

Molecular Prevalence of Pulmonary Tuberculosis in Prisons: Case of the Central Prison of Franceville

*Bourdettes Meye¹, Guy Roger Ndong Atome², Cedric Sima Obiang², Hilaire Kenguele Moundounga³, Thièry Ndong Mba^{2,3}, Dieudonné Nkoghe⁴, Joseph Privat Ondo² and Louis-Clément Obame Engonga²

¹Medical analysis laboratory of Amissa Bongo Regional Hospital Center of Franceville (CHRAB), Gabon.

²Laboratory of Research in Biochemistry (LAREBIO), University of Sciences and Techniques of Masuku (USTM) Franceville, Gabon.

³Laboratory of Molecular and Cellular Biology (LABMC) University of Science and Technology of Masuku (USTM), Franceville, Gabon.

⁴Ministry of health and social affairs

*Corresponding Author: Bourdettes Meye, Medical analysis laboratory of Amissa Bongo Regional Hospital Center of Franceville (CHRAB), Gabon

Abstract:-

Background: In Gabon, the epidemic of pulmonary tuberculosis (TB) in prisons is poorly documented. There is no official data, even though these environments meet the perfect conditions for transmission of the disease: overcrowding, close and prolonged contact, and the inexistence of a policy of screening/medical check-up of inmates upon their admission to prison. The objective of this study was to conduct a prospective and cross-sectional study to assess the prevalence of pulmonary tuberculosis in the prison environment of Yéné, the central prison of Franceville, capital of the Haut-Ogooué province.

Methods: A preliminary clinical survey of inmates identified a cohort of 100 individuals suspected of having TB based on clinical symptoms. Subsequently, from June 9 to 13, 2022, we collected sputum samples from inmates suspected of having TB. These samples were analyzed by the molecular biology technique GeneXpert MTB/RIF.

Results: Among the 100 inmates suspected of having tuberculosis, *Mycobacterium tuberculosis* was detected in seven male patients (prevalence of 7%) and these germs did not present any resistance to rifampicin, they are of sensitive phenotype. Among the seven inmates diagnosed with tuberculosis, 4 (57.1%) were in their first incarceration while 3 (42.9%) were in their second incarceration after more than 5 years of liberty, thus we are dealing with imported cases of tuberculosis. These prisoners complained of fever (71.4%), cough (57.1%) and chest pain (28.6%).

Conclusion: In Yéné prison, the non-existence of diagnostic tests for TB to newly incarcerated inmates puts other inmates as well as prison officers at risk for TB infection.

Keywords:- *Mycobacterium tuberculosis*, *Tuberculosis*, *GeneXpert*, *prison environment*, *Haut-Ogooué*.

I. INTRODUCTION

Tuberculosis (TB) is a major public health problem worldwide [1]. According to the World Health Organization, one third of the world's population is latently (asymptotically) infected with *Mycobacterium tuberculosis* (*M. tuberculosis*), the etiological agent of tuberculosis, while 5-10% of the world's population is actively (symptomatically) infected. The transmission of *M. tuberculosis* is human-to-human via aerosols emitted when a sick person with advanced clinical signs coughs, the contamination occurs when a healthy person inhales these aerosols [2].

Despite the availability of antibiotic chemotherapy, TB remains the third leading cause of death due to an infectious germ, and death occurs when the disease is partially or not managed with drugs. TB is unevenly distributed across WHO health regions, with the greatest number of cases occurring in the developing countries of Southeast Asia (44%), Africa (25%), and the Western Pacific (18%) due to weak health systems. In 2020, during the COVID-19 pandemic, 87% of new cases occurred in the 30 countries with the highest TB burden. Two-thirds of these were concentrated in India, Indonesia, China, the Philippines,

Pakistan, Nigeria, Bangladesh and South Africa [2]. Studies across the globe have shown that HIV and TB in prisons are the leading causes of morbidity and mortality in all regions of the world. The WHO strategy identifies prisoners as a key population to be addressed in order to stop TB and AIDS [3, 4].

In Gabon, with an incidence of 521 cases per 100,000 population, TB is a key concern for incarcerated people [5].

