Journal of Biosciences and Medicines, 2024, 12, 214-224
https://www.scirp.org/journal/jbm
ISSN Online: 2327-509X
ISSN Print: 2327-5081

Tuberculosis in the Carcinal Environment in Chad Due to the Mycobacterium Tuberculosis Circulante Complex

Ahmat Idriss Ahmat[1], Mahamat Tahir Ngaré Hassan[1], Ngandolo Bongo Nare Richard[2], Mahamat Adanao Adoudou[1], Mbah Ntepe Leonel Javeres[3], Hamidou Yacoubou[4], Ali Mahamat Moussa[5]

[1]Laboratory for Diagnostic Research and Scientific Expertise, University of N'Djamena, N'Djamena, Chad
[2]Veterinary and Zootechnical Research Laboratory of Farcha N'Djamena, Livestock and Development Research Institute, N'Djamena, Chad
[3]Institute of Medical Research and Medicinal Plant Studies (IMPM), Ministry of Scientific Research and Innovation, Yaoundé, Cameroon
[4]Cameroon Ministry of Public Health, Yaoundé, Cameroon
[5]Faculty of Human Health Sciences, University of N'Djamena, N'Djamena, Chad
Email: mahamattahirngare@gmail.com

How to cite this paper: Ahmat, A.I., Hassan, M.T.N., Richard, N.B.N., Adoudou, M.A., Javeres, M.N.L., Yacoubou, H. and Moussa, A.M. (2024) Tuberculosis in the Carcinal Environment in Chad Due to the Mycobacterium Tuberculosis Circulante Complex. *Journal of Biosciences and Medicines*, **12**, 214-224.
https://doi.org/10.4236/jbm.2024.122016

Received: January 1, 2024
Accepted: February 17, 2024
Published: February 20, 2024

Abstract

Tuberculosis (TB) is a serious infectious disease and its control is considered a challenge, particularly among vulnerable populations such as prisoners. The prevalence of TB in prisons is an alarming public health problem in many countries. The aim of this study is to describe the epidemiology of tuberculosis and the strategies for controlling this disease in the Chadian prison population. During the course of our study, the prevalence of tuberculosis in prisons was 9.64%. The age group between 55 years and over (43.33%) was the most represented in this study, and all patients were men with a frequency of 62.66%. The cross-tabulation of Culture_7H9G and Culture_7H9P showed that out of our total positive sample, we found a total of 87 positive strains and 63 negative strains. Our study shows that it is essential to know the prevalence of tuberculosis in all the country's prisons. Indeed, this can serve as an indication of the need for action in prisons to reduce TB rates, in particular by improving the structure of prison environments, diagnosing new cases quickly and accurately, identifying drug-resistant strains and implementing effective, direct treatment observed in people with tuberculosis.

Keywords

Mycobacterium, Prison, Tuberculosis and Chad

1. Introduction

Tuberculosis (TB) remains a major public health problem worldwide, particularly in emerging countries where 80% of TB cases occur. Following the adoption in 2015 by the United Nations (UN) of the Sustainable Development Goals (SDGs), one of the targets is to put an end to the tuberculosis epidemic. In 2018, there were an estimated 10 million new cases of tuberculosis, of which 1.5 million died [1]. Tuberculosis remains a transmissible disease affecting various age groups and social classes [1] [2]. In this sense, there are populations at increased risk of developing tuberculosis (called key populations by the Global Fund to Fight AIDS, Tuberculosis and Malaria), such as people living with the human immunodeficiency virus (HIV), migrants, refugees, children, people with diabetes, indigenous populations and prisoners [3]. Tuberculosis in prisons is a major public health problem worldwide. A meta-analysis revealed that the incidence of tuberculosis in prisoners was 4.1 to 26.9 times higher than in the general population [4]. Prisons are environments conducive to the transmission of Mycobacterium tuberculosis, as in most of these settings there is a high turnover of prisoners, in addition to overcrowded and poorly ventilated conditions [5]. The frequent transfer of prisoners between prisons creates a network of contacts within the prison which probably facilitates the spread of M. tuberculosis and may spread the risk of infection to the general population [6]. The estimated prevalence of latent tuberculosis infection (LTI) and active tuberculosis in prisons is higher than in the general population. In addition, many of these individuals consume tobacco, alcohol and illicit drugs and are therefore considered risk factors, as they favour the development of active tuberculosis. Unfortunately, TB control measures in these settings are lacking, and this population has limited access to healthcare [7] [8].

