Treatment outcomes of drug-susceptible tuberculosis and its predictors among male prison inmates in Bauchi State, Nigeria, 2014-2018

CURRENT STATUS: POSTED

Peter Okpeh Amede
African Field Epidemiology Network

e perosports05@gmail.com

CORRESPONDING AUTHOR

ORCID: https://orcid.org/0000-0002-9200-0379

Elizabeth Adedire
African Field Epidemiology Network

Aishat Usman
African Field Epidemiology Network

Celestine A. Ameh
African Field Epidemiology Network

Faruk S. Umar
Nigerian Prisons Service

Chukwuma David Umeokonkwo
Department of community medicine, Alex Ekwueme Federal University Teaching Hospital Abakiliki, Ebonyi State, Nigeria

Muhammad Shakir Balogun
African Field Epidemiology Network

DOI: 10.21203/rs.2.17443/v2

SUBJECT AREAS

Infectious Diseases Health Economics & Outcomes Research

KEYWORDS

Tuberculosis, Treatment outcomes, Prison inmates, Predictors, Bauchi State, Nigeria
Abstract
Background: Tuberculosis (TB) is a contagious disease and its transmissibility potential is increased in congregate settings like the prisons. TB incidence rates are five to fifty times higher among prison inmates than the general population which has a direct impact on the outcome of TB treatment. There is paucity of information on TB treatment outcomes and its predictors in Nigerian prisons. We therefore assessed TB treatment outcomes among prison inmates in Bauchi State, Nigeria.

Method: We conducted a retrospective data analysis of inmates with TB in the five main prisons in Bauchi State. We extracted sociodemographic, clinical and treatment outcome characteristics from TB treatment register of inmates treated for TB between January 2014 and December 2018, using a standardized checklist. We estimated the TB treatment success rate (TSR) and explored the relationship between the TSR and sociodemographic and clinical characteristics. Related variables were modelled in multiple logistic regression to identify predictors of TSR at 5% level of significance.

Results: All 216 inmates were male with mean (SD) age of 37.6±11.4 years. Seventy-six (35.2%) were cured, 61 (28.2%) completed treatment, 48 (22.2%) were lost to follow-up, 17 (7.9%) were transferred out without evaluation and 14 (6.5%) died. Overall TSR was 72.9%. Predictors of successful treatment outcome were age; 20-29 years (AOR=10.5; 95% CI: 3.2-35.1), 30-39 years (AOR=4.2; 95% CI: 1.3-13.1), pretreatment weight; ≥ 55kg (AOR = 13.3; 95% CI: 6.0-29.6), imprisonment for ≤ 2 years (AOR= 2.6; 95% CI: 1.3-5.4) and being HIV negative (AOR=3.3; 95% CI:1.4-7.8).

Conclusion: The predictors of successful TB treatment outcome were being less than 40 years of age, having a pretreatment body weight of or greater than 55 kg, imprisonment for less than 2 years, and being HIV negative. We recommended that to improve TB TSR among prison inmates; age, duration of imprisonment, weight and TB/HIV co-infection should be the major consideration during pretreatment, psychological and nutritional counselling and a tracking system be developed by the prisons authority to follow-up inmates transferred-out to other health facilities to ensure they complete the treatment and outcomes evaluated.

Background
Tuberculosis (TB) is a preventable and curable disease with effective drugs, despite this, TB has remain a major killer with over 4,500 dying daily from the infection globally.\textsuperscript{1,2} In 2017, TB was reported worldwide as the 10\textsuperscript{th} leading cause of death; with 10 million cases and 1.6 million deaths attributed to the disease.\textsuperscript{3} The high global prevalence of TB is driven by HIV infection, lack of TB diagnostic laboratories, poverty and weak healthcare systems.\textsuperscript{4} Nigeria ranked 7\textsuperscript{th} in the world and 2\textsuperscript{nd} in Africa among the 30 countries with the highest burden of TB, in 2017.\textsuperscript{3} Tuberculosis transmissibility potential is increased in congregate settings such as prisons due to a high prevalence of HIV infection among prison inmates, overcrowding, poor nutrition, poor hygiene, prolonged indoor confinement without adequate ventilation and limited access to healthcare.\textsuperscript{5-8} Overcrowding in Nigerian prisons has been on a steady rise; the total prison population in 2018 was 73,631 up from 44,450 in 2000 and 57,313 in 2015 without a corresponding expansion of the capacity of the prisons.\textsuperscript{9} Globally, TB burden among prison inmates is 5-50 times higher than among the general population and is estimated to be the leading cause of death among prison inmates.\textsuperscript{10} A case of active Pulmonary TB (PTB) can infect 10-15 persons over the course of a year, this might be higher among prison population due to overcrowding and prolonged close contacts.\textsuperscript{11,12} In sub-Saharan African prisons, TB remains one of the fastest growing infectious diseases.\textsuperscript{12-14} The goal of TB treatment is to cure those infected, prevent deaths from the disease and stop transmission of tubercle bacilli from infected individual to the host community.\textsuperscript{15} Treatment outcome is influenced by socio-demographic characteristics, socio-economic factors (such as poverty, housing), nutrition, HIV coinfection, Multi-Drugs Resistant TB (MDR-TB), and strategies for TB management including Directly Observed Treatment short (DOTS) course.\textsuperscript{2,16,17} Tuberculosis treatment success is the sum of cured and treatment completed, and unsuccessful TB treatment outcome is the sum of treatment failure, lost to follow-up, transferred out and died. Treatment Success Rate (TSR) is the percentage of all new TB cases in a given year that successfully completed treatment with bacteriological evidence (cured) or without bacteriological evidence
(treatment completed) of success among all who commenced the treatment. The numerator are TB cases that successfully completed treatment and the denominator are the new cases. World Health Organization (WHO) set ≥ 90% as the global target for TSR to eliminate TB as a global public health concern and a cure rate of ≥85%.\textsuperscript{18} The TB TSR globally was 83% in 2017 and the corresponding TSR for sub-Saharan Africa was 76%.\textsuperscript{16,18} In 2015, TB TSR in Nigeria was 84% below the WHO target, and ranked 84\textsuperscript{th} in the global rating and 23\textsuperscript{rd} in Africa.\textsuperscript{19}