Although the prisons of Libreville, Lambaréné and Tchibanga have benefited from TB screening campaigns in 2018, 2020 and 2021 respectively with the financial support of the Global Fund, unfortunately there is no information on TB in the prison of Franceville [6]. In order to overcome this problem, this field study proposes to make a molecular diagnosis of this disease in suspected prisoners in the central prison of Franceville with the main objective of assessing the prevalence of tuberculosis in this prison and to study the socio-demographic characteristics of suspected prisoners and particularly those diagnosed with tuberculosis.

II. MATERIAL & METHODS

A. Setting and location of the study

This study took place in the south-east of Gabon in Franceville, in the province of Haut-Ogooué, in the only prison in the town of Franceville, the capital of the locality. Initially built during the colonial era in the second district of the town, the central prison of Franceville was relocated in 2011 in the fourth district in the Yéné district because of the dilapidation of the buildings and its capacity deemed insufficient. A thick concrete wall 10 meters high surrounds the prison, topped with electrified barbed wire. The prison has several buildings, including the infirmary, which is run by a senior nurse and four assistant nurses. This health staff provides nursing care and manages health emergencies. The inmates are housed in a four-story building divided into quarters and blocks or dormitories compartmentalized into cells. The number of inmates per cell varies from 1 to 16 for cells of 12 m². The inmate population is disparate due to the diversity of charges, socio-professional diversity, penal status, and nationalities. Prison guards assign tasks to fellow inmates, such as maintenance, cleaning, and emptying septic tanks.

B. Type and period of study

From June 9 to 13, 2022, a prospective and cross-sectional study was conducted in the central prison of the city of Franceville.

C. Study population

The study population was made up of all the inmates entering the prison from liberty or from another prison. The study population consisted of approximately 500 inmates and included adolescents, young adults, and adults of both sexes. Most of the inmates were single and there were a few repeat offenders.

D. Inclusion and exclusion criteria

Inmates suspected of having pulmonary tuberculosis with (symptomatic) or without (asymptomatic) clinical signs of the disease, inmates undergoing treatment for tuberculosis or in relapse, treatment discontinuation, or treatment failure were included in this study.

Inmates who did not meet the above criteria, i.e., who had symptoms other than pulmonary TB and were being followed up for another condition, were not included in the sample.

E. Sampling

The sampling was exhaustive and included all symptomatic and asymptomatic patients suspected of having pulmonary TB. Thus, of the 500 inmates in the prison, 100 inmates met the inclusion criteria and among them, 2 inmates had been on first-line treatment for six months.

F. Conduct of the study

➤ Study approval and ethical considerations

The study was approved by the General Management of CHRAB and by the Director of the Franceville Central Prison, subject to compliance with the law on the protection

of the privacy of prisoners, according to the code of ethics in the Gabonese Republic.

The information necessary for the realization of this work was collected on anonymous survey forms. In addition, no information related to a patient will be disclosed, as well as the confidentiality of their information after approval.

➤ Preliminary steps to conduct the study

The protocols for data collection and sample analysis were presented two months before the start of the study to the senior nurse in charge of the prison infirmary. The General Management of CHRAB wrote a letter of correspondence to the Director of the prison. Once the administrative formalities were settled, a training on the good practices of the data collection forms was conducted with the nursing staff of the prison. They were then given office equipment, personal protective equipment (PPE: over blouse, KN95 respiratory protection mask, single-use latex gloves) and tools for sampling and collecting samples (spittoons).

➤ Method of data collection, sample collection, and transport of samples to CHRAB

On collection days, in the morning, the prison nurses wore PPE and sat in pairs at two tables. A guard called the inmates selected for the study who lined up one behind the other to form a line of 10 people. Under the supervision of two other guards, the detainees took turns sitting on a stool placed in front of each nursing pair.

For each pair, the first nurse collected sociodemographic data using the questionnaire on the pre-established data collection form. The questionnaire collected personal data (age and sex), demographic data (place of residence, date of incarceration, number of incarcerations), marital status, professional status, level of education, and history of tuberculosis (treatment, appearance of symptoms).