In Chad, tuberculosis must therefore be one of the priority diseases to be monitored in prisons [9]. Diagnostic and therapeutic methods are available to reduce the spread of the disease among inmates, guards and visitors, and also to reduce the cost to the state of treating the disease [10]. In Chad, the literature on tuberculosis in prisons is almost non-existent. A partial study was carried out in 2023 in six prisons to assess the effectiveness of tuberculosis control [9]. The province of N'Djamena accounts for the largest proportion with about 33% of cases. Then, 35 patients resided in Mongo province, corresponding to about 23% of the cases. Abéché province had 20 patients, or about 13% of cases. Sarh and Kelo had 5 patients (approximately 3%) and 25 patients (approximately 16%) respectively [9]. Knowledge of the epidemiological and operational indicators of tuberculosis is fundamental for planning interventions to control the disease and identifying areas for intervention and systems improvement. The aim of this study is therefore to analyse the epidemiological and operational indicators of tuberculosis among prisoners in selected prisons in Chad.

2. Methodology

1) Study locations:

The data was collected in the six prisons in Chad (N'Djamena, Abéché, Mongo, Kelo, Lai and Sarh). Data collection was carried out between November 2022 and September 2023 in the six prisons. Bacteriological and molecular diagnostics were carried out at the Institute of Research in Livestock for Development (IRED) in N'Djamena.

2) Study subjects

The patients

These were all cases suspected by a health centre manager of having had a cough for more than 15 days. The patient's suspected tuberculosis status and socio-demographic parameters such as sex, age, occupation, etc. were recorded on a survey form. Cases of extra-pulmonary tuberculosis identified by a prison health centre manager were also included in the study.

3) Sample sizes

The sample sizes for prisoners in six provinces were selected at random according to the criteria of clinical signs.

4) Sampling and laboratory analysis equipment

This consisted of sampling bottles and tubes, coolers and carboglasses. The laboratory equipment consists of small items such as pipettes, sterile bags for grinding, culture tubes, beakers, etc., culture media (Middle Brook 7H9, Loewenstein Jensen), buffer solution, reagents (Master mix, primers, etc.) and large items (biological safety hood, centrifuge, thermocycler, electrophoresis apparatus and a computer with a camera for images, etc.).

5) Biological material

The biological material collected from each patient consists of a 5 mL sample of sputum in a 5 mL volume of CPC kept at room temperature until dispatched to the IRED.

6) Sample processing and laboratory analyses

The sputum samples, decontaminated with cetyl pyridinium chloride (CPC), were washed with phosphate buffer pH 6.8 by adding 30 mL of phosphate buffer to the CPCCrachat mixture (10 m). After centrifugation for 15 min at 3500 rpm, the supernatant was discarded and the pellet suspended in 2 mL sterile distilled water and homogenised using a vortex mixer. A volume of 0.5 mL of this suspension was inoculated onto Loewenstein Jensen solid medium (8 mL of medium containing pyruvate or glycerol). A smear was then taken directly from the remaining homogenate. These inoculated solid media were incubated at 37˚C for eight (8) weeks, and monitored once a week until the growth of mycobacterial colonies was observed. Samples collected at the abattoir were decontaminated using NaOH-N-acetyl L-cysteine as a decontaminant. After homogenisation, the samples were vortexed for 15 minutes in biological safety cabinet 14. The homogenate was then washed by adding 30 mL of phosphate buffer (pH 6.8) and after centrifugation for 15 minutes at 3500 rpm, the supernatant was discarded in a sodium hypochlorite solution. The pellet was resuspended in 2 mL STERILE distilled water and 0.5 mL of the suspension was inoculated into two tubes containing 5 mL each of Middle brook Broth 7H9 liquid medium supplemented with