TB TSR among prison inmates in the European region in 2015 was 59.7%, likewise a study in 2017 among 162 prison inmates with TB in Ethiopia, reported TSR of 63.62%.\textsuperscript{19,20} No available data for TB TSR among prison population in Nigeria.

The prison population is a dynamic and unstable one and this might impact negatively on TB treatment outcomes. Poorly treated TB case in the prison could compound TB burden within the prison and increase the risk of MDR-TB outbreaks in the general population; however, there is limited information about TB treatment outcome among prison inmates in Nigeria. Assessing TB treatment outcome and identifying possible predictors of successful outcome could reveal gaps in the TB treatment programme in the prison and this will help policy makers to institute evidence based interventions in the prisons. We therefore conducted this study to assess TB treatment outcomes and its predictors among prison inmates in Bauchi State, Nigeria.

\textbf{Methods}

\textbf{Study setting, diagnostic criteria and treatment regimen}

The study was conducted in all the five main prisons (Bauchi, Azare, Ningi, Misau and Jama‘are) in Bauchi State. The prisons housed both male and female inmates and lock-up above its maximum capacity and the holding cells are usually overcrowded. The maximum capacity of Bauchi prison is 500, Azare 320, Misau 120, Ningi 110 and Jama‘are 151. At the time of the study the total inmates’ population was 2106 out of this figure, eleven were females. Bauchi prison had 1006 inmates, Azare 501, Misau 204, Ningi 159 and Jama‘are 236. The prisons have clinics with various cadre of healthcare workers (Doctor, nurses, community health officers, pharmacy assistant, dental assistant,
community health extension workers, laboratory technologists and radiographer) that provides mainly
curative services for inmates, staff and staff relations. These prisons clinic were poorly equipped with
no Gene Xpert, sputum microscopy or drug susceptibility testing services. TB diagnosis in these
prisons relied mainly on referral of inmates with presumptive TB to public health facilities outside the
prisons. Bauchi prison refer to State specialist hospital, Bauchi; Azare prison to federal medical
center, Azare; Ningi, Jama’are and Misau prisons refer to Ningi, Jama’are and Misau general hospital
respectively. Presumptive TB case is an inmate with cough of ≥ 2 weeks with at least one of the
following symptoms; fever, night sweats, shortness of breath, chest pain, haemoptysis and or
unintentional weight loss. The diagnosis was carried out at the referral hospitals using Gene X-pert
MTB/RIF rapid diagnostic test or the direct smear microscopy and/or chest X-ray, and
histopathological investigation. A presumptive TB case positive for Gene X-pert, or with at least two
sputum smear positive for AFB (Acid Fast Bacilli) by direct smear microscopy or one sputum smear
positive for AFB with radiological abnormalities consistent with active pulmonary TB is considered as a
smear positive TB case. A presumptive TB case negative for Gene X-pert, or all three sputum samples
negative for AFB by direct smear microscopy and with radiological abnormalities consistent with
pulmonary TB is considered as a smear negative TB case. An inmate with TB of other organs outside
the lungs as detected by tissue biopsy or based on strong clinical evidence consistent with active
extra-pulmonary TB.

