prisons. **Methods:** this is a one-year cross-sectional study from February 17, 2024, to February 24, 2025, at the Pointe-Noire central prison. A questionnaire was used to collect sociodemographic and epidemiological data. We carried out systematic screening for TBC. Diagnosis was based on PCR analysis of sputum. **Results:** the mean age was 30.45 ± 11.32 , with extremes ranging from 14 to 71 years. 98% of our patients were male. We identified 30 cases of TBC, i.e., 2.40% of the 1249 inmates screened, all of them pulmonary TBC. Eighty-six point sixty-seven percent (86.67%) were symptomatic and 13.33% asymptomatic on clinical examination, with a case-fatality rate of 23.3%. **Conclusion:** the average cumulative incidence rate was 6.5 times higher than in the general Congolese population. TB in prisons is a public health problem in the tropics, and systematic screening for TB should be instituted.

Introduction

Tuberculosis is an infectious disease caused by *Mycobacterium tuberculosis* (Mtb) that mainly affects the lungs, although it can also affect other organs. It remains one of the world's ten leading causes of death, particularly in developing countries where prevalence is particularly high, with 10.6 million cases of active tuberculosis in 2022, including 2.6 million in Africa, and 13511 new cases of tuberculosis in the Congo [1]. In sub-Saharan Africa, prisons are high-risk environments

for TB transmission due to overcrowded conditions, poor ventilation, unsanitary conditions, and a lack of adequate medical care. Poor living conditions and inefficient health services in prisons are fertile ground for Mtb bacteria. The spread of tuberculosis among prisoners, prison staff, and visitors has become a threat to the control efforts of national tuberculosis programs. Accurate data needed to develop appropriate interventions to tackle the worrying problem of TB in African prisons is scarce and unreliable. Prisoner health is, by default, a neglected policy issue [2]

The Republic of Congo, one of the most affected countries in the world, ranks 6th in Africa [3,4]. It faces a high burden of tuberculosis [5], with prisons representing a favorable environment for the spread of this disease. According to the World Health Organization (2010) [6], prisons are often hotbeds of TB transmission, complicating eradication efforts in these settings. Despite public health efforts, obstacles such as low socio-economic status, stigmatization of patients, previous contact with TB patients, low body mass index, and difficulty of access to adequate treatment remain major challenges. Prisons are regulated but not closed systems, due to the number of people constantly entering, leaving, and returning. Consequently, prison health is an essential element of public health, as health problems inside and outside prisons are interdependent [7]. This study aims to determine the incidence of TB and to highlight the challenges and difficulties encountered in the fight against tuberculosis in Congolese prisons, through a survey of inmates. In particular, the study analyzes the effectiveness of screening and diagnostic methods used, as well as the obstacles to eradicating the disease in this context.

Methods

Type and period of study: this was a descriptive cross-sectional study with prospective data collection, conducted from February 17, 2024, to February 24, 2025, under the auspices of the

Pointe-Noire Departmental Directorate of Health Care and Services, with support from Perenco-Congo.

Population and study sites: a total of 1249 inmates were screened for tuberculosis at the Pointe Noire prison infirmary. The *Laboratoire de Biologie Moléculaire of the Clinique Médicale Guenin* in Pointe noire performed PCR analyses.

Inclusion and non-inclusion criteria: all inmates were included in the study. Inclusion criteria were based on inmate availability and informed consent to participate in the study.

Clinical survey: data such as age, sex, and symptoms were collected using a survey form.

Biological survey: laboratory analyses were carried out in the *Laboratoire de Biologie Moléculaire of the Clinique Médicale Guenin* in Pointe noire.

Sampling: before starting, we prepared the patient by explaining the procedure. Sputum collection requires the patient's active cooperation. We explained that the aim was to collect sputum from the lungs, as this contains the bacteria responsible for tuberculosis if the patient is infected. That he should spit deeply to produce sputum directly from the lungs, not just saliva. Avoid collecting saliva alone, as this will not provide a representative sample for diagnosis. And these steps were followed to the letter.

Equipment used: i) a sterile sputum collection vessel (plastic spittoons with tight-fitting lids to prevent contamination); ii) protective mask: the patient wore a mask during sputum collection to reduce the spread of airborne tuberculosis; iii) staff hygiene and safety: staff wore disposable gloves and an N95 mask to avoid exposure to potentially infectious aerosols; iv) a clean, well-ventilated environment, ideally outside the infirmary, was used for operations.

Collection procedure: sputum collection. 1) Patient preparation: i) the patient was made comfortable in a well-ventilated area; ii) the patient was asked to rest for a few minutes to allow sputum to accumulate in the lungs; iii) we explained to the patient that he should cough deeply to obtain sputum from the lower respiratory tract, not just saliva. 2) Sputum instructions: i) we asked the patient to rinse his mouth with clear water before starting to eliminate any contamination of the mouth or teeth, as saliva could falsify the test; ii) the patient was then asked to inhale deeply to expel air, and to cough in a controlled manner to expel sputum from the bronchi and lungs; iii) when the patient coughed, he spat directly into the sterile container; iv) collection was carried out two or three times to obtain a representative sample. 3) Sample conditioning: i) sputum was collected in a clean, hermetically sealed container. ii) the container was labeled with the patient's name, date, time of collection, and other relevant identifying information. 4) Transmission of sample to laboratory: the sample was transported quickly, placed in a refrigerated cooler, and then forwarded to the laboratory to avoid any possible decline in sample quality.