PANTA-OADC antibiotic, The cultures were then incubated at 37˚C for eight (8) weeks until growth was observed. The presence of Acid-Alcohol-Resistant Bacilli (AARB) was confirmed by staining smears taken from colonies or shoots harvested from the cultures using the Ziehl Neelsen method and observation under an optical microscope with an X100 objective, under immersion. After two months, all cultures that did not show growth were eliminated from the search for members of the M. tuberculosis complex. Colonies of bacilli collected from sputum samples on solid medium (Loewenstein Jensen) or from animal samples on liquid medium (7H9 Middle broth) were heat denatured on a heating block (85˚C for 30 min). The DNA extracts obtained following this denaturation were then analysed by various molecular diagnostic techniques using Polymerase Chain Reaction (PCR).

7) Data entry and statistical analysis

Data collected in the field and diagnostic results (bacteriological and molecular) were entered in duplicate into a secure database using Microsoft Excel. Data was transferred from Excel to spss version 25 using the spss/transfer software. The "prevalence rate" was used as a statistical measure to express 17 the frequency (number of cases present) of patients in relation to the total number sampled. Relative frequency was used to express the number of cases in age groups, genders and socio-professional categories. Multivariate analysis (GLM: Generalized Linear Models) was used to identify factors significantly dependent on PCR positivity.

8) Ethical considerations:

To carry out this study, a research authorisation was issued by the Chad Ministry of Public Health and Prevention, and the approval of the governors of the six prisons in the province was obtained.

3. The Results

Prevalence during the period of our study from November 2022 to September 2023, *i.e.* 9 months, an average of 1555 detainees was arrested in the six prisons of Chad (N'Djamena, Abéché, Mongo, kelo, Lai and Sarh). A total of 150 cases of tuberculosis were recorded in Chad's six prisons, representing a prevalence rate of 9.64% (Table 1).

Table 1. Breakdown of tuberculosis cases according to place of residence sex.

Residence	Gender		Total
	Female	Male	
Abéché	10	10	20
Kélo	3	22	25
Lai	6	9	15
Mongo	15	20	35
N'Djamena	21	29	50
Sarh	1	4	5
Total	56	94	150

The highest frequencies were observed in the city of N'Djamena with a number of 50 cases, *i.e.* 33.33%. The majority of patients (33.33%) were incarcerated at the N'Djamena prison, while the lowest percentage (3%) was incarcerated in Sarh.

The average age of patients was 53.4 ± 11.7 years, with extremes of 18 and 70 years. The most active age group was 55 years and over, with a percentage of 43%, whereas the least active age group was 18 to 24 years.

All the patients were males, who had more cases of tuberculosis, with a frequency of 62.66%. On the other hand, among female prisoners with tuberculosis, we found that 37.33% of our samples came from six prisons in Chad.

A wide range of socio-professional categories were represented, with 83.33% of patients not attending school, 30.66% of patients were unemployed, and 60% of inmates were married, civil servants 6% of cases and students 3% of the sample. The lowest percentages were inmates who were artisans and widows, with 5 cases.

3.1. Biological Data

Bacteriological examination of sputum, used as a basis for the diagnosis of tuberculosis, was performed on all patients. A predominance of microscopy-positive pulmonary tuberculosis (MPT+) was noted on the slides in 9.64% of cases.