At the end of the interview, each inmate was given a plastic screw-top jar on which was written in indelible marker their first and last name, their registration number on the laboratory register and the date of the day of the sample collection. Each inmate was also given a single-use disposable handkerchief to wipe his or her mouth after sputum production. The nursing team's master corporal, who ensured that the inmates were spitting properly, that the amount of collection was sufficient and that the spittoons were tightly closed after the exercise, supervised sputum collection by the inmates. The supervisor then placed the spittoons in a plastic wrapper and carefully placed them in a refrigerated electric cooler (Campingaz) at +4°C with a volume capacity of 12 liters. At the end of each collection session, the CHRAB ambulance driver was called by telephone to the central prison to transport the biotechnologist to the analysis room with the completed data collection forms and the cooler containing the freshly collected samples.

➤ *Molecular analysis of samples*

Upon arrival at the CHRAB bacteriology unit, the samples were taken out of the refrigerated cooler and plastic packaging and placed on a clean bench. The number of data collection sheets was compared with the number of samples on the bench, and the samples were stored in batches of 50 in a LIEBHERR refrigerator at +4°C.

The pre-analytical phase consisted of ensuring the conformity of the sample (correct identification, quality and quantity of sputum, appropriate container, absence of food debris, ...), then the recording of the patients' data in the central activity register of the NTP (serial number, date of receipt of the sample, name and surname, sex, age, address, nature of the sample, HIV infection, previous anti-tuberculosis treatment, diagnosis, examination results and observation).

The GeneXpert MTB/RIF procedure consisted of mixing the GeneXpert reagent (Sample Reagent, SR) and the sputum sample in a 2:1 ratio (2 ml SR to 1 ml sample). The resulting mixture was vigorously shaken 10 to 20 times and then left to stand on the bench at room temperature for 15 minutes. The mixture was again vigorously shaken and allowed to stand at room temperature for 5 minutes. Following this and using a graduated plastic Pasteur pipette, 2 ml of the mixture obtained was gently transferred into an Xpert cartridge previously identified with the identifiers of each of the inmates. The finished cartridge was inserted into a module of the GeneXpert MTB/RIF analyzer after the preliminary steps of setting up the analyzer.

III. RESULTS

A. Sociodemographic characteristics of the inmates selected for the study

100 inmates were recruited for this study, 94 were male. The average age of the inmates was 36.5 years, with a range of 15 to 58 years. The majority of the detainees were of Gabonese nationality (92%) and the rest were of Congolese nationality (4%), with Chadian, Cameroonian, Nigerian and Equatorial Guinean nationalities accounting for 1% of the frequencies respectively.

The detainees were arrested in various localities in the province of Haut-Ogooué, 70% in Franceville, the remaining 30% of the detainees came from the surrounding towns: Moanda, 18%; Okondja, 4%; Mounana, 3%; Bongoville, Leconi, Ngouoni, Bakoumba each represented 1% of the frequencies. One inmate was from Libreville, the national capital of Gabon (1%). The largest number of inmates (63%) were first-time offenders, while repeat offenders accounted for 37%.

The number of inmates in the cells varied: 81% of the cohabitations had between 11 and 16 individuals per cell, 18% of the cohabitations had less than or equal to 10 inmates and 1% were in isolation.

Regarding the education of the inmates, 2% were university graduates, 60% had secondary education, 36% had primary education, and illiterates accounted for 2%. Concerning the professions, 77% had no activity, 5% were employed in car mechanics, 4% were cab drivers (clando man) or bricklayers, 2% were shopkeepers and 1% of the inmates were respectively animators, welders, scrap metalworkers, electricians and elementary school teachers. In terms of drug use, 41% drank alcohol, 38% smoked tobacco and 21% smoked cannabis (Table 1).

