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Prevalence of Tuberculosis and Human Immunodeficiency Virus in Zambian correctional facilities

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Key words: Correctional facilities, Tuberculosis, HIV, Zambia

ABSTRACT

Objective: To determine the prevalence of Tuberculosis (TB) and Human Immunodeficiency virus (HIV) in Zambian correctional facilities.

Methods: Cross sectional study

Setting: 13 correctional facilities in 7 of the 10 provinces in Zambia.

Participants: All incarcerated individuals were eligible for TB and HIV screening and testing. Of the total population of 9,699 individuals, 8,271 and 8,164 were screened for TB and HIV respectively.

Interventions: Mass and entry screening in correctional facilities was done between July 2018 and February 2019.

Primary outcome measures: All forms of TB, bacteriologically confirmed TB, drug resistant TB, HIV

Results: Prevalence of all forms of TB and bacteriologically confirmed TB was 1598 per 100,000 population and 1056 per 100,000 population, respectively. Among those with bacteriologically confirmed TB, 4.6% had drug resistant TB. The prevalence of HIV was 14.3%.

Conclusion: Prevalence of all forms of TB and HIV in correctional facilities has reduced by about 75% and 8.6% respectively. However, the prevalence of all forms of TB and HIV was 3.5 and 1.3 times higher than in the general population, respectively. TB/HIV programs in correctional facilities need further strengthening.

ARTICLE SUMMARY

Strengths and limitations of this study

- Results are generalisable as a large sample was screened.
- Variations in TB screening algorithms could have underestimated TB prevalence.
- Asymptomatic TB was not consistently screened for.

INTRODUCTION

Globally, correctional facilities are disproportionately affected by tuberculosis (TB) and the Human Immunodeficiency Virus (HIV). (1-3) In some correctional facilities: the prevalence of TB has been reported to be up to 100 times higher than the prevalence in the general population (1) while the prevalence of HIV has been reported to be up to 23 times higher than the prevalence in the general population(3). Much as the living conditions in correctional facilities perpetuate TB and HIV (4, 5), incarcerated people also often come from socio-economically disadvantaged backgrounds where the burden of TB and HIV is already high. (1, 3)

The prevalence of all forms of TB in Zambian correctional facilities was 6,428 per 100,000 population, in 2011, which was 18 times higher than the national estimates. (6) In the same study, 0.6% of those with bacteriologically confirmed TB had rifampicin-resistant TB and the overall prevalence of HIV was 22.9%, which was 1.5 times the national prevalence.

Since the last documented prevalence survey, several interventions including test and treat for HIV, health systems strengthening, nutritional support, entry TB and HIV screening, among others, have been put in place to control the burden of TB and its associated risk factors in Zambia correctional facilities. (7-10)

This study aimed to determine current prevalence of all forms of TB, bacteriologically confirmed TB, and drug resistant (DR) TB and the prevalence of HIV in Zambian correctional facilities.

METHODS

Study design

We present an analysis of cross-sectional programmatic data collected by the Elton John Juvenile Offenders health (EJJOH) project during entry and mass screening of incarcerated people. The EJJOH project was a health system strengthening project aimed at supporting provision of holistic and integrated health services to juvenile offenders. While the project primarily targeted juveniles, it extended support to incarcerated adults in relation to infectious disease control. The project conducted a mass screening of inmates as part of its baseline assessment and strengthened entry screening, a routine practice in correctional facilities.

Study setting and population

Zambia has 87 correctional facilities with a total population of 21,000 incarcerated people. (11) The data was collected between July 2018 and February 2019 in 13 correctional facilities with a combined population of 9,699, representing 46.2% of the total correctional facility population in Zambia. The 13 facilities include Lusaka Central, Kamwala Remand, Livingstone Central, Katombora Reformatory School, Nakambala Approved school, Mukobeko Medium, Ndola remand, Kamfinsa State, Chingola, Insakwe Approved School, Chipata Central, Mongu Central and Kasama Central (locations shown in Supplementary Figure 1). The Reformatory and approved schools hold juveniles (persons less than 19 years old)(12); the other facilities are intended only for adults and circumstantial children(13) but also hold juveniles who are still undergoing trial.

Routinely, incarcerated people undergo TB screening and HIV testing at entry or within 7 days of admission into correctional facilities. Depending on availability of logistics, periodic TB and HIV mass screening are carried out, with freedom to opt out of HIV testing but not TB screening and testing.

Study Procedures

A project specific register was used; it was a modification of the National Presumptive TB register with additional data elements on entry point, category of individual and previous history of TB. All inmates were screened for TB; those who did not opt out were tested for HIV. The screening entry point was documented under one of the following: mass screening, entry screening from the community or entry screening transfer from other correctional facility. The categories of individuals included adults, juveniles and circumstantial children. Those already on anti-TB treatment at the time of screening were documented as TB cases and those on anti-retroviral therapy (ART) were recorded as HIV positive; they were not retested. Those with cough, fever, weight loss, night sweats, chest pain and shortness of breath, irrespective of duration, were considered presumptive TB patients and submitted sputum for testing using GeneXpert (Xpert MTB/Rif Assay. Cepheid, Sunnyvale, California, USA). Symptomatic individuals with a negative GeneXpert were referred for Chest x-ray (CXR) depending on the clinician's discretion. There were 3 variations to this algorithm: 1) In Lusaka central, a random proportion of the incarcerated population received CXR in addition to symptoms screening and those with either abnormal CXR or symptoms submitted sputum for GeneXpert; 2) at Ndola remand, all except those already on TB treatment submitted sputum

irrespective of symptoms; and 3) in Kabwe medium, Fluorescent Microscopy (FM) was used for sputum examination instead of GeneXpert.