Of the 150 positive sputum samples collected, all were treated. After culture on specific media, 87 strains of bacteria were isolated, representing a percentage of isolation of 58.00% (87/150). Mycobacteria accounted for more than 36.78% (32/87) of the bacteria isolated, including 25 strains of M. tuberculosis, the majority of which were found in the 55+ age group. The unemployed and farmers were the socio-professional categories most affected. Univariate analysis gave $p > 0.05$.

3.2. Radiological Data

Detention was found in 33.33% of cases, followed by pleurisy in 20% and infiltrates in 3%. Images of normal appearance were found in 33.33% of our inmates in the six provinces.

3.3. Treatment Data

Treatment was based on the recommendations of the national tuberculosis control programme (NTP) in force in Chad during the study period. Overall, the standard treatment for pulmonary tuberculosis was a combination of isoniazid and rifampicin for 6 months, supplemented by 1) ethambutol for the first 2 months to prevent failure by selection of a rifampicin-resistant strain in the event of primary resistance to isoniazid, and 2) pyrazinamide for the first 2 months (which reduced the duration of treatment from 9 to 6 months). Treatment durations for extra-pulmonary tuberculosis are shown in **Table 2**.

Total duration of treatment of 9 months due to an increased risk of relapse for a duration of 6 months. Studies evaluating shorter treatment durations were accompanied by excessively high relapse rates ranging from 11% to 40%, making it impossible to consider a duration of less than 6 months (Table 3).

A large part of the socio-professional categories was represented with 83.33% of the patients not in school, 30.66% of the patients were unemployed, and 60% of the inmates were married, civil servants 6% of the cases and students 3% of the sample and the lowest percentages were craftsmen and widowers with 5 cases (Figure 1).

Table 2. Breakdown of tuberculosis cases by age and sex.

Workforce		Age					Total
		18 to 24	25 to 34	35 to 44	45 to 54	55 to more	
Gender	Female	0	11	3	40	2	56
	Male	2	1	23	5	63	94
Total		2	12	26	45	65	150

Table 3. Total duration of anti-tuberculosis treatment according to the type of disease.

Disease	Duration in months
Lung, lymph node, pericardial, pleural, abdominal, genitourinary 6	6
Bone	6 to 9
Pulmonary with culture still positive after 2 months of treatment	9
Meningitis	12