Prison inmates diagnosed of TB by the public health facilities are placed on Anti-TB drugs for the full
course depending on the treatment category but continued the treatment in the prisons under the
supervision of the TB desk officers, who also kept the TB treatment cards. Inmates diagnosed with TB
are kept in isolation cells within the prisons during the intensive phase of treatment and the drugs are
administered through the DOTS strategy. The treatment is based on new or retreatment TB cases;
new cases (treatment category 1) received 6 months treatment regimen of two months of intensive
phase of combination of four drugs (Rifampicin, Isoniazid, Pyrazinamide and Ethambutol) and four
months of continuation phase of two drugs (Rifampicin and Isoniazid) while previously treated cases
(category 2) received 8 months regimen consisting of two months treatment with Streptomycin,
Rifampicin, Isoniazid, Pyrazinamide and Ethambutol followed by a month treatment of Rifampicin, Isoniazid Pyrazinamide and Ethambutol during the intensive phase followed by five months continuation phase with Rifampicin, Isoniazid and Ethambutol. The dosage of the drugs depends on the patient’s pre-treatment weight. Follow-up bacteriological test is done during treatment at the end of second, fifth and sixth months for all new sputum smear positive cases and at the end of the third, fifth and eight months of treatment for previously treated sputum smear positive cases. Weight follow-up measurements are done at the end of the second, fifth and at the end of the last month of treatment. Inmates on Anti-TB are not allowed to be transferred to other prisons but those discharged from prisons are given transfer form by the desk officer to the nearest DOTS center to the inmate’s residence. These inmates are not followed up to know if they actually reported to the DOTS center or continued the treatment. All presumptive TB cases are counselled and tested for HIV using determine (rapid HIV test kit), positive cases were confirmed with Stat-Pak (rapid HIV diagnostic kits), while Uni-Gold recombinant assay is used as tie-breaker for discordant results.

**Study design and population**

We conducted a review of the treatment outcomes of all prison inmates treated for TB from January 2014 to December 2018 in all five prisons in Bauchi State. All prison inmates treated for TB with Anti-TB drugs from January 2014 to December 2018 were included. Inmates with missing variable(s) of interest in the TB treatment register were excluded (Figure 1).

**Data tool and collection**

The data source was the TB treatment register and patient health records in the five selected prisons. Data were extracted using a structured checklist. The checklist collected information on age, pretreatment weight, duration of imprisonment, TB class (Smear Positive Pulmonary Tuberculosis [SPPTB], Smear Negative Pulmonary Tuberculosis [SNPTB], Extra-Pulmonary Tuberculosis [EPTB]), treatment category (New, Retreatment, Unknown), HIV status, treatment outcomes (cured, treatment completed, failure, lost to follow-up, transferred out and died), from the TB treatment registers in the various study prisons by five trained healthcare workers (HCWs). The five HCWs (one from each prison) were trained for a day on how to collect the data and use the checklist. The principal
researcher daily reviewed the filled format and strictly supervised the trained research assistants. Data were collected over a period of five weeks. Each prison was assigned a week; this enabled the researcher to supervise the process of data abstraction.

**Measurement**

The dependent variable (treatment outcome) was dichotomized as successful (cured and treatment completed) and unsuccessful (treatment failure, lost to follow-up, transferred out and died) and the independent variables were socio-demographic characteristics (age, weight, duration of incarceration) and clinical characteristics (HIV status, TB class and treatment history). The following operational definitions were adopted from WHO for drug-susceptible TB.\(^{21}\)

Cured: A PTB case with bacteriologically confirmed TB at the beginning of treatment who was smear or culture negative in the last month of treatment and on at least one previous occasion.

Treatment completed: A TB case who completed treatment without evidence of failure but without records to show that sputum smear or culture results in the last month of treatment and on at least one previous occasion were negative, either because tests were not done, or results were unavailable.

Treatment failure: A TB case whose sputum smear or culture is positive at month 5 or later during treatment.

Lost to follow-up: A TB case who did not start treatment or whose treatment was interrupted for two consecutive months or more.

Not evaluated: A TB case for whom no treatment outcome is assigned. This includes cases transferred out to another treatment unit as well as cases for whom the treatment outcome is unknown to the reporting unit.

Died: A TB case who dies for any reason during treatment.

New TB patient: A TB case who has not previously been treated for TB and is now diagnosed and has started the current treatment.

Relapse/Retreatment: A TB case who was previously treated for TB and was declared cured and now diagnosed and started the current treatment.
Data analysis

Extracted data were checked for its completeness, correctness and analyzed using Epi-info software version 7.2.2.6. Descriptive statistics was used to generate summary frequencies, percentages, and means. Bivariate analysis was performed to measure association between treatment outcome and independent variables. Covariates with p-value of ≤ 0.2 in the bivariate analysis were included in the multiple logistic regression model to identify predictors of treatment outcomes at 95% confidence intervals (CIs).

Ethical consideration

Ethical approval was obtained from the Bauchi State Health Research Ethics Committee. Permission was sought and obtained from the Controller of Prisons, Bauchi State command, where the aim and objectives of the study were explained. The information obtained was made anonymous and de-identified prior to analysis to ensure confidentiality.

Results

Out of 228 TB patients treated for TB during the period, only 216 (95%) had complete variable of interest and were therefore used for the analysis (Figure 1). Although there were few female inmates, all of the 216 TB patients registered during the study period were males.

The mean age (SD) was 37.6±11.4 years. The mean (SD) weight was 55.2±9.8kg with 98 (72.1%) having weight ≥ 55kg, 97 (44.9%) were incarcerated in Bauchi prison, the median (IQR) duration of imprisonment was 21 months (14-28 months) and 134 (62.0%) were imprisoned for less than 2 years (Table 1). One hundred and eighty-eight (87.0%) were newly diagnosed, 152 (70.3%) were SPPTB and 46 (21.3%) TB patients were co-infected with HIV (Table 2).