Alere Determine™ HIV-1/2 test (AlereHIV-1/2; Abbott, Chicago, IL, USA) was used for HIV screening and SD-Bioline HIV-1/2 (SD-Bioline HIV-1/2; Abbott, Chicago, IL, USA) for confirmation of positive screening test, following the standard Zambian HIV testing algorithm. All individuals received pre- and post-test HIV counselling. HIV positive inmates were commenced on ART within 1-2 days.

Data analysis

STATA Statistical Software (Stata Corporation Version 14. College Station, Texas 77845, USA) was used for data analysis. A descriptive analysis was done to determine the characteristics of the population screened and the prevalence of TB and HIV; overall prevalence and prevalence among subgroups was determined. The prevalence of all forms of TB included bacteriologically confirmed TB and clinically diagnosed TB. Bacteriologically confirmed TB prevalence included those who had a positive GeneXpert or FM result, while patients already on TB treatment at time of screening were excluded from this analysis since data on the type of TB had not been collected. DR-TB prevalence included incarcerated people with rifampicin resistance on GeneXpert. Missing data was excluded from the analysis.

Additionally, a chi-square test was done to determine if there was a statistically significant difference in prevalence of TB and HIV between residents and new entrants into correctional facilities. New entrants were defined as incarcerated people whose entry point was entry

screening from community while residents were defined as those whose entry point was either mass screening or entry screening transfer from other correctional facility.

Ethical issues

Approval to use the programmatic data was obtained from the University of Zambia Biomedical Research Ethics Committee No: 018-11-18 and the London School of Hygiene and Tropical Medicine Ethics Committee No: 21332. The EJJOH project had obtained permission from the Zambia Correctional service and the Ministry of Community Development and Social services to conduct the screening activities. When migrating data from the paper-based registers to the electronic database, participant identifying information was excluded.

Patient and Public involvement

The development of the research questions was intended to inform priority setting by the EJJOH project based on the disease burden in correctional facilities. The incarcerated population were not involved in the design of the project. The correctional health committee constituting of the incarcerated persons, correctional officers and health care workers were involved in the data collection. A representative of the correctional health committee at each correctional facility participated in the dissemination meeting on project findings.

RESULTS

Flow diagram and participant characteristics

Of the total population of 9,699 in the 13 correctional facilities, 8164 (84.2%) were screened for HIV and 8,271(85.3%) individuals were screened for TB (Figure 1). Of those screened for HIV, 1170(14.3%) were HIV positive while 6994 were HIV negative. Of those screened for TB, 3,085 (37.3%) individuals had symptoms of TB, 5,173 (62.5%) were asymptomatic while 13 (0.2%) had missing data. Of the 4,278, who submitted sputum, 3,085 (72.1%) were symptomatic and 1,193 (27.9%) were asymptomatic for TB. Of the asymptomatic who submitted sputum 25(2.1%) were bacteriologically confirmed while of the symptomatic, 62(2.0%) submitted sputum. A total of 132 TB cases were identified including 87 (65.9%) bacteriologically confirmed TB cases, 28 (21.2%) clinically diagnosed TB cases and 17 (12.9%) that were already on TB treatment at the time of screening.

Figure 1: Flow diagram of TB screening and diagnosis

Of those screened, 7,805 (94.37%) were adults, 462 (5.59%) were juveniles while 4 (0.05%) were circumstantial children (Table 1). The overall median age (interquartile range (IQR)) of the participants was 32 years (IQR 10-93); 8,181 (98.75%) of the participants were male and 467 (5.65%) of the participants had a history of previous TB. Among those screened, 8099 (97.92%) were resident inmates while 169 (2.04%) were new entrants.

Table 1: Characteristics of population screened

Variable	**Participants (n= 8271)**
Category of individual, n (%)	
Adults	7,805 (94.37%)
Juveniles	462 (5.59%)
Circumstantial children	4 (0.05%)
Median Age (interquartile range)	
Overall	32(10-93)

Adults	33 (19-93)
Juveniles	17 (10-18)
Circumstantial children[1]	
Sex, n (%)	
Male	8,168 (98.75%)
Female	92 (1.11%)
Missing	11 (0.13%)
History of previous TB, n (%)	
Yes	467 (5.65%)
No	7,790 (94.18%)
Missing	14 (0.17%)
Type of screening visit, n (%)	
Mass screening	7,602 (91.92%)
Entry screening other correctional facility	497 (6.01%)
Entry screening community	169 (2.04%)
Missing	3 (0.03%)

[1] Ages of circumstantial children were missing.

Prevalence of all forms of TB and bacteriologically confirmed TB

The overall prevalence of all forms of TB was 1,598 (1339-1892) per 100,000 population while the overall prevalence of bacteriologically confirmed TB was 1,056 (844-1301) per 100,000 population (Table 2). There was no statistically significant difference in the prevalence of both all forms of TB and bacteriologically confirmed TB between males and females (p=0.51) and (p=1.00) respectively. It was the same for adults and juveniles (p= 0.82) and (p= 0.23) for the respective types of TB. There were no prevalent TB cases among circumstantial children.

Table 2: Prevalence of all forms of TB and bacteriologically confirmed TB

	Cases/ Participants (n/N)	**Prevalence of all forms of TB per 100,000 (CI)**	**p-value**	**Cases/ Participants (n/N)**	**Prevalence of Bacteriologically confirmed TB per 100,000 (CI)**	**p-value**

Overall	132/8,258[2]	1598 (1339-1892)		87/8,241[2,3]	1056 (844-1301)	
Sex						
Male	129/8,155	1582 (1322-1877)	0.51	84/8,138	1032 (824-1276)	1.00
Female	1/92	1087 (27- 5908)		1/92	1087 (27- 5908)	
Missing gender	2/11			2/11		
Category of individual						
Adult inmate	124/7,792	1591 (1325- 1894)	0.82	79/7,775	1016 (805-1265)	0.23
Juvenile inmate	8/462	1732 (750-3383)		8/462	1732 (750-3383)	
Circumstantial children	0/4	0 (0-60236) *		0/4	0 (0-60236) *	

[2] Thirteen (13) participants had missing values on TB.