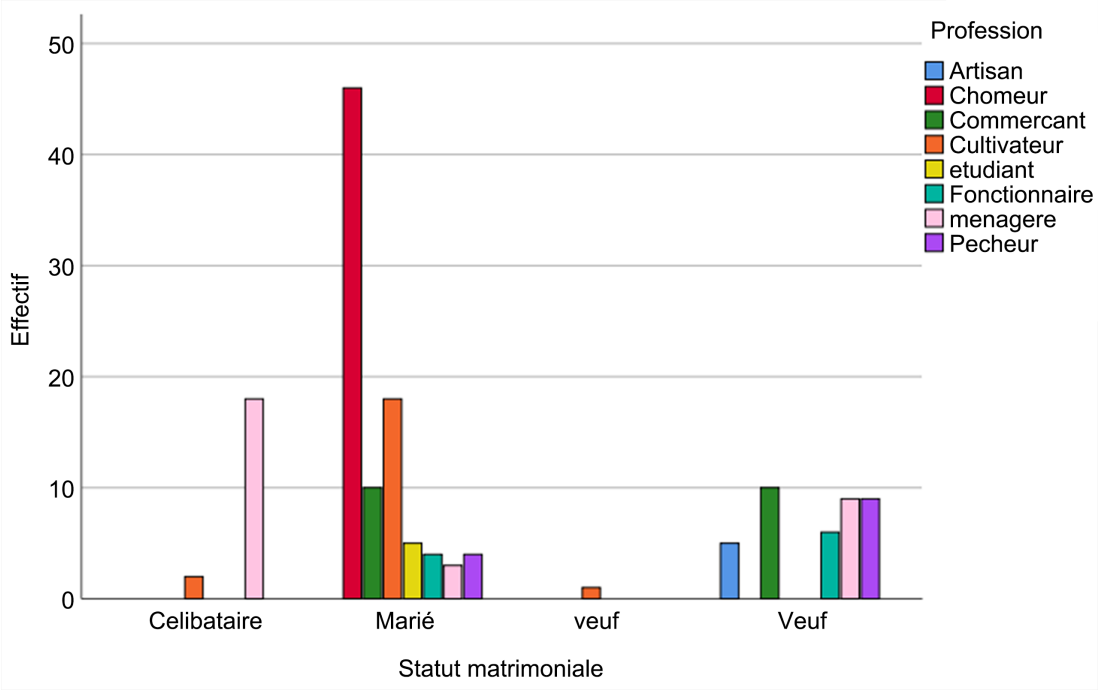

Figure 1. Distribution of patients by marital status and occupation.

Culture_7H9G and Culture_7H9P results cross-tabulated				
		Result Culture_7H9P		Total
		Negative	Positive	
Result Culture_7H9G	Negative	63	26	89
	Positive	25	36	61
Total		88	62	150

Symmetrical Measurements		
Result Crop (G, P) Total		Value
Negative	Number of valid G, P observations	63
Positive	Number of valid G, P observations	87
Total	Number of valid observations	150

The cross-tabulation of Culture_7H9G and Culture_7H9P showed us that out of our total positive sample, we found a total of 87 positive strains and 63 negative strains, which may explain the cross-tabulation of Culture_7H9G and Culture_7H9P by the simplicity that if 7H9P positive and 7H9G negative, we considered the culture to be positive, just as if 7H9P positive and 7H9G positive, we considered the culture to be positive.

4. Discussion

In our study, the prevalence of tuberculosis in prisons was 9.64%. This prevalence varies from study to study, but is still very high compared with the general population, as shown by the results of studies carried out in Côte d'Ivoire (0.23% vs 9.3%), Malawi (5%), Ethiopia (8.33%), Niger (0.84%) and Guinea Conakry (0.075%). (23% vs 9.3%), Malawi (5%), Ethiopia (8.33%), Niger (0.84%) and Guinea Conakry (0.075%vs 2.4%) [10]-[18].

The length of stay in prison, which presumably increases the contact time with the source of contamination, does not seem to influence the extent of this prevalence, as 58% of patients have been incarcerated. Our study does not corroborate those of Kadri Sani *et al.* [10] in Niger, who found 12 cases in 2008 (42.85%) and 32.14% in 2009. The majority of patients were incarcerated in Niamey prison (71.42%), compared with 28.58% in Kollo.

The age group between 55 and over (43.33%) is the most represented in this study. These results are similar to those found in Morocco by El Ghazi [19], who reports a predominance of this age group, which is more active and more exposed to promiscuity and abuse.

All the patients were male, with a frequency of 62.66%; these results are similar to those in the literature, such as those observed by Melese [20]; Bah [21]; Adane [16]. This could be explained by the fact that remand prisons are largely staffed by men and that the movement of prisoners between the men's and women's quarters was limited. Contrary to the results reported by Melese [20]; Bah [21], Ravahatra [22], the patients' clinical picture was dominated by cough

(100% of cases), fever (92.85% of cases) and expectoration (67.85% of cases).

It was found that in the health facilities visited, bacilloscopy was the only diagnostic technique used, given the lack of appropriate laboratory equipment for characterising mycobacteria of the M. tuberculosis complex, as in most health facilities in sub-Saharan African countries Boukary *et al.* [21]. Diagnosis (bacteriological and molecular) of the samples taken took place in the IRED's mycobacteria and PCR units, which have a security level II laboratory but meet the requirements of a level III laboratory. The methodology used means that the results can be extrapolated to the whole of southern and western Chad.