Molecular analysis

Extractions: we extracted DNA from the sputum using the PureLink® Microbiome DNA Purification Kit according to the manufacturer's recommendations.

Amplification: the extracted DNA underwent RT-PCR using the Mycobacterium tuberculosis TaqMan PCR Kit DX.

Procedure: 1) the first step consisted of preparing the Mix according to the following protocol: i) 10 µl MDx TaqMan 2X PCR Master Mix; ii) 02 µl *M. tuberculosis* primer/probe; iii) 03 µl nuclease-free water; iv) 05 µl DNA. 2) The second step was to program the Mic (thermal cycler) according to the data in Table 1. The targets selected were FAM for *Mycobacterium tuberculosis* and HEX for internal

control. The PCR lasted only 1 hour, 5 minutes, and 30 seconds. 3) The third step was to interpret the results in relation to the information in Table 2.

Statistical analyses: categorical data are expressed as headcounts (percentages) and quantitative variables as means $\pm$ standard deviation. All analyses were carried out using SPSS software (version 26.0; IBM).

Ethical considerations: this study was conducted in accordance with good clinical practice, the principles of the Declaration of Helsinki (October 2008 version), and Congolese legislation (law on medical research involving human subjects and law on the protection of personal data). No subjects were included without prior agreement and informed consent. Analyses were free of charge for all subjects included in the study.

Results

Sociodemographic data: the study population consisted of 1249 subjects, 98% of whom were male and 02% female (Table 3). The mean age was 30.45 ± 11.32 with extremes ranging from 14 to 71 years, and the most represented age group was 20-40 with a proportion of 64.8%.

Incidence of mycobacterium tuberculosis infection: the average cumulative incidence rate was 25 per 1249 inmates. More than half the cases diagnosed (86.67%) were contagious; 13.33% were asymptomatic on clinical examination (Table 4).

Distribution of cases of death and survival among prisoners tested positive for tuberculosis: the mortality rate among infected subjects was 23.3%, while the survival rate was 76.7% (Table 5).

Aggravating factors for tuberculosis among TB infection positives: the most frequently reported aggravating factors among patients in Table 6 were delayed diagnosis (86.02%), overcrowding (100%), and poor hygiene (100%).

Discussion

Ending the tuberculosis epidemic by 2030 is one of the health-related targets of the United Nations' Sustainable Development Goals. However, there are still many challenges to overcome in the face of a disease that killed a total of 1.25 million people in 2023 (161,000 of whom were also infected with HIV). Globally, tuberculosis has once again become the leading cause of death due to a single infectious agent, whereas coronavirus 2019 (COVID-19) held this position for the previous three years. Tuberculosis is also the leading cause of death among people living with HIV, and one of the main causes of death linked to antimicrobial resistance [8]. Our study aimed to describe the epidemiology of tuberculosis and strategies for controlling this disease in Congolese prisons.

The results of this study carried out among prisoners in Pointe-Noire reveal a worrying situation. The cumulative incidence of tuberculosis among prisoners (30 new cases out of 1249 inmates, i.e., 2.40% of the prison population tested) is significantly higher than the national incidence, estimated at 368 cases per 100,000 inhabitants in the general Congolese population [8]. In comparison, the incidence rate in the prison population is 6.5 times higher than the national incidence. The work of Murthy *et al.* 2007 in India revealed that the incidence rate of tuberculosis in prisons was 10 to 20 times higher than in the general population, attributed to overcrowding and poor living conditions. In South Africa, prevalence rates in prisons were reported to be around 5 to 10 times higher than in the general population. This was attributed to the coexistence of HIV and difficult environmental factors [9]. Several other cross-sectional studies have estimated the prevalence of TB in African prisons. Studies published in Cameroon, Zambia, and Malawi reported a relatively different prevalence, between 2.6 and 10 times that of the general population of the country concerned [10-12]. This points to a prison environment that is particularly conducive to TB

transmission. This is often due to overcrowding, insalubrity, and social isolation, all of which favor aerosolized spread of the disease [6,13]. The presence of tuberculosis in prisons is a persistent scourge. Rates among prisoners remain much higher (5 to 50 times) than national averages, in both developed and developing countries [6].

Our results showed that 86.67% of diagnosed cases were contagious. This shows that the majority of infected inmates were active and capable of transmitting the disease. Tuberculosis is mainly airborne, and the high proportion of contagious cases suggests that transmission within the prison is a major cause of the high incidence observed in this study [14]. One of the main reasons for this dynamism would be found in unsanitary and overcrowded prisons, which represent a "time bomb". Thirteen-point-three percent (13.3%) of cases were asymptomatic; a non-negligible proportion of asymptomatic cases underlines the need to screen all inmates, even those with no obvious symptoms. Asymptomatic individuals can nevertheless transmit TB, reinforcing the need for early and systematic detection in prison environments [15].