[3] Seventeen participants were already on TB treatment, bacteriological status unknown

(*) one-sided, 97.5% confidence interval

The differences in prevalence of all forms TB and bacteriologically confirmed TB between residents and new entrants in correctional facilities were not statistically significant (p= 0.25) and (p=0.21) respectively (Supplemental Table 1).

Prevalence of DR TB

Among the bacteriologically confirmed TB cases, the overall prevalence of DR-TB was 4.6% (1.3%-11.4%) (Table 3). There was no statistically significant difference in prevalence of DR-TB between males and females (p=0.95), between adults and juveniles (p=0.68) and between those with and those without previous history of TB (p=0.72).

Table 3: Prevalence of drug resistant TB

	Cases/ Participants (n/N)	Prevalence of DR TB % (CI)	p-value
Overall	4/87	4.6 (1.3-11.4)	
Sex			
Male	4/84	4.8 (1.3-11.7)	0.95
Female	0/1	0 (0- 97.5) *	
Missing	0/2		
Category of individual			
Adult incarcerated people	4/79	5.1 (1.4- 12.5)	0.68
Juveniles	0/8	0 (0-3.7) *	
Circumstantial children	0/0	0	
Previous History of TB			
No	3/64	4.7 (1.0-13.1)	0.72
Yes	1/23	4.3 (0.1- 21.9)	

* one-sided, 97.5% confidence interval

There was no statistically significant difference in prevalence of DR TB between resident incarcerated people and new entrants into correctional facilities (p= 0.26).

Prevalence of HIV

The overall HIV prevalence was 14.3% (13.6%-15.1%) (Table 4). The prevalence of HIV among males was 14.1% (13.4%-14.9%) and among females 25.0% (16.6%-35.1%) (p=0.01). The prevalence of HIV among adults and juveniles was 15.0% (14.1%-15.7%) and 3.9% (2.3%-6.2%) (p<0.01). There were no prevalent HIV cases among circumstantial children.

Table 4: Prevalence of HIV

	Cases/ Participants (n/N)	Prevalence of HIV % (CI)	p-value
Overall	1,170/8,164[4]	14.3 (13.6-15.1)	
Sex			

Male	1,139/8,062	14.1 (13.4-14.9)	0.01
Female	23/92	25.0 (16.6-35.1)	
Missing sex	8/10		
Category of individual			
Adults	1,153/7,727	15.0 (14.1-15.7)	0.00
Juveniles	17/433	3.9 (2.3- 6.2)	
Circumstantial children	0/4	0 (0-60.2) *	

[4] One hundred and seven (107) participants either opted out of HIV testing or had missing data
(*) one-sided, 97.5% confidence interval.
** not determined.

The differences in prevalence of HIV between residents and new entrants into correctional facilities were not statistically significant (p=0.05) (Supplemental Table 1).

DISCUSSION

This study found that in Zambian correctional facilities, the prevalence of all forms of TB, bacteriologically confirmed TB and DR-TB were 3.5 times higher, 1.7 times higher and almost twice as high as in the general population, respectively. (14, 15) Additionally, the prevalence of HIV was 1.3 times higher than the prevalence in the general population (16). 25.8% of the bacteriologically confirmed TB cases were asymptomatic.

In comparison to the 2010-2011 study, the prevalence of all forms of TB had reduced by about 75%, the prevalence of bacteriologically confirmed TB has reduced by 50% but the prevalence of DR-TB has increased by 4%. (6) The prevalence of DR-TB among people with no history of TB is similar to the prevalence among people with previous history of TB, suggesting

significant transmission of DR-TB either in correctional facilities or in the communities where the incarcerated people come from, or both. Strengthening TB infection control can reduce transmission of DR-TB. (17) There has been an 8.6% reduction in prevalence of HIV since the study in 2010-2011. (6) Similar to the national picture, the prevalence of HIV was higher among adults than juvenile incarcerated people and was higher among females than males. (16) However, the prevalence of HIV in women relative to the prevalence of HIV in men is much higher in the incarcerated population than the general population because women with HIV risk factors like sex worker status, intimate partner violence, drug and substance abuse are overrepresented in this population. (18)

The difference in prevalence of TB and HIV between residents and new entrants into correctional facilities was not statistically significant. This is possibly due to the following reasons: a) individuals entering correctional facilities come from socio-economically disadvantaged backgrounds where prevalence of TB and HIV are already high (1); b) there are high rates of recidivism (19); and c) detainees spend long periods in police cells, which have similar conditions to the correctional facilities (20, 21).

The results of our study are generalizable to all correctional facilities in Zambia, as a large sample of the inmate population, representing 36.3% of the total correctional facility population, was screened.(11) However, there were variations in the strength of screening algorithms for TB, hence the prevalence of TB could have been underestimated in some correctional facilities. Additionally, asymptomatic TB was not consistently screened for.

CONCLUSION

Despite significant progress over the last decade in controlling TB and HIV in Zambian correctional facilities, these continue to be disproportionately affected by both diseases. TB/HIV programs in correctional facilities need further strengthening including aspects of gender responsive HIV programming. Additional studies that screen for asymptomatic TB are required.