The detection of human tuberculosis due to M. bovis in co-infection with M. avium, on the one hand, and M. tuberculosis in cattle, on the other, is the first of its kind in Chad and represents a danger for the country. This result may be due to the close contact between humans and animals, but it is also proof of the poor management of health risks on farms, especially as the presence of these strains (bovine and avian) in humans could compromise the therapeutic regimen applied at national level for the treatment of tuberculosis. Cases of human tuberculosis due to M. bovis have been reported in eight African countries (Benin, Eritrea, Ethiopia, Rwanda, South Africa, Tanzania, Tunisia, Uganda), Boukary *et al.* [21], as well as in Nigeria and Madagascar [23] [24] [25] [26].

Our results concur with their findings, confirming the importance of molecular diagnosis in the epidemiology of tuberculosis in Africa. The present study focused on the population in areas of high human concentration, and tuberculosis infection is linked to gender ($p = 0.03$, OR = 3.3 IC OR 95%: 1.071 - 10.333), with women three 22 times more likely than men to be infected. This could be due to the fact that women are in much closer contact with the sick than men (in our societies, women are often at the bedside of the sick).

The 55+ age group, which is the active age group, was the most affected. Balako *et al.*, (29) found M.tuberculoisis at a rate of 61.53% in 260 people in Ethiopia, but our results (9%) differ from theirs. The difference may be due to the fact that the patients sampled in Ethiopia may constitute a high-risk group. The proportion of NCDs was 5%, close to Balako *et al.* [27] with 3.83%.

Out of 150 strains of bacteria isolated after culture, only 87 belong to the M. tuberculosis complex after PCR analysis, while the remainder is environmental bacteria that can give false positives during a CDI test in livestock Ngandolo *et al.* [28]. This demonstrates the sensitivity of molecular diagnosis compared with bascilloscopic diagnosis and intradermal tuberculin testing, except that it is too time-consuming.

However, in terms of prevention in the human population, the "Mantoux test followed by BCG vaccination"model remains the benchmark.

5. Conclusions

Tuberculosis remains one of the diseases that still pose problems of compliance and monitoring in prisons. It should be one of the diseases to be monitored as a

priority. Certain socio-demographic characteristics of the prison population, dominated by socio-economic insecurity and combined with their environmental vulnerability marked by poor ventilation and overcrowding, mean that prisoners are at very high risk of developing tuberculosis.

Effective preventive and therapeutic measures are essential, and surveillance must be stepped up in order to prevent and reduce the morbidity and mortality of tuberculosis in prisons.

Conflicts of Interest

The authors declare no conflict of interest in relation to this article.

Scientific Contribution

This article provides important scientific information on the prevalence of tuberculosis in all the country's prisons.

Limitations of the Study

Due to a lack of resources, this study was limited to sequencing the strains, which meant that it was not possible to differentiate between the different sub-species of the strains isolated, and it was not possible to carry out a search for resistance genes.

References

[1] WHO (2019) Global Tuberculosis Report 2018. World Health Organization Document 2019; WHO/CDS/TB/2019.15.

[2] Cervantes, J. (2016) Tuberculosis. Digging Deep in the Soul of Humanity. *Respiratory Medicine*, **119**, 20-22. https://doi.org/10.1016/j.rmed.2016.08.009

[3] World Health Organization (2021) Global Tuberculosis Report 2021. World Health Organization, Geneva.

[4] Cords, O., Martinez, L., Warren, J.L., O'Marr, J.M., Walter, K.S., Cohen, T., *et al*. (2021) Incidence and Prevalence of Tuberculosis in Incarcerated Populations: A Systematic Review and Meta-Analysis. *The Lancet Public Health*, **6**, e300-e308. https://doi.org/10.1016/S2468-2667(21)00025-6

[5] Walter, K.S., Martinez, L., Arakaki-Sanchez, D., Sequera, V.G., Sanabria, G.E., Cohen, T., *et al*. (2021) The Escalating Tuberculosis Crisis in Central and South American Prisons. *The Lancet*, **397**, 1591-1596. https://doi.org/10.1016/S0140-6736(20)32578-2