Seventy-six (35.2%) were cured while 61 (28.2%) had completed treatment, with no treatment failure recorded during the study period. Forty-eight (22.2%) were lost to follow-up, 17(7.9%) were transferred out without evaluation and 14 (6.5%) patients died. (Figure 2)

The overall TSR was 72.9%. The highest TSR was observed in Azare prison (82.9 %) and the lowest in Jama’are prison (57.1 %), Bauchi prison (78.1%), Ningi prison (70.8%) and Misau prison (57.9%), over the five year-period. The difference in the treatment outcome across the five prisons formation was
not statistically significant p= 0.158 (Figure 3)

The trend in TSR of all TB patients decreased from (79.5 %) in 2014 to (76.8 %) in 2015, to (69.5 %) in 2016, further down to (58.4 %) in 2017 and rose to (77.8 %) in 2018. (Figure 4) TSR was higher in HIV negative patients (77.1 %) compared with HIV positive patients (57.1 %) p≤ 0.001; SPPTB (73.4%), compared to SNPTB (60.0 %) and EPTB (57.1 %) P≤ 0.001 TSR was higher among age group 20-29 years (89.5%), compared to 30-39 years (83.1%), 40-49 years (56.8%), lowest among age group ≥50years (42.9%); p≤ 0.001 and in those with weight ≥55kg (99.0%) compared to <55kg (43,2%); p≤ 0.001.

The TSR for TB cases that were evaluated excluding those lost to follow-up and transferred out was 95.1%.

The Odds of having successful treatment outcome was higher among the younger age groups compared to older age; 20-29 years (AOR=10.5; 95% CI: 3.2-35.1), 30-39 years (AOR=4.2; 95% CI: 1.3-13.1), and higher among TB patients with heavier weight; ≥55kg (AOR=13.3; 95%CI: 6.0 – 26.8), those imprisoned for ≤2years had a 2.3 times odds of successful treatment than those who were imprisoned for >2years (AOR=2.3; 95%CI=1.1-4.9). TB patients who were not co-infected with HIV were more likely to have a successful treatment outcome compared to those co-infected with HIV (AOR=3.3; 95% CI: 1.4-7.8). TB treatment history, year of enrollment into treatment, prisons formation and TB class were not predictors of successful treatment outcomes. (Tables 3&4)

Discussion
This paper describes TB treatment outcome and its predictors among male prison inmates in Bauchi State. We found a high treatment success rate among the inmates. The high TSR could be due to the dedication of trained TB desk officers in all the prisons with administration of the drugs under strict supervision and the inmates are readily accessible to the desk officers. This rate though high was still below the national and international recommended minimum level for treatment success. This may not be unrelated to overcrowding, the poor sanitary condition of the prisons and the mobile nature of the inmates as they are transferred out without evaluation. The risk of reinfection could be high, likewise the risk of treatment interruption resulting in treatment failure.
An effective TB control programme is determined mainly by access to TB treatment. Tuberculosis treatment is free for prison inmates in Nigeria as it is for the general population but the prisons is known to cause TB treatment interruption resulting in poor treatment outcomes. The high rate of lost to follow-up and transferred out without evaluation negatively impacted on the TSR. The TSR was 95.1% after excluding TB cases that were not evaluated, indicating the negative impact of this on the TSR in this study.

The cure rate in this study is higher than the studies conducted in Northern Ethiopian prisons and in North Shoa, Ethiopia but lower than that recorded in El-Salvador prison.\textsuperscript{20,22,23} The low cure rate in this study compared to the El-Salvador study could be attributed to the lower sample size in this study and the high rates of loss to follow-up and transferred-out, since there was no system to track their progress, the final treatment outcomes of these patients were not known, so were not evaluated.

All the TB patients studied were males, this is similar to the study among prison inmates in North Shoa Ethiopia.\textsuperscript{20} The prison population are predominantly male and most prisons are male only institutions, including prisons staff. Worldwide, females makes-up just 7% of prison population, and is much lower in African countries including Nigeria.\textsuperscript{24} Female inmates constitute 2% of the total prison population in Nigeria.\textsuperscript{24} Over three-fifth of the patients studied were in the age group <40 years, this is similar to other findings among prison inmates with TB in North Shoa, Ethiopia but lower than that found among prison inmates in North West province, South Africa and in the general population in Western Ethiopia.\textsuperscript{10,20,25} This could be so because of high mobility, high criminal activities and imprisonment among this age group.

Tuberculosis TSR provides a useful indicator of the quality of health services. A low rate suggests that infectious patients may not be receiving adequate treatment and stand the risk of developing drug resistant TB and could serve as a potential reservoir for the transmission of MDR-TB. The overall TSR for this study is lower than the WHO set target and the Nigerian national average but similar to the rate among prison inmates in Ethiopia and higher than the rate among inmates in Uganda\textsuperscript{20,26,27,28}
The lower TSR in this study compared to the WHO target and the Nigeria national average results from the large number of TB patients lost to follow-up and transferred-out without evaluation of their treatment outcomes, and the significant cases of TB/HIV coinfection which is a predictor for poor TB treatment outcome in this study.