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AUTHOR CONTRIBUTIONS

Conceived and designed the study: MK, SH, CNM, MM. Database design and data curation: PS, JB. Implemented the study: MK, SH, MT, TZ, CNM, MM. Data analysis: PS, MK, FB. Wrote the original draft: MK. Reviewed the manuscript: SH, MT, JB, PS, TZ, FB, CNM, MM. Approved the final version to be published: MK, SH, PS, MT, JB, TZ, FB, CNM, MM.

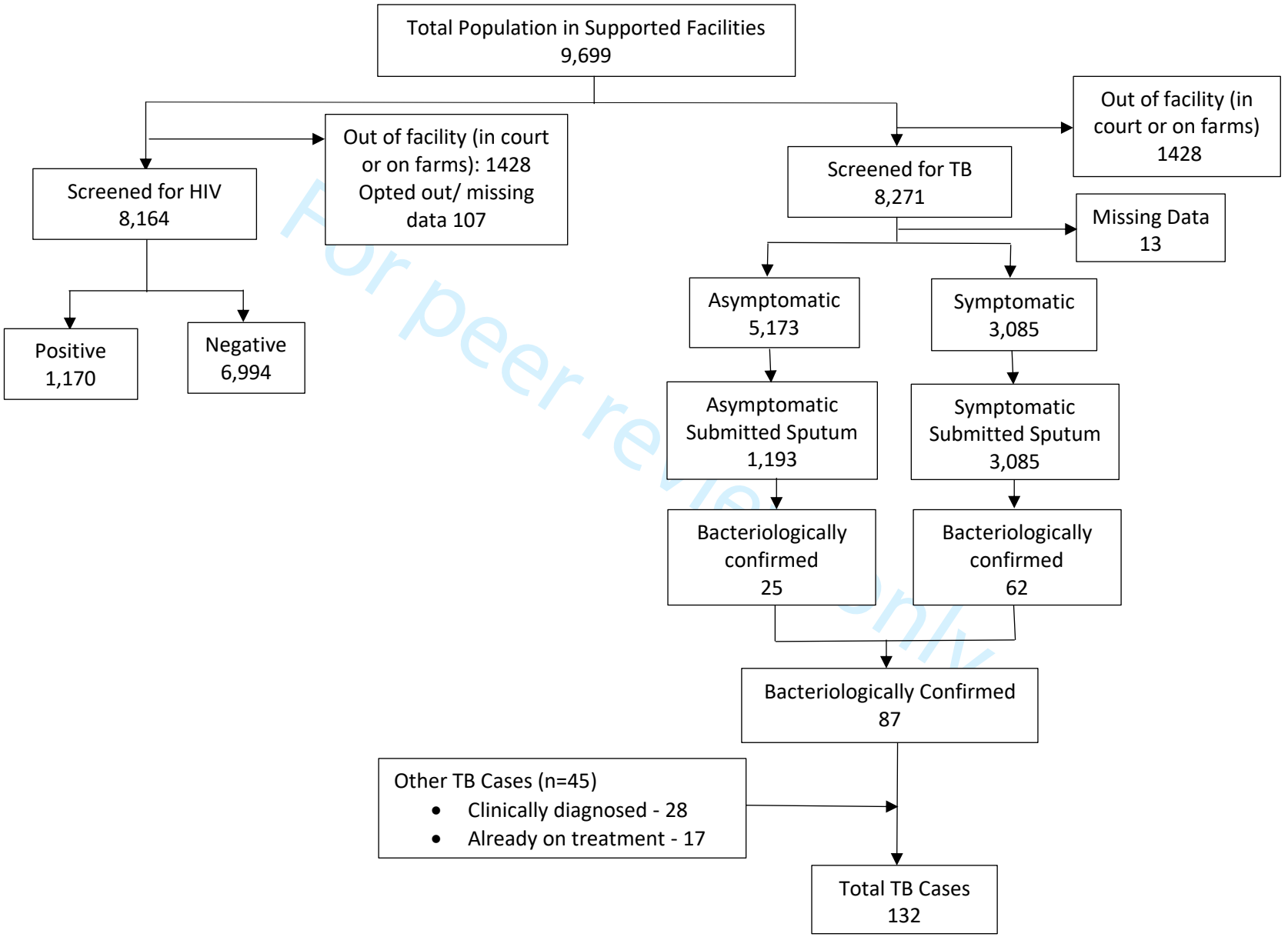
The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

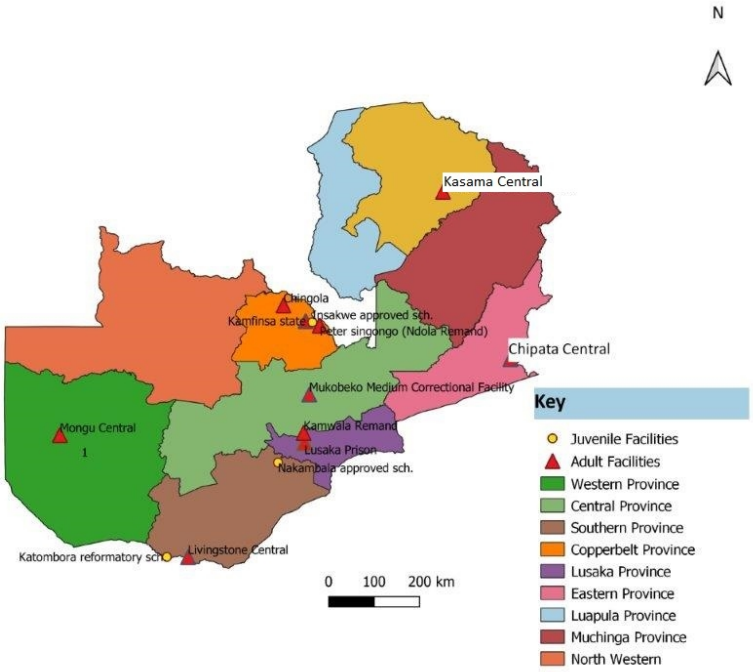
CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA SHARING STATEMENT