[6] Walter, K.S., dos Santos, P.C.P., Goncalves, T.O., da Silva, B.O., Santos, A.S., Leite, A.C., *et al*. (2022) The Role of Prisons in Disseminating Tuberculosis in Brazil: A Genomic Epidemiology Study. *The Lancet Regional Health—Americas*, **9**, Article ID: 100186. https://doi.org/10.1016/j.lana.2022.100186

[7] Paião, D.S.G., Lemos, E.F., Carbone, A., Da, S.S., Sgarbi, R.V.E., Junior, A.L., Da Silva, F.M., *et al*. (2016) Impact of Mass-Screening on Tuberculosis Incidence in a Prospective Cohort of Brazilian Prisoners. *BMC Infectious Diseases*, **16**, Article No. 533. https://doi.org/10.1186/s12879-016-1868-5

[8] Ely, K.Z., Dotta, R.M., Jarczewski, C.A., Valim, A.R., De, M. and Possuelo, L.G. (2020)

Diagnóstico bacteriológico de tuberculose na população privada de liberdade: Ações desenvolvidas pelas equipes de atenção básica prisional. *Jornal Brasileiro de Pneumologia*, **46**, e20190179. https://doi.org/10.36416/1806-3756/e20190179

[9] Ahmat, A.I., Hassan, M.T.N., Richard, N.B.N. and Moussa, A.M. (2023) Prévalence de la tuberculose chez les personnes diabétiques en milieu carcéral au tchad. *American Journal of Innovative Research and Applied Sciences*, **17**, 110-116. https://www.american-jiras.com

[10] Sani, K., Mahaman Laouali, H.A., Laminou, A.M., Azize, G.A., Mamane, D., Piubello, A. and Eric, A. (2021) Pulmonary Tuberculosis in Prisons in Niger: Epidemiological, Diagnostic, Therapeutic and Evolutionary Aspects. *European Scientific Journal*, **17**, 41. https://doi.org/10.19044/esj.2021.v17n14p41

[11] Gizachew Beza, M., Hunegnaw, E. and Tiruneh, M. (2017) Prevalence and Associated Factors of Tuberculosis in Prisons Settings of East Gojjam Zone, Northwest Ethiopia. *International Journal of Bacteriology*, **2017**, Article ID: 3826980. https://doi.org/10.1155/2017/3826980

[12] Edge, C.L., King, E.J., Dolan, K. and McKee, M. (2016) Prisoners Co-Infected with Tuberculosis and HIV: A Systematic Review. *Journal of the International AIDS Society*, **19**, 20960. https://doi.org/10.7448/IAS.19.1.20960

[13] Koffi, N., Ngom, A.K., Aka-Danguy, E., Séka, A., Kouassi, N. and Fadiga, D. (1997) Bacilliferous Tuberculosis in Prisons. Our Experience in the Bouaké Penal Camp, Côte d'Ivoire. *The International Journal of Tuberculosis and Lung Disease*, **11**, 250-253.

[14] Auregan, G., Rakotomanana, F., Ratsitorahina, M., Rakotoniaina, N., Rabemananjara, O., Raharimana, R. and Boisier, P. (1995) Tuberculosis in Prisons in Antananarivo from 1990 to 1993. *Archives de l'Institut Pasteur Madagascar*, **62**, 18-23.