We found out that age, duration of imprisonment, weight and HIV status were predictors of successful TB treatment outcome in this study. The odds of successful treatment outcome decrease with advancing age, this is comparable with the study in Zimbabwe on age-stratified tuberculosis treatment outcomes, where the elderly had a poorer treatment outcome compared to the younger patients. This might be due to better immune response among the younger age group and probably other associated comorbidities among the older age group. Duration of incarceration was significantly associated with successful treatment outcome, this is similar to the finding among inmates in Ethiopia prisons. This similarity could be attributed to poor adherence to treatment protocol due to difficulty of prison life and mental stress associated with prolonged incarceration. The odds of successful treatment outcome increase with heavier body weight. Similarly, a study in Ethiopia revealed that pretreatment weight category of 55.0-70.9kg and ≥71.0kg were significantly associated with successful treatment outcome. This might be explained by undernutrition which increases the risk of advanced TB disease and lowers immune response, resulting to poor treatment outcome. This study revealed that TB/HIV coinfection was associated with poor treatment outcome. HIV negative TB patients had a higher odds of successful treatment outcome compared to HIV positive TB patients. This is in contrast to finding among prison inmates in northern Ethiopia where HIV coinfection was not associated with treatment outcomes but similar to that in Ethiopian university hospital. This could be attributed to the immune compromised associated with both disease, poor adherence to drugs due to large daily pills intake and the negative drug-to-drug interaction between Anti-TB and Anti-Retroviral drugs.

Our study is limited by our inability to add other variables of interest which were not in the TB treatment register and may influence the treatment outcome such as height so we couldn’t calculate
Body Mass Index (BMI), educational status, cigarette smoking, comorbidity, substance use as the study relied on historical records. Also data analysis from historical records might affect the validity of the results and the study used 5.4% of the national inmates’ population which might affect the generalizability of the study. For the purposes of understanding the predictors of treatment outcome of drug-susceptible TB among prison inmates in Bauchi State, the sample was adequate.

Conclusion
This study demonstrated that TB treatment success rate among prison inmates in Bauchi state was lower than the recommended WHO target. The TSR in this study was significantly influenced by age, duration of imprisonment, pretreatment body weight and HIV status, hence to improve TB TSR among prison inmates, these factors should be the major consideration during pretreatment, psychological and nutritional counselling and the prison authority should develop a follow-up strategy to track inmates with TB transferred-out or discharged from prison while on treatment, this has impacted negatively on the treatment outcome and has implication for TB control programme with the risk of those who interrupted treatment developing drug-resistant TB and could serve as reservoir for the transmission of resistant strains to contacts. Dissemination meeting was held with the TB desk officers and the superintendents of the five-prisons where findings were communicated for sensitization and resolutions reached for improved treatment outcome.

Abbreviations

- **EPTB**: Extra Pulmonary Tuberculosis
- **HCW**: Healthcare Worker
- **HIV**: Human Immunodeficiency Virus
- **MDR**: Multi-Drug Resistant
- **SD**: Standard Deviation
- **SNPTB**: Smear Negative Pulmonary Tuberculosis
- **SPPTB**: Smear Positive Pulmonary Tuberculosis
- **TB**: Tuberculosis
- **TSR**: Treatment Success Rate

Declarations
Ethics approval and consent to participate

Ethical approval was obtained from ethical committee of Bauchi State Ministry of Health. Consent to participate is not applicable.

Availability of data and material

The data generated and used for this research is available from the corresponding author on reasonable request.

Competing interest

The authors have no conflict of interest to declare.

Funding

The authors did not receive any funding for this work.

Author’s Contribution

Conceptualization: Peter Amede, Faruk S.Umar

Data curation: Peter Amede, Faruk S. Umar

Formal analysis: Peter Amede, Aishat Usman, Elizabeth Adedire, Celestine Ameh, Muhammad Shakir Balogun, Chukwuma Umeokonkwo

Methodology: Peter Amede, Aishat Usman, Elizabeth Adedire, Celestine Ameh, Muhammad Shakir Balogun, Chukwuma Umeokonkwo

Writing - review and editing: Peter Amede, Aishat Usman, Elizabeth Adedire, Celestine Ameh, Muhammad Shakir Balogun, Chukwuma David Umeokonkwo

Consent for publication

Not applicable

Acknowledgement

The authors thank the Controller and staff of the Bauchi State prisons service for their support and the research assistants for helping to abstract information from the TB registers. We also thank the Nigeria Field Epidemiology and Laboratory Training Program.

References

1. World Health Organization (WHO): World tuberculosis day; 2018 available
2. Park K. Epidemiology of communicable diseases: Tuberculosis. Park’s Textbook of Preventive and Social Medicine, 23rd Edition; 2015. Pg176

3. World Health Organization (WHO): Global TB report. Geneva, Switzerland; 2018.

4. Reid SE, Topp SM, Turnbull ER, et al. Tuberculosis and HIV Control in sub-Saharan African prisons: ‘thinking outside the cell’. J infectious Diseases. 2012; 205(suppl 2): S265-273

5. World Health Organization (WHO): Tuberculosis in prisons. Geneva; 2011

6. Baussano I, Williams BS, Nunn P, et al. Tuberculosis incidence in the prison: a systematic review. Plos Med. 2010; 7: e1000381

7. Dara M, Grzemska M, Kimerling ME, Reyes H, Zagorskiy A. Washington DC, USA. The Global Health Bureau office of Health, Infectious Disease and Nutrition (HIDN), US Agency for International Development; 2009.