Additional data is available upon request by emailing Monde.Muyoyeta@cidrz.org





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Supplementary Table 1: Difference in prevalence of TB and HIV between resident incarcerated people and new entrants

Type of TB	**Cases/ Participants (n/N)**	Residents	**Cases/ Participants (n/N)**	New Entrants	P-value
All forms TB prevalence per 100,000 per 100,000 population (CI)	121/7,780	1555 (1280-1830)	11/496	2218 (917-3518)	0.25
Bacteriologically confirmed TB prevalence per 100,000 population (CI)	79/7,763	1018 (794- 1241)	8/496	1613 (500-2725)	0.21
DR TB prevalence	3/76	3.9 (0.8-10.7)	1/8	12.5 (0.4-52.7)	0.26
HIV prevalence % (CI)	1,119/7,722	14.5 (13.7-15.3)	52/462	11.3 (8.4-14.1)	0.05

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4,5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5,6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5,6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8,9
		(b) Indicate number of participants with missing data for each variable of interest	9-12
Outcome data	15*	Report numbers of outcome events or summary measures	9-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	

		(*b*) Report category boundaries when continuous variables were categorized	9-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A cross sectional assessment of Tuberculosis and Human Immunodeficiency Virus prevalence in 13 correctional facilities in Zambia

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A cross sectional assessment of Tuberculosis and Human Immunodeficiency Virus prevalence in 13 correctional facilities in Zambia

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Key words: Correctional facilities, Tuberculosis, HIV, Zambia

ABSTRACT

Objective: To determine the prevalence of Tuberculosis (TB) and Human Immunodeficiency virus (HIV) in 13 Zambian correctional facilities.

Methods: Cross sectional study

Setting: 13 correctional facilities in 7 of the 10 provinces in Zambia.

Participants: All incarcerated individuals were eligible for TB and HIV screening and testing. Of the total study population of 9,695 individuals, which represent 46.2% of total correctional population at the beginning of the study, 8,267 and 8,160 were screened for TB and HIV respectively.

Interventions: TB and HIV screening and testing was done between July 2018 and February 2019.

Primary outcome measures: All forms of TB, bacteriologically confirmed TB, drug resistant TB, HIV

Results: Prevalence of all forms of TB and bacteriologically confirmed TB was 1598 per 100,000 population and 1056 per 100,000 population, respectively. Among those with bacteriologically confirmed TB, 4.6% had drug resistant TB. The prevalence of HIV was 14.3%.

Conclusion: Compared to the study in 2011 which screened inmates representing 30% of the country's inmate population then, the prevalence of all forms of TB and HIV in correctional facilities has reduced by about 75% and 8.6% respectively. However, compared to the general population, the prevalence of all forms of TB and HIV was 3.5 and 1.3 times higher, respectively. TB/HIV programs in correctional facilities need further strengthening.

ARTICLE SUMMARY

Strengths and limitations of this study

- This is the only study on prevalence of TB and HIV in Zambian correctional facilities in the past 8 years.
- Results are generalisable to the 13 correctional facilities as a large sample was screened for TB and HIV.
- Data disaggregates can inform targeted interventions to reduce the burden of both diseases.
- Variations in TB screening algorithms could have underestimated TB prevalence.
- Asymptomatic TB was not consistently screened for.

INTRODUCTION

Globally, correctional facilities are disproportionately affected by tuberculosis (TB) and the Human Immunodeficiency Virus (HIV). (1-3) In some correctional facilities: the prevalence of TB has been reported to be up to 100 times higher than the prevalence in the general population (1) while the prevalence of HIV has been reported to be up to 23 times higher than the prevalence in the general population(3). The poor living conditions in correctional facilities perpetuate TB and HIV. While overcrowding, poor ventilation, HIV, poor nutrition and late case detection perpetuate TB; sexual violence, sharing of sharp objects and lack of access to condoms perpetuate HIV. (4, 5) Additionally, incarcerated people often come from socio-economically disadvantaged backgrounds where the burden of TB and HIV is already high. (1, 3)

In 2011, the prevalence of all forms of TB in 6 Zambian correctional facilities representing 30% of the total incarcerated population was 6,428 per 100,000 population, which was 18 times higher than the national estimates. (6) In the same study, 0.6% of those with bacteriologically confirmed TB had rifampicin-resistant TB and the overall prevalence of HIV was 22.9%, which was 1.5 times the national prevalence.

Since the last documented prevalence survey, several interventions including test and treat for HIV, health systems strengthening, nutritional support, TB and HIV entry screening, among others, have been put in place to control the burden of TB and its associated risk factors in Zambia correctional facilities. (7-10)

This study aimed to determine current prevalence of all forms of TB, bacteriologically confirmed TB, and drug resistant (DR) TB and the prevalence of HIV in 13 Zambian correctional facilities.

METHODS

Study design

We present an analysis of cross-sectional data collected under programmatic conditions by the Elton John Juvenile Offenders' health (EJJOH) project. The EJJOH project was a health system strengthening project aimed at supporting provision of holistic and integrated health services to juvenile offenders. While the project primarily targeted juveniles, where these were held in adults' facilities, support was extended to incarcerated adults in relation to infectious disease control. The project screened as part of its baseline assessment.