The tuberculosis case-fatality rate was high (23.3%). This mortality is almost 13.3 times higher than the national average (45 per 100,000) reported in Congo (WHO, 2024). Research carried out in various prisons around the world has shown that tuberculosis-related mortality rates vary according to the context. A study in the Democratic Republic of Congo reported a mortality rate of 17.9 deaths per 1,000 person-months, identifying malnutrition and tuberculosis as the main risk factors [16]. In Venezuela, problems of malnutrition and overcrowding have led to high mortality rates, with tuberculosis and malnutrition being the main causes of death in prison. In Russia, prison conditions have favored the spread of tuberculosis, with around 10% of inmates infected, and more than a quarter with multidrug-resistant strains [17]. These studies illustrate that risk factors and conditions specific

to each prison environment significantly influence tuberculosis mortality rates.

Risk factors among TB positives, such as limited or delayed access to care and diagnosis, HIV co-infection, and overcrowding, often aggravate the situation. Studies carried out in several countries reveal higher incidences in prisons than in the general population, due to various prison-specific factors such as promiscuity, malnutrition, psychological stress, delayed diagnosis, and limited access to care, all of which contribute to making prisons an active reservoir for TB transmission. These findings concur with those of several international studies that describe the prison environment as a priority epidemiological focus in the fight against tuberculosis [6,18]. In sum, the results of this study argue in favor of urgently strengthening screening, treatment, and post-treatment follow-up in prisons, in conjunction with the national public health system.

Conclusion

The results show that the average cumulative incidence rate was 6.5 times higher and the mortality rate around 13.3 times higher than in the general Congolese population. This study highlights the difficulties encountered in eradicating tuberculosis in prisons in the Congo. Public health policies should focus on improving the living conditions of prisoners and increasing access to healthcare, particularly concerning diagnostic tests and treatment of tuberculosis. Future studies should focus not only on individual risk factors but also on factors inherent to the general population and the prison environment, including the functioning of tuberculosis control strategies. Continued attention is required for inmates with specific risk factors for TB, such as family contact with TB, alcohol consumption, and, despite this, known HIV status.

What is known about this topic

- Tuberculosis is highly prevalent in prisons, with rates much higher than in the general population;
- Contributing factors include: overcrowding, inadequate ventilation, co-infections (HIV), poor nutrition, and late diagnosis;
- Limited access to screening and treatment is a major obstacle to eradication.

What this study adds

- It highlights the specific realities of the Pointe-Noire prison, including diagnostic delays, prevalence of TB, the rarity of bacteriological tests, and the lack of post-prison follow-up;
- It also highlights institutional barriers, such as poor coordination between the prison system and the health system;
- It proposes concrete areas for improvement tailored to the local context (strengthening screening, isolation, awareness-raising, continuity of care).

Competing interests

The authors declare no competing interests.

Authors' contributions

The group consisting of Aubierge Victoire Kimpamboudi Matondo, Freddy Saturnin Pouki, Parode Ragive Takale, and Siméon Nama, conducted the analyses and drafted the first version of the article. The group consisting of Axelle Paquet, Jery Steve Ferole Bounbou, Aladin Atandi Batchy, Christy Parfait Nganga, Luc Magloire Anicet Boumba, and Donatien Moukassa provided critical review, corrections, and scientific validation of the final content. All authors have read and approved the final version of the manuscript.

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Table 1: genesig advanced kit program

Cycles	Temperature	Temps	Step
1 cycles	95°C	3 min	Polymerase activation
40 cycles	95°C	15 sec	Denaturation
	60°C	30 sec	Hybridisation/elongation

Table 2: interpretation of results

FAM (target detection)	HEX (PCR validation)	Result
+	+	Positive
-	+	Negative
-	-	PCR inhibited

FAM: false alarm mitigation, HEX: Hexachlorofluorescein

Table 3: distribution of subjects by age group and gender

Age range	Male		Female		Total	
	N	%	N	%	N	%
<20 years	86	6.9	0	0	86	6.9
[20-40]	789	63.2	20	1.6	809	64.8
[40-60]	297	23.8	03	0.24	300	24.0
>60 years	53	4.1	01	0.08	54	4.3
Total	1225	98	24	2	1249	100

Table 4: incidence of tuberculosis

Incidence	Asymptomatic		Symptomatic		Total	
	n	%	n	%	N	%
Positive	4	13.33	26	86.67	30	100

Table 5: distribution of deaths and survival among positives

Clinical outcome	Survivors		Deaths		Total	
	n	%	n	%	N	%
	23	76.7	07	23.3	30	100

Table 6: aggravating factors for tuberculosis						
Risk factors	Yes		No		Total	
	n	%	n	%	N	%
HIV co-infection	01	3.34	29	96.66	30	100
Multidrug resistance	0	0	30	100	30	100
Malnutrition	26	89.65	4	10.35	30	100
Overcrowding	30	100	0	0	30	100
Delayed diagnosis	25	86.02	5	13.98	30	100
Lack of hygiene	30	100	0	0	30	100