8. Nolan CM, Blumberg HM, Taylor Z, et al. Controlling tuberculosis in the United States. AM J Respiratory Critical Care Medicine. 2005; 172:1169-1227.

9. World Prison Brief: The world prison population list. Institute for Criminal Policy Research (ICPRR); 12th Birkbeck publishers, University of London. September, 2018. [Online database]. Available at https://www.prisonstudies.org Accessed on 2/03/2019

10. Muluye AB, Kebamo S, Teklia T, Alemkere G. Poor treatment outcomes and its determinants among tuberculosis patients in selected health facilities in East Wollega, Western Ethiopia. PLoS ONE. 2018; 13(10): e0206227. Available @https://doi.org/10.1371/journal.pone.0206227

11. United Nations Office on Drugs and Crime (UNODC). Persisting challenges and emerging strengths: findings and recommendations. Vienna, Austria; 2009. Report on
the UNODC prisons assessment mission to Uganda.

12. O’ Grady J, Mwaba P, Bates M, Kapata N, Zumla A. Tuberculosis in prisons in sub-Saharan Africa, a potential time bomb. S Afri Med Journal. 2011; 101(2): 107

13. O’ Grady J, Hoelscher M, Atun R, et al. Tuberculosis. S Afri Med Journal. 2011; 91(3):173-178

14. Todrys KW, Amon JJ, Malembeka G, Clayton M. Imprisoned and Imperiled: Access to HIV and TB prevention and management and denial of human rights in Zambian prisons, J Intl AIDS Society. 2011; 14:1-11

15. Todrys KW, Amon JJ. Criminal Justice Reform as HIV and TB prevention in African prisons. Plos Med. 2012;9:e1001215

16. Jordan TS, Davis PD. Clinical tuberculosis and treatment outcomes. International J of tuberculosis and lung disease. 2010;14(6):683-688

17. Vesosky B, Turner J. The influence of age on immunity to infection with Mycobacterium tuberculosis. Immunological reviews. 2005; 205:229-243

18. Global tuberculosis report. Geneva Switzerland; 2015

19. World Health Organization (WHO): Global TB report: TB treatment success rate-country ranking. Geneva Switzerland; 2017.

20. Yonas AB, Teklehaimanot MN, Gebremedhin BG. Prevalence of Tuberculosis and Treatment Outcomes of Patients with Tuberculosis among inmate in Debrebirhan prison, North Shoa Ethiopia. Ethiopian J of Health Science. 2018; 28(3):347-354

21. World Health Organization. Definitions and reporting framework for tuberculosis - 2013 revision. Multi-country global workshop on TB surveys and surveillance, 29 April - 3 May 2013, Accra.

22. Kelemework Adane, Spigt MG, Geert-Jan. Tuberculosis treatment outcome and predictors in northern Ethiopian prisons: A five-year retrospective analysis. BMC
Pulmonary Medicine. 2018; 18(1):13

23. Ayala G, Garay J, Aragon M, Decroo T, Zachariah R. Trends in tuberculosis notification and treatment outcomes in prisons: a country wide assessment in El Salvador from 2009-2014. Rev Panam Salud publica. 2016; 39(1):38-43

24. World Prison Brief. World female imprisonment list. 4th edition; 2017. Available at https://www.prisonstudies.org>world_female_prison_4th_edn_V4_web Accessed 19/02/2019

25. Tirhani I. Mnisi, John T, Indiran G. Factors associated with pulmonary tuberculosis outcomes among inmates in Potchefstroom prison in North West province. Southern African Journal of epidemiology and infection. 2013;28(2):96-101

26. World Health Organization (WHO): TBFACTS.ORG; End TB Strategy 2016-2035. Available @https://www.tbfacts.org>end-tb Last accessed 11/01/2019

27. World Health Organization (WHO). Global tuberculosis report. Geneva; 2017 Available @http://www.who.int/tb/publications/global_report/en/

28. Schwitters A, Kaggwa M, Omiel P, Nagadya G, Kisa N, Dalal S. Tuberculosis and treatment completion among Ugandan prison inmates. Int J Tuberc Lung DIS.2014; 18(7):781-786

29. Ncube RT, Takarinda KC, Zishiri C et al. Age-stratified tuberculosis treatment outcomes in Zimbabwe: are we paying attention to the most vulnerable? Public Health Action. 2017; 7(3): 212-217

30. Minaleshewa B, Yiman B, Hailay A, Biruk S, Zewdu F. Treatment outcomes of Tuberculosis and associated factors in an Ethiopian University Hospital. Advances in Public Health. 2016; Vol. 2016, Article ID 8504629, 9 pages. Available at http://dx.doi.org/10.1155/2016/8504629 Last accessed 20/01/2019
Tables