Study setting and population

Zambia has 87 correctional facilities with a total capacity of 9,150 incarcerated individuals. (11) However, the total incarcerated population in Zambia was slightly over 21,000 in 2018 and 22,823 in 2019. In 2019, almost one in five individuals detained was in pre-trial detention. (11) The data was collected between July 2018 and February 2019 in 13 correctional facilities with a combined population of 9,695, representing 46.2% of the total correctional facility population in Zambia in 2018. The 13 correctional facilities had been purposefully selected by the EJJOH project because they held a significant number of juveniles. The facilities include; Lusaka Central, Kamwala Remand, Livingstone Central, Katombora Reformatory School,

Nakambala Approved school, Mukobeko Medium, Ndola remand, Kamfinsa State, Chingola, Insakwe Approved School, Chipata Central, Mongu Central and Kasama Central (locations shown in Supplementary Figure 1). The Reformatory and approved schools hold ordered (convicted) juveniles (persons less than 19 years old)(12); the other facilities are intended only for adults and circumstantial children(13) but also hold juveniles who are still undergoing trial.

Across Zambia, routinely, incarcerated people should undergo universal TB screening and HIV testing at entry or within 7 days of admission into correctional facilities. However, in some facilities entry screening is not done due to various constraints. Depending on availability of logistics, periodic TB and HIV mass screening are carried out, with freedom to opt out of HIV testing but not TB screening and testing. TB screening is mandatory to increase early TB detection and treatment so as to protect other inmates from TB.

Study Procedures

A project specific register was used; it was a modification of the National Presumptive TB register with additional data elements on entry point, category of individual and previous history of TB. All inmates were screened for TB; those who did not opt out were tested for HIV. The screening point was documented under one of the following categories: mass screening, entry screening from the community or entry screening transfer from other correctional facility. The categories of individuals included adults and juveniles. Those already on anti-TB treatment at the time of screening were documented as TB cases and those on anti-retroviral therapy (ART) were recorded as HIV positive and were not retested. Those with

cough, fever, weight loss, night sweats, chest pain and shortness of breath, irrespective of duration, were considered presumptive TB patients and submitted sputum for testing using GeneXpert (Xpert MTB/Rif Assay. Cepheid, Sunnyvale, California, USA). Symptomatic individuals with a negative GeneXpert were referred for Chest x-ray (CXR) depending on the clinician's discretion. There were 3 variations to this algorithm: 1) In Lusaka central, a random proportion of the incarcerated population received CXR in addition to symptoms screening and those with either abnormal CXR or symptoms submitted sputum for GeneXpert; 2) at Ndola remand, all except those already on TB treatment submitted sputum irrespective of symptoms; and 3) in Kabwe medium, Fluorescent Microscopy (FM) was used for sputum examination instead of GeneXpert.

Alere Determine™ HIV-1/2 test (AlereHIV-1/2; Abbott, Chicago, IL, USA) was used for HIV screening and SD-Bioline HIV-1/2 (SD-Bioline HIV-1/2; Abbott, Chicago, IL, USA) for confirmation of positive screening test, following the standard Zambian HIV testing algorithm. All individuals received pre- and post-test HIV counselling. HIV positive inmates were commenced on ART within 1-2 days.

Data analysis

STATA Statistical Software (Stata Corporation Version 14. College Station, Texas 77845, USA) was used for data analysis. A descriptive analysis was done to determine the characteristics of the population screened and the prevalence of TB and HIV; overall prevalence and prevalence among subgroups was determined. The prevalence of all forms of TB included bacteriologically confirmed TB and clinically diagnosed TB. Bacteriologically confirmed TB prevalence included those who had a positive GeneXpert or FM result, while patients already

on TB treatment at time of screening were excluded from this analysis since data on the type of TB had not been collected. DR TB prevalence included incarcerated people with rifampicin resistance on GeneXpert. Missing data was excluded from the analysis.

Additionally, a chi-square test was done to determine if there was a statistically significant difference in prevalence of TB and HIV between residents and new entrants into correctional facilities. New entrants were defined as incarcerated people whose entry point was entry screening from community while residents were defined as those whose entry point was either mass screening or entry screening transfer from other correctional facility.

Patient and Public involvement

The development of the research questions was intended to inform priority setting by the EJJOH project based on the disease burden in correctional facilities. The incarcerated population were not involved in the design of the project. The correctional health committee constituting of the incarcerated persons, correctional officers and health care workers were involved in the data collection. A representative of the correctional health committee at each correctional facility participated in the dissemination meeting on project findings.

RESULTS

Flow diagram and participant characteristics

Of the total adult and juvenile population of 9,695 in the 13 correctional facilities, 8160 (84.2%) were screened for HIV and 8,267(85.3%) were screened for TB (Figure 1). Individuals

not screened were 1,428 (14.7%) and they constituted those either in court or the farms. Of those screened for HIV, 1170(14.3%) were HIV positive, of which 816 were known positive and 354 were new positives, while 6,990 (85.7%) were HIV negative. Of those screened for TB, 17(0.2%) were already on treatment, 3,076 (37.3%) individuals had symptoms of TB, 5,161 (62.5%) were asymptomatic while 13 (0.2%) had missing data. A total of 4,269 individuals had documented sputum results. Eighty seven (87) bacteriologically confirmed TB cases were reported including 25(28.7%) asymptomatic individuals 62(71.3%) symptomatic individuals. A total of 132 TB cases were identified including 87 (65.9%) bacteriologically confirmed TB cases, 28 (21.2%) clinically diagnosed TB cases and the 17 (12.9%) that were already on TB treatment at the time of screening.