Table 1: Sociodemographic characteristics of inmates (n = 100)

Characteristics	Frequencies	Percentages (%)
Nationality	Gabonese	92
	Congolese	4
	Chadian	1
	Cameroonian	1
	Nigerian	1
	Equatorial Guinean	1
Gender	Male	94
	Female	6
Age range (years)	15 – 28	43
	29 – 39	26
	40 – 50	23
	51 – 61	8
City of residence	Franceville	70
	Other locations	30
Number of co-detainees in cell	1 (isolation)	1
	2 – 10	18
	11 - 16	81
Level of education	without	2
	Primary	36
	Secondary	60
	University	2
Professional status	Without	77

	Mechanic	5	5
	Driver	4	4
	Animator	1	1
	Cook	3	3
	Welder	1	1
	Mason	4	4
	Ironworker	1	1
	Electrician	1	1
	Shopkeeper	2	2
	Teacher	1	1
Number of incarcerations	1	63	63
	≥ 2	37	37
Drug use	Alcohol	70	41
	Tobacco	64	38
	Cannabis	36	21

B. Clinical characteristics of the inmates selected for the study.

At the time of their entry into detention at the Yéné penitentiary center, 69% of the incarcerated persons did not present any symptoms related to tuberculosis, while 11% reported weight loss (somewhat considerable), 9% experienced chest pain, 6% felt suffocation, and the remaining 5% had a persistent cough.

Regarding TB treatment history, 3 inmates were former TB cases known to the NTP and had been on TB therapy, resulting in 2 dropouts and 1 failure. The HIV status of the prisoners was unknown for a good number of them (81%), nevertheless 18% tested HIV-negative and 1 prisoner (1%) was diagnosed HIV-positive (Table 2). In addition, 4 individuals had a medical history of high blood pressure (3 cases) and asthma (1 case).

Table 2: Clinical profile of inmates at the Franceville central prison (n = 100).

Characteristics	Variables	Frequency	Percentage (%)
General symptoms at incarceration	Persistent cough	5	5
	Chest pain	9	9
	Thinness	11	11
	Choking	6	6
	No signs	69	69
History of tuberculosis treatment	Discontinuation of treatment	2	66,7
	Relapse	0	0
	Treatment failure	1	33,3
Medical history	high blood pressure	3	75
	Asthma	1	25
HIV infection	Yes	1	1
	No	18	18
	Unknown	81	81

C. Prevalence of tuberculosis in the Franceville penitentiary

Of the 100 inmates retained and screened with the GeneXpert automated system, the positivity rate for the detection of M. tuberculosis was 7% (7 positive cases). All TB cases were susceptible to rifampicin, i.e. no mutations were detected in the rpoB gene area of interest (AOI). In contrast, 93% (93/100) of the remaining inmates were GeneXpert MTB/RIF negative.

Of the positive cases, all were male, 85.7% were of Gabonese nationality and 14.3% were of Congolese nationality. The inmates with tuberculosis were between 19 and 49 years of age with an average age of 30.85 years. Most of them, 85.7%, had attended college while 14.3% had stopped at elementary school. Before their incarceration, all of them lived in Franceville and did not have a job. The majority of them (57.1%, 4/7) had never been incarcerated

while 42.9% (3/7) were repeat offenders. Among the recidivists, the duration of new incarceration was 3 months and 6 months after 1 year, 4 years and 12 years of freedom. The distribution of TB cases within the prison blocks is unknown; however, TB patients were located in five separate cells including: 1 TB patient in a cell with 16 individuals, 2 TB patients in a cell with 14 individuals, 1 TB patient in a cell with 11 individuals, 1 TB patient in a cell with 6 individuals, and 1 TB patient in a cell with 4 individuals.

The consumption of illicit products such as alcohol, tobacco and Indian hemp are recurrent among the detainees, among the detected cases of tuberculosis 38.5% consumed alcohol and tobacco, and 23% marijuana. The patients presented symptoms suggestive of TB, notably fever (57.1%, the most frequent sign) and persistent cough (44.5%). The rate of TB-HIV/AIDS co-infection was

unknown for most of them (85.7%) and only 14.3% had been diagnosed as HIV negative (Table 3). TB inmates also presented with neurological problems such as dizziness

(60%) and headaches (40%); digestive problems such as epigastralgia (66.7%) and diarrhea (33.3).