Table 1: Sociodemographic characteristics and successful treatment outcome of TB patients treated in five main prisons in Bauchi State from January 2014 to December 2018 (n=216)

| Variable             | Frequency (%) | Successful n (%) | Unsuccessful n (%) |
|----------------------|---------------|------------------|--------------------|
| **Age (years)**      |               |                  |                    |
| 20-29                | 64 (29.6)     | 51 (79.7)        | 13 (20.3)          |
| 30-39                | 68 (31.5)     | 49 (72.1)        | 19 (27.9)          |
| 40-49                | 50 (23.2)     | 25 (50.0)        | 25 (50.0)          |
| ≥50                  | 34 (15.7)     | 11 (32.3)        | 23 (67.7)          |
| **Weight (kg)**      |               |                  |                    |
| ≥50                  | 111 (51.4)    | 98 (72.1)        | 13 (16.2)          |
| <50                  | 105 (48.6)    | 38 (27.9)        | 67 (83.8)          |
| **Duration of imprisonment** |       |                  |                    |
| ≤2 years             | 134 (62.0)    | 99 (72.8)        | 35 (43.8)          |
| >2 years             | 82 (38.0)     | 37 (27.2)        | 45 (56.2)          |
| **Prison formation** |               |                  |                    |
| Azare                | 40 (18.5)     | 29 (21.4)        | 11 (13.8)          |
| Bauchi               | 97 (44.9)     | 63 (46.2)        | 34 (42.5)          |
| Jama’are             | 30 (13.9)     | 16 (11.8)        | 14 (17.5)          |
| Misau                | 24 (11.1)     | 11 (8.1)         | 13 (16.2)          |
| Ningi                | 25 (11.6)     | 17 (12.5)        | 8 (10.0)           |
| **Year of enrolment**|               |                  |                    |
| 2014                 | 54 (25.0)     | 36 (26.1)        | 18 (23.1)          |
| 2015                 | 64 (29.6)     | 43 (31.2)        | 21 (26.9)          |
| 2016                 | 42 (19.5)     | 27 (19.6)        | 15 (19.2)          |
| 2017                 | 34 (15.7)     | 18 (13.0)        | 16 (20.5)          |
| 2018                 | 22 (10.2)     | 14 (10.1)        | 8 (10.3)           |

Table 2: Clinical characteristics and successful treatment outcome of TB patients treated in five main prison formation in Bauchi State from January 2014 to December 2018 (n=216)

| Variable             | Frequency (%) | Successful n (%) | Unsuccessful n (%) |
|----------------------|---------------|------------------|--------------------|
| **Treatment history**|               |                  |                    |
| New                  | 188 (87.0)    | 124 (89.9)       | 64 (82.1)          |
| Retreatment          | 6 (2.8)       | 3 (2.2)          | 3 (3.9)            |
| Unknown              | 22 (10.2)     | 11 (8.0)         | 11 (14.0)          |
| **HIV status**       |               |                  |                    |
| Positive             | 46 (21.3)     | 19 (13.4)        | 27 (33.7)          |
| Negative             | 170 (78.7)    | 123 (86.6)       | 47 (66.3)          |
| **TB class**         |               |                  |                    |
| SPPTB**              | 152 (70.4)    | 103 (74.6)       | 49 (62.8)          |
| SNPTB+               | 43 (19.9)     | 21 (15.2)        | 22 (28.2)          |
| EPTB                 | 21 (9.7)      | 14 (10.2)        | 7 (9.0)            |

**Smear Positive Pulmonary Tuberculosis
+Smear Negative Pulmonary Tuberculosis; E Extra Pulmonary Tuberculosis**

Table 3: Socio-demographic and clinical variables associated with treatment outcome of tuberculosis
in five main prisons in Bauchi State from January 2014 to December 2018