Figure 1: Flow diagram of TB screening and diagnosis

Of those screened, 7,805 (94.41%) were adults and 462 (5.58%) were juveniles (Table 1). The overall median age (interquartile range (IQR)) of the participants was 32 years (IQR 10-93); the median ages for the adults and juveniles were 33(IQR 19-93) and 17(IQR 10-18) respectively. The males were 8,167 (98.79%), participants with a history of previous TB were 467 (5.65%), resident inmates were 7,767 (93.95%) while new entrants were 497 (6.01%).

Table 1: Characteristics of population screened

Variable	**Participants (n= 8267)**
Category of individual	n (%)
Adults	7,805 (94.41%)
Juveniles	462 (5.58%)
Median Age (IQR)	
Overall	32(10-93)
Adults (≥19 years)	33 (19-93)

Juveniles (<19 years)	17 (10-18)
Sex	n (%)
Male	8,167 (98.79%)
Female	89 (1.08%)
Missing	11 (0.13%)
History of previous TB	n (%)
Yes	467 (5.65%)
No	7,786 (94.18%)
Missing	14 (0.17%)
Type of screening visit	n (%)
Mass screening	7,602 (91.92%)
Entry screening other correctional facility	165 (2.00%)
Entry screening community	497 (6.01%)
Missing	3 (0.04%)

Abbreviations: IQR- Interquartile range, TB- Tuberculosis

Prevalence of all forms of TB and bacteriologically confirmed TB

The overall prevalence of all forms of TB was 1,598 (1339-1892) per 100,000 population while the overall prevalence of bacteriologically confirmed TB was 1,056 (844-1301) per 100,000 population (Table 2). There was no statistically significant difference in the prevalence of both all forms of TB and bacteriologically confirmed TB between males and females, (p=0.51) and (p=1.00) respectively. It was the same for adults and juveniles (p= 0.82) and (p= 0.23) respectively and the new entrants and residents (p=0.25) and (p=0.21) respectively.

Table 2: Prevalence of all forms of TB and bacteriologically confirmed TB

	Cases/ Participants (n/N)	**Prevalence of all forms of TB per 100,000 (CI)**	**p-value**	**Cases/ Participants (n/N)**	**Prevalence of Bacteriologically confirmed TB per 100,000 (CI)**	**p-value**
Overall	132/8,254[1]	1599 (1340-1894)		87/8,237[1,2]	1056 (847-1301)	

Sex						
Male	129/8,154	1582 (1322-1877)	0.60	84/8,137	1032 (824-1276)	0.79
Female	1/89	1124 (28- 6102)		1/89	1124 (28- 6102)	
Missing gender	2/11			2/11		
Category of individual						
Adult (≥19 years)	124/7,792	1591 (1325- 1894)	0.82	79/7,775	1016 (805-1265)	0.23
Juvenile (<19 years)	8/462	1732 (750-3383)		8/462	1732 (750-3383)	
Entry point[1,3]						
Residents	121/ 7757	1560 (1296- 1861)	0.25	79/7740	1020 (809-1270)	0.21
New entrants	11/494	2227 (1117-3949)		8/494	1619 (702-3166)	

Abbreviations: CI- Confidence interval, TB- Tuberculosis
Residents include those screened through mass screening and those under entry screening as a transfer from other correctional facility.
New entrants include those screened under entry screening from the community (police cells).
[1] Thirteen (13) participants had missing values on TB.
[2] Seventeen participants were already on TB treatment, bacteriological status unknown
[3] Three (3) participants had missing values on entry point

Prevalence of DR TB

Among the bacteriologically confirmed TB cases, the overall prevalence of DR TB was 4.6% (1.3%-11.4%) (Table 3). There was no statistically significant difference in prevalence of DR TB between males and females (p=0.95), between adults and juveniles (p=0.68), between those with and those without previous history of TB (p=0.72) and between the new entrants and residents(p=0.26).

Table 3: Prevalence of drug resistant TB

	Cases/ Participants (n/N)	Prevalence of DR TB % (CI)	p-value
Overall	4/87	4.6 (1.3-11.4)	
Sex			
Male	4/84	4.8 (1.3-11.7)	0.95
Female	0/1	0 (0- 97.5) *	
Missing	0/2		
Category of individual			
Adults (≥19 years)	4/79	5.1 (1.4- 12.5)	0.68
Juveniles (<19 years)	0/8	0 (0-3.7) *	
Previous History of TB			
No	3/64	4.7 (1.0-13.1)	0.72
Yes	1/23	4.3 (0.1- 21.9)	
Entry point			
Residents	3/76	3.8 (0.8-10.7)	0.26
New entrants	1/8	12.5 (0.3-52.7)	

Abbreviations: DR TB- Drug Resistant Tuberculosis CI- Confidence interval
Residents include those screened through mass screening and those under entry screening as a transfer from other correctional facility.
New incarcerated individuals include those screened under entry screening from the community (police cells).
* one-sided, 97.5% confidence interval

Prevalence of HIV

The overall HIV prevalence was 14.3% (13.6%-15.1%) (Table 4). The prevalence of HIV among males was 14.1% (13.4%-14.9%) and among females 25.0% (16.6%-35.1%) (p=0.01). The prevalence of HIV among adults and juveniles was 15.0% (14.1%-15.7%) and 3.9% (2.3%-6.2%) (p<0.01) respectively. There was no statistically significant differences in prevalence of HIV between residents and new entrants (*p*=0.05).