Table 3: Prevalence of TB among inmates (n = 7)

	Characteristics	Frequencies	Percentages (%)
Nationality	Gabonese	6	85,7
	Congolese	1	14,3
Gender	Male	7	100
	Female	0	00
Age (years)	19 – 29	5	71,4
	30 – 40	0	00
	41 – 49	2	28,6
City of residence	Franceville	7	100
Level of education	Primary	1	14,3
	Secondary	6	85,7
Number of incarcerations	1 time	4	57,1
	2 times	3	42,9
Tuberculosis cases and number of co-inmates in the cell	1 (R) among 3 inmates = 4 inmates	7	100
	1 (P) among 5 inmates = 6 inmates		
	1 (P) among 10 inmates = 11 inmates		
	2(R-P) among 12 inmates = 14 inmates		
	1 (P) among 15 inmates= 16 inmates		
1 (?)			
Drug Use	Alcohol	5	71.4
	Tobacco	5	71.4
	cannabis	3	42.8
Xpert MTB/RIF test result	Positive	7	100
	Négative	0	00
General symptoms	Asthenia	1	14,3
	Fever	5	71,4
	Loss of taste	1	14,3
	Loss of sense of smell	1	14,3
	Loss of weight	1	14,3
	Nocturnal sweating	1	14,3
Respiratory symptoms	Choking	1	14,3
	Coughing	4	57,1
	Chest pain	2	28,6
Neurological symptoms	Dizziness	3	42,9
	Headache	2	28,6
Digestive symptoms	Epigastralgia	3	42,9
	Diarrhea	1	14,3
HIV infection	Unknown	6	85.7
	No	1	14.3

Legend: R = recidivism; P = first incarceration; ?= number of incarcerations and co-inmates unknown.

IV. DISCUSSION

The purpose of this study was to determine the prevalence of pulmonary TB in the prison environment of the city of Franceville, a health region located in southeastern Gabon.

A. Prison occupancy rate and TB occurrence

For several African countries, prison occupancy rates (prison density) are reaching record proportions, sometimes exceeding 300%, well beyond the actual capacity of the prisons. This was the case in 2020 in Senegal (383%), Liberia (329%), Côte d'Ivoire (266%), Nigeria (137%) [7, 8] and in the central prison of Libreville in Gabon (583%). The

overcrowding of these prisons creates favorable conditions for TB transmission, including permanent promiscuity throughout the period of incarceration. In fact, according to the data collected for the Yéné prison, the number of inmates per cell (about 12 m²) varied from 2 to 16 individuals. Despite these extreme prison densities, the prevalence of pulmonary TB is very low. In this study at Yéné prison, the prevalence of TB was 7% (7 positive cases/100 suspects). This prevalence is particularly high when compared to Cameroonian prisons 3.9% (136/3423) in 2020 [9], Nigerian prisons 0.84% (28/3324) [10] in 2021 and French prisons 0.24% (45/18,356) in 2019 [11]. The comparison of these data supports the idea that TB circulates much more in Gabon than in the countries mentioned above.

Indeed, according to WHO statistics [12] Gabon is categorized among the 30 countries worldwide with a high burden of TB and ranks 3rd in Africa, far ahead of Cameroon and Niger.

B. Number of incarcerations, length of incarceration, and importation of tuberculosis

Recidivism rates are not well known in Gabon today because data on prisoners are not kept after their release. Each time a prisoner is re-incarcerated, he or she is assigned a new prison number. Of the 7 TB cases detected, 57.1% (4/7) were first-time offenders and 42.9% were repeat offenders (2nd incarceration) after 1, 4 and 12 years of freedom. It appears that the TB cases in Yéné prison are imported TB cases because no TB inmate has stayed for more than 2 to 5 years in a row. In other words, because of their recent re-incarceration (less than 6 months), these people contracted the infection outside the prison during their years of freedom. This phenomenon of importation of TB into the prison environment is far from trivial and specific to the Yéné prison. A study conducted in 2011 in Burkina Faso showed that 260 inmates with TB (86.7%) were in their first incarceration [13]. These incarcerations of new inmates without hospital biological checkups run the risk of transmitting tuberculosis to those already incarcerated.