| Variable                          | Successful n (%) | Unsuccessful n (%) | cOR          | P-val |
|-----------------------------------|------------------|--------------------|--------------|-------|
| **Age (years)**                   |                  |                    |              |       |
| 20 – 29                           | 51 (37.5)        | 13 (16.3)          | 8.2 (3.2 – 21.0)* | p≤0.0 |
| 30 – 39                           | 49 (36.0)        | 19 (23.7)          | 5.4 (2.2 – 13.2)* |       |
| 40 – 49                           | 25 (18.4)        | 25 (31.2)          | 2.1 (0.8 – 5.2)  |       |
| ≥50                               | 11 (8.1)         | 23 (28.8)          | 1            |       |
| **Weight (kg)**                   |                  |                    |              |       |
| ≥55                               | 98 (72.1)        | 13 (16.2)          | 13.3(6.6–26.8)* | p≤0.0 |
| <55                               | 38 (27.9)        | 67 (83.8)          | 1            |       |
| **Duration of imprisonment**      |                  |                    |              |       |
| ≤ 2years                          | 99 (72.8)        | 35 (43.8)          | 3.4 (1.9 – 6.2)* | p≤0.0 |
| >2years                           | 37 (27.2)        | 45 (56.2)          | 1            |       |
| **Prison formation**              |                  |                    |              |       |
| Bauchi                            | 63 (46.2)        | 34 (42.5)          | 1.4 (0.6 – 3.2) | p=0.1 |
| Jama‘are                          | 16 (11.8)        | 14 (17.5)          | 2.3 (0.9 – 6.3) |       |
| Misau                             | 11 (8.1)         | 13 (16.2)          | 3.1 (1.1 – 9.0) |       |
| Ningi                             | 17 (12.3)        | 8 (10.0)           | 1.2 (0.4 – 3.7) |       |
| Azare                             | 29 (21.4)        | 11 (13.8)          | 1            |       |
| **Year of enrollment**            |                  |                    |              |       |
| 2014                              | 36 (26.5)        | 18 (22.5)          | 1.1 (0.4 – 3.2) | p=0.6 |
| 2015                              | 41 (30.1)        | 23 (28.8)          | 1.2 (0.4 – 3.2) |       |
| 2016                              | 27 (19.9)        | 15 (18.7)          | 1.0 (0.4 – 3.0) |       |
| 2017                              | 18 (13.2)        | 16 (20.0)          | 0.6 (0.2 – 1.9) |       |
| 2018                              | 14 (10.3)        | 8 (10.0)           | 1            |       |
| **Treatment history**             |                  |                    |              |       |
| New                               | 124 (91.2)       | 64 (80.0)          | 1.9 (0.8 – 4.7) | p=0.2 |
| Retreatment                       | 3 (2.2)          | 3 (3.8)            | 1.0 (0.2 – 6.1) |       |
| Unknown                           | 9 (6.6)          | 13 (16.2)          | 1            |       |
| **HIV status**                    |                  |                    |              |       |
| Positive                          | 17 (12.5)        | 29 (36.3)          | 1            | p≤0.0 |
| Negative                          | 119 (87.5)       | 51 (63.7)          | 4.0 (2.0 – 7.9)* |       |
| **TB class**                      |                  |                    |              |       |
| SPPTB                             | 103 (78.7)       | 49 (61.3)          | 1.1 (0.4 – 2.8) | p=0.0 |
| SNPTB                             | 19 (13.0)        | 24 (30.0)          | 0.4 (0.1 – 1.2) |       |
| EPTB                              | 14 (10.3)        | 7 (8.7)            | 1            |       |

*Statistically significant

Table 4: Predictors of successful treatment outcome of tuberculosis in five main prisons in Bauchi State from January 2014 to December 2018
| Variables                              | Successful n (%) | Unsuccessful n (%) | c |
|---------------------------------------|------------------|--------------------|---|
| Age (years)                           |                  |                    |   |
| 20-29                                 | 51 (79.7)        | 13 (20.3)          | 8.2 (3) |
| 30-39                                 | 49 (72.1)        | 19 (27.9)          | 5.4 (2) |
| 40-49                                 | 25 (50.0)        | 25 (50.0)          | 2.1 (1) |
| ≥50                                   | 11 (32.3)        | 23 (67.7)          |   |
| Duration of imprisonment              |                  |                    |   |
| ≤2 years                              | 99 (72.8)        | 35 (43.8)          | 3.4 (1) |
| >2                                    | 37 (27.2)        | 45 (56.2)          |   |
| HIV status                            |                  |                    |   |
| Positive                              | 19 (14.0)        | 27 (33.7)          | 4.0 (1) |
| Negative                              | 117 (86.0)       | 47 (66.3)          |   |
| Weight (kg)                           |                  |                    |   |
| ≥50                                   | 98 (72.1)        | 13 (16.2)          | 13.3 (6.6-2) |
| <50                                   | 38 (27.9)        | 67 (83.8)          |   |
| Prison formation                      |                  |                    |   |
| Bauchi                                | 63 (46.2)        | 34 (42.5%)         | 3.1 (1) |
| Jama’are                              | 16 (11.8)        | 14 (17.5)          | 1.2 (1) |
| Misau                                 | 11 (8.1)         | 13 (16.2)          | 2.3 (1) |
| Ningi                                 | 17 (12.5)        | 8 (10.0)           |   |
| Azare                                 | 29 (21.4)        | 11 (13.8)          |   |
| TB class                              |                  |                    |   |
| SPPTB                                 | 103 (78.7)       | 49 (61.3)          | 1.1 (0) |
| SNPTB                                 | 19 (13.0)        | 24 (30.0)          | 0.4 (0) |
| EPTB                                  | 14 (10.3)        | 7 (8.7)            |   |

* Statistically significant; cOR-Crude Odds Ratio; aOR-Adjusted Odds Ratio

SPPTB- smear positive pulmonary TB; SNPTB- smear negative pulmonary TB

EPTB- extra-pulmonary TB

Figures

![Data collection flowchart](image-url)

Figure 1

Data collection flowchart
Figure 2

Treatment outcome of TB cases in the five main prisons in Bauchi State from January 2014 to December 2018
Figure 3

Treatment success rates of TB patients in the five main prisons in Bauchi State from January 2014 to December 2018
Figure 4

Trends of treatment success rates of TB patients in five main prisons in Bauchi State from January 2014 to December 2018