[15] Nassik, S., Masmoudi, A., Nafizy, S., Mouine, S., Kouisbahi, A. and Berraho, A. (2018) Atypical Clinical Aspect of Ocular Tuberculosis a Propos D'un Cas. *European Scientific Journal*, **14**, 122. https://doi.org/10.19044/esj.2018.v14n9p122

[16] Kiady, R., Harison, M.T., Davidson, R.I., *et al*. (2017) Diagnostic Delay Factors of Pulmonary Tuberculosis Seen at the Befelatanana Pneumology Care, Training and Research Unit. *European Scientific Journal*, **13**, 413-424. https://doi.org/10.19044/esj.2017.v13n27p413

[17] Melese, A. and Demelash, H. (2017) The Prevalence of Tuberculosis among Prisoners in Ethiopia: A Systematic Review and Meta-Analysis of Published Studies. *Archives of Public Health*, **75**, Article No. 37. https://doi.org/10.1186/s13690-017-0204-x

[18] Bah, H., Cisse, F.A., Camara, L.M., Diallo, O.H., Diallo, M. and Sow, O.Y. (2012) Prevalence of Tuberculosis in Prisons in Conakry, Republic of Guinea. *La Revue de Médecine Légale*, **3**, 146-150. https://doi.org/10.1016/j.medleg.2012.06.003

[19] El Ghazi, I., Berni, I., Menouni, A., Kestemont, M., Amane, M. and Jaafari, S. (2020) Profil Épidémiologique des Pathologies Respiratoires Aux Services de Pneumologie de la Ville de Meknès (Maroc). *European Scientific Journal*, **16**, 274-283. https://doi.org/10.19044/esj.2020.v16n33p274

[20] Adane, K., Spigt, M. and Dinant, G.-J. (2018) Tuberculosis Treatment Outcome and Predictors in Northern Ethiopian Prisons: A Five-year Retrospective Analysis. *BMC Pulmonary Medicine*, **18**, Article No. 37. https://doi.org/10.1186/s12890-018-0600-1

[21] Boukary, A.R., Thys, E., Mamadou, S., *et al*. (2011) *Mycobacterium bovis* Tuberculosis in Sub-Saharan Africa. *Annales de Médecine Vétérinaire*, **115**, 23-37.

[22] World Health Organization (2020) Global Tuberculosis Report 2020. World Health Organization, Geneva.

[23] Cadmus, S. (2007) Bovine Tuberculosis in Nigeria (5-6). *Proceedings of the* 1*st Meeting African Bovine TB Network*: *Effective Management of Bovine Tuberculosis in Africa*: *Towards Adapted Control Policy*, Bamako, June 2012, 23-37.

[24] Jenkins, A.O., Cadmus, S.I.B., Venter, E.H., *et al*. (2011) Molecular Epidemiology of Human and Animal Tuberculosis in Ibadan, South Western Nigeria. *Veterinary Microbiology*, **151**, 139-147. https://doi.org/10.1016/j.vetmic.2011.02.037

[25] Addo, K., Owusu-Darko, K., Yeboah-Manu, D., *et al*. (2007) Mycobacteria Species Causing Pulmonary Tuberculosis at Korle Bu Teaching Hospital, Accra, Ghana. *Ghana Medical Journal*, **41**, 52-57. https://doi.org/10.4314/gmj.v41i2.55293

[26] Rasolofo, R.V., Menard, D. and Rasolonavalona, T. (1999) Prevalence of *Mycobaterium bovis* in Human Pulmonary and Extra Pulmonary Tuberculosis in Madagascar. *The International Journal of Tuberculosis and Lung Disease*, **3**, 632-634.

[27] Balako, G., Schelling, E., Stefan, B., *et al*. (2012) Zoonotic Transmission of Tuberculosis between Pastoralists and Their Livestock in South-East Ethiopia. *EcoHealth*, **9**, 139-149. https://doi.org/10.1007/s10393-012-0754-x

[28] Ngandolo, B.N., Diguimbaye-Djaibe, C., Müller, B., *et al*. (2009) Ante- and Post-Mortem Diagnosis of Bovine Tuberculosis in Southern Chad: The Case of Cattle Destined for Slaughter. *Revue D'élevage et de Médecine Vétérinaire Des Pays Tropicaux*, **62**, 5-12. https://doi.org/10.19182/remvt.10094