C. Socio-demographic characteristics of tuberculosis cases

The ratio of men to women in prison cases is largely to the disadvantage of men, and men always constitute the most represented prison population. In the Yéné prison, the tuberculosis patients were mainly men (100%), a somewhat surprising fact, even though in certain circumstances and periods, men and women may share certain rooms for various common activities: recreation, religious worship or maintenance of the prison. An inmate with tuberculosis is likely to infect any room by coughing repeatedly, and this room will constitute a spot of infection if the ventilation is practically null. This high prevalence of male tuberculosis patients has also been observed in prisons in Cameroon in 2020 with 96.6% [14], in Niger in 2021 with 100% [15], in Ethiopia in 2018 with 97% [16], in France in 2019 with 95.6% [17]. This trend is probably because during their periods of freedom men are led to establish many more social and (pseudo) professional connections within society than women [18; 19] because of its cultural and even religious character as a provider of shelter and food within the family. This high level of interaction increases the risk of contracting tuberculosis infection [20]. The role of women would be somewhat limited to performing domestic tasks. All of the people who tested positive for TB were nationals of the city of Franceville, which is sufficient proof that TB circulates in the Franceville community. In our African societies, the male role of provider is inherent to people between 30 and 45 years of age or even 50 years of age (productive age) [20, 21]. The minority, 28.6% (2/7) of TB cases were productive (adults) aged 47 and 49 years respectively while the largest number of inmates detected with active TB were 71.4% (5/7) young individuals aged between 19-29 years. Cases of TB transmission in young individuals usually incriminate domestic transmissions of parental origin, however, given the prison context; it is quite

possible that these young people acquired the infection during their various risky social activities. The results of the study revealed that all the inmates with tuberculosis (n=7, 100%) were drug addicts, 71.4% (5/7) used tobacco. According to the World Health Organization and Zhang et al, (2007), smoking is indirectly responsible for 20% of tuberculosis cases worldwide [22]; both passive and active exposure to cigarette smoke are associated with an increased risk of M. tuberculosis infection and the development of active tuberculosis [23]. Regular ingestion of toxic smoke is thought to promote low production of interleukin-12 and TNF- α , pro-inflammatory cytokines essential for activation and communication/coordination of immune cells located in the pulmonary alveoli. The decreased production prevents granuloma formation [24; 25]. Another factor in the development of tuberculosis is alcohol abuse. According to Soh et al (China) and Lönnroth et al, chronic alcohol consumption is indeed a risk factor for the development of tuberculosis, especially among heavy drinkers [26, 27]. In this study, five of the inmates (71.4%) drank alcohol.

D. Medical characteristics of prisoners with TB

Depending on the stage of infection, TB manifests itself through various symptoms ranging from non-specific (common to most other pathologies) to more specific. According to our results on the clinical symptoms of TB inmates in Yéné prison, 71.4% (5/7) of the patients complained of fever associated with coughing (57.1%, 4/7) and to a lesser extent with choking (14.3%, 1/7), night sweats (14.3%, 1/7) and weight loss (14.3%, 1/7) The results of our study are similar to those of Sani et al, conducted in 2021 in a prison setting in Niger [28] who stated that people with TB often complained of fever 92.85% and cough 100%. As reported in the literature, cough is the most frequent symptom lasting more than 2 to 3 weeks due to bronchial irritation. Fever is a clinical manifestation that indicates an ongoing infection. The severity of M. tuberculosis infection determines the level of fever, and usually fever in patients with tuberculosis is subfebrile (40-41°C) and intermittent [29; 30].

E. Limitations of the study

The present study is far from exhaustive and therefore has some limitations. The GeneXpert MTB/RIF technique is only limited to the detection of mutations associated with RIF. The use of other molecular diagnostic tools, such as Hain GenoType MTBDRplus and Sanger sequencing, would have allowed the screening of mutations conferring resistance to INH and PZA in order to determine whether TB cases are susceptible or mono-resistant to INH or PZA with respect to these first-line antituberculosis drugs. Moreover, due to the relatively short time available, we were not able to genotype the strains of the TB inmates. Genotyping would have allowed us to identify the strain or strains involved.

V. CONCLUSION

Tuberculosis is an airborne disease, and communities or groups of people characterized by close and prolonged contact are very prone to disseminate the disease among their members. With occupancy rates far in excess of the actual capacity of the prison, inmates in African prisons constitute a population group at high risk of tuberculosis, a disease known to national tuberculosis control programs.

The aim of the prospective cross-sectional study conducted in the Yéné prison in Franceville from 9 to 13 June 2022 was to determine the prevalence of tuberculosis in this prison. Among the 100 cases of suspected clinical tuberculosis examined, the detection rate of tuberculosis with rifampicin-sensitive germs was 7%. The major finding of the study was that these TB cases were imported into the prison. This unexpected characterization on our part highlights flaws in the health protocols and procedures at Yéné prison. This sanitary flaw is of major importance because inmates as well as prison officers (guards, administrators, doctors and nurses...) are exposed to the disease.

In order to prevent possible transmissions or contaminations within Gabon's prisons, the authorities in charge of prisons should implement preventive measures to limit transmission/contamination in prisons. As a preventive measure, prisoners could be subjected to a lung X-ray and/or TST test, and possibly to an IGRA test for latent TB, as soon as they arrive in the prison and periodically. The same applies to the prison staff. As another preventive measure, an optimal ventilation system should be put in place for the premises (prison blocks). In the end, adequate sensitization of inmates and prison staff about TB is an essential part of the TB control strategy.

ACKNOWLEDGMENTS

The authors would like to thank all the medical staff, participants, and director of the hospital center for their valuable contribution. The authors declared no conflicts of interest.

REFERENCES

[1.] Yombi J. C., & Olinga U. N. (2015). La tuberculose: épidémiologie, aspect clinique et traitement. *Louvain med*, 134(10), 549-559.

[2.] WHO. (2020). *Global tuberculosis report*. Geneva, Switzerland.

[3.] OMS. (2015). *Stratégie de l'OMS pour mettre fin à la tuberculose*. Genève, Suisse

[4.] OMS. (2016). *Stratégie mondiale du secteur de la santé contre le VIH, 2016-2021*.

[5.] Direction Générale de la Statistique (DGS) du Gabon et ICF International. (2012). *Enquête Démographique et de Santé du Gabon (2012) : Rapport de Synthèse*. Calverton, MD: DGS et ICF International.

[6.] Programme national de lutte contre la tuberculose. *Plan stratégique de lutte contre la tuberculose au Gabon (2014) – 2018* p. 26-27

[7.] Ndione A. G., Desclaux A., Bâ I., Sow K., Ngom M., Diop, M. (2020). Usagers de drogues et Covid-19: comment réduire la surpopulation carcérale en Afrique de l'Ouest? *The Conversation*, 19, 6-p.

[8.] Fischer B. (2021). Interroger la promotion internationale de l'État de droit à l'aune de la détention avant jugement. L'exemple de la Côte d'Ivoire. *Déviance et Société*, 45(3), 417-448.

[9.] Morelle M., Awondo P., Birwe H., Eyenga, G. M. (2018). Politique de réforme et matérialité de la prison au Cameroun. *Politique africaine*, (2), 75-96.

[10.] Kolappan, C., Gopi, P. G., Subramani, R., & Narayanan, P. R. (2007). Selected biological and behavioural risk factors associated with pulmonary tuberculosis. *The International Journal of Tuberculosis and Lung Disease*, 11(9), 999-1003.

[11.] Bouvier, J.C et Blisson, L. (2020). En finir avec la crise permanente de la surpopulation carcérale. *Deliberee*, 11 (3), 34 – 38.

[12.] Matteelli A., Centis R., D'Ambrosio L., Sotgiu G., Tadolini M., Pontali E., Migliori G. B. (2016). WHO strategies for the programmatic management of drug-resistant tuberculosis. *Expert review of respiratory medicine*, 10(9), 991-1002.

[13.] Trop M. (2011). Prévalences et facteurs associés aux infections à Virus de l'Immuno-déficience Humaine et virus de l'hépatite B, à la syphilis et à la tuberculose pulmonaire bacillifères en milieu carcéral au Burkina Faso. *Médecine tropicale*, 71(5), 464-467.

[14.] Kuate A. K., Wandji A., Belinga E., Bekang F., Evouna A. E., Mbassa, V. (2020). Amélioration du diagnostic de la tuberculose dans les prisons Camerounaises en 2018 à travers des campagnes de masse de la tuberculose. *Revue des Maladies Respiratoires Actualités*, 12(1), 61.

[15.] Sani K., Laouali H. A. M., Laminou A. M., Azize G. A., Mamane D., Piubello A., Eric, A. (2021). Tuberculose pulmonaire en milieu carcéral au Niger: aspects épidémiologiques, diagnostiques, thérapeutiques et évolutifs.

[16.] Adane K., Spigt M., Dinant, G. J. (2018). Tuberculosis treatment outcome and predictors in northern Ethiopian prisons: a five-year retrospective analysis. *BMC Pulmonary Medicine*, 18(1), 1-8.

[17.] Caudrelier, L., & Le Grusse, J. (2019). Tuberculose en prison: incidence, caractéristiques des cas et évaluation du dépistage. *Médecine et Maladies Infectieuses*, 49(4), S33.

[18.] Yang K. and Girgus J. S. (2019). Are women more likely than men are to care excessively about maintaining positive social relationships? A meta-analytic review of the gender difference in sociotropy. *Sex Roles*, 81(3), 157-172.

[19.] Kimbrough A. M., Guadagno R. E., Muscanell N. L., Dill J. (2013). Gender differences in mediated communication: Women connect more than do men. *Computers in Human Behavior*, 29(3), 896-900.

[20.] Hudelson, P. (1996). Gender differentials in tuberculosis: the role of socio-economic and cultural factors. *Tubercle and lung disease*, 77(5), 391-400.

[21.] Kolappan, C., Gopi, P. G., Subramani, R., & Narayanan, P. R. (2007). Selected biological and

- behavioural risk factors associated with pulmonary tuberculosis. *The International Journal of Tuberculosis and Lung Disease*, 11(9), 999-1003.
- [22.] WHO. (2009). *Tuberculosis & Tobacco Final TB Fact Sheet*. Geneva.
- [23.] Zhang H, Xin H, Li X, Li H, Li M, Lu W. (2017). A dose-response relationship of smoking with tuberculosis infection: A cross-sectional study among 21008 rural residents in China. *PLoS One*. 12(4):e0175183. <https://doi.org/10.1371/journal.pone.0175183>.
- [24.] North RJ & Jung YJ. (2004). Immunity to tuberculosis. *Ann Rev Immunol.*; 22:599-623. <https://doi.org/10.1146/annurev.immunol.22.012703.104635>.
- [25.] Cosio MG, Saetta M, Agusti A. (2009) Immunologic aspects of chronic obstructive pulmonary disease. *N Engl J Med.*; 360 (23):2445- 54.
- [26.] Soh A. Z., Chee C. B. E., Wang Y. T., Yuan J. M., Koh W. P. (2017). Alcohol drinking and cigarette smoking in relation to risk of active tuberculosis: prospective cohort study. *BMJ open respiratory research*, 4(1), e000247.
- [27.] Shin SS, Mathew TA, Yanova GV, Fitzmaurice GM, Livchits V, Yanov SA. (2010). Alcohol consumption among men and women with tuberculosis in Tomsk, Russia. *Cent Eur J Public Health*. 18(3):132-8.
- [28.] Sani K., Laouali H. A. M., Laminou A. M., Azize G. A., Mamane D., Piubello A., Eric, A. (2021). Tuberculose pulmonaire en milieu carcéral au Niger: aspects épidémiologiques, diagnostiques, thérapeutiques et évolutifs.
- [29.] Li J. C. H., Fong W., Wijaya L., Leung Y. Y. (2018). Disseminated tuberculosis masquerading as a presentation of systemic lupus erythematosus. *International Journal of Rheumatic Diseases*, 21(1), 352-355.
- [30.] Ismail Y. (2004). Pulmonary tuberculosis-a review of clinical features and diagnosis in 232 cases. *Med J Malaysia*, 59(1), 56-64.