Table 4: Prevalence of HIV

	Cases/ Participants (n/N)	Prevalence of HIV % (CI)	p-value

Overall	1,170/8,160[1]	14.3 (13.6-15.1)	
Sex			
Male	1,139/8,061	14.1 (13.4-14.9)	0.00
Female	23/89	25.8 (17.4-36.2)	
Missing sex	8/10		
Category of individual			
Adults (≥19 years)	1,153/7,727	15.0 (14.1-15.7)	0.00
Juveniles (<19 years)	17/433	3.9 (2.3- 6.2)	
Entry point[1,2]			
Residents	1,118/7699	14.5(13.7-15.3)	0.06
New entrants	52/460	11.3 (8.6-14.6)	

Abbreviations: CI- Confidence interval, HIV- Human Immunodeficiency virus

Residents include those screened through mass screening and those under entry screening as a transfer from other correctional facility. New incarcerated individuals include those screened under entry screening from the community (police cells).

[1]One hundred and seven (107) participants either opted out of HIV testing or had missing data

[2]Three (3) participants had missing entry point, 2 of which also had missing HIV status

(*) one-sided, 97.5% confidence interval.

** not determined.

DISCUSSION

Statement of principal findings

This study found that in Zambian correctional facilities, the prevalence of all forms of TB, bacteriologically confirmed TB and DR TB were 3.5 times higher, 1.7 times higher and almost twice as high as in the general population, respectively. (14, 15) Additionally, the prevalence of HIV was 1.3 times higher than the prevalence in the general population (16). 28.7% of the bacteriologically confirmed TB cases were asymptomatic.

Study findings in relation to other studies

It is noteworthy that there is no statistically significant difference in prevalence of all forms TB and bacteriologically confirmed TB between juveniles and adults and that in fact the point estimates for TB in juveniles were higher; generally older adults have a higher TB burden than adolescents and young adults. (17, 18) This suggests that the disproportionate access to TB services and health services in general among juveniles in Zambian correctional facilities reported between 2009-2010 have persisted. (19) Another significant contrast relative to the general population is the absence of a statistically significant difference in prevalence of bacteriologically confirmed TB between males and females. (15) This could be due to absence of gender related differences in exposure to risk factors for TB infection and disease but could also be due to the small sample size and very wide confidence intervals among females.

In comparison to the 2010-2011 study, the prevalence of all forms of TB has reduced by about 75% while the prevalence of bacteriologically confirmed TB has reduced by 50%. (6) The reduction in prevalence of all forms of TB and bacteriologically confirmed TB could be a result of the TB control interventions being implemented within the Zambian correctional facilities. However, it could also be in part because the correctional facilities in the two studies are not the same and the variations in the sensitivity of screening algorithms as a more sensitive algorithm involving x-ray and culture(20, 21) for all inmates was used in the previous study. An observational and modelling study done in Brazil supports the hypothesis of effectiveness of TB control interventions being implemented: entry screening, active screening for TB among inmates, TB preventive therapy and annual mass screening independently reduce the incidence of TB in correctional facilities by 10.3%, 35%, 23.5% and 47.5% respectively after a period of 10 years and a combination of these interventions reduces the TB incidence by 79.2% after a period of 10 years. (22). Other countries in sub-Saharan Africa with results

involving multiple correctional facilities report TB prevalence ranging from 457 - 888 per 100,000 population. (23-25) However, a direct comparison to the prevalence reported in the other countries can't be done due to differences in definitions of TB used.

The prevalence of DR TB among people with no history of TB is similar to the prevalence among people with previous history of TB, suggesting significant transmission of DR TB either in correctional facilities or in the communities where the incarcerated people come from, or both. Strengthening TB infection control can reduce transmission of DR TB. (26) In comparison to the 2010-2011 study, the prevalence of DR TB has increased by 4%. (6) The increasing trend of DR TB in the Zambian correctional facility setting is also seen at the global and national levels.(27) The prevalence of DR TB in this study can't be directly compared to other correctional facility settings since the forms of drug resistance reported are different. (28-30)

Similar to the national picture, the prevalence of HIV was higher among adults than juveniles and was higher among females than males. (16) However, the prevalence of HIV in women relative to the prevalence of HIV in men is much higher in the incarcerated population than the general population because women with HIV risk factors like sex worker status, intimate partner violence, drug and substance abuse are overrepresented in this population. (31) Despite the very high rates of HIV in this group, relative to the study done by Simooya et al in 1999 which showed a prevalence of 33% in females, the prevalence of HIV has reduced.(32) There has been an 8.6% reduction in overall prevalence of HIV since the study in 2010-2011. (6) The reduction in prevalence of HIV in correctional facilities is attributable to the reduction of HIV prevalence in the general population(16), the implementation of test and treat across Zambia(33), entry HIV testing and treatment(6) and use of correctional health committees to

strengthen TB/HIV service delivery at facility level(9). Among African countries with studies involving several correctional facilities, Zambia's prevalence is lower than South Africa's (25) but higher than Burkina Faso and Uganda.

The difference in prevalence of TB and HIV between residents and new entrants into correctional facilities was not statistically significant. This is possibly due to the following reasons: a) individuals entering correctional facilities come from socio-economically disadvantaged backgrounds where prevalence of TB and HIV are already high (1); b) there are high rates of recidivism (34); and c) detainees spend long periods in police cells, which have similar conditions to the correctional facilities (35, 36). However, the small sample size and wide confidence intervals especially for the new entrants is a limiting factor for drawing any inferences from this comparison.

Strengths and limitations

This study provides the most recent evidence on prevalence of TB and HIV in Zambian correctional facilities. The results of this study are generalizable to the 13 correctional facilities, as a large sample representing 85% and 84% of the correctional facility population, was screened for TB and HIV respectively. By virtue of the data being disaggregated, it provides an opportunity for targeting of interventions that can reduce the burden of both diseases. However, there were variations in the strength of screening algorithms for TB, hence the prevalence of TB could have been underestimated in some correctional facilities. That said, among all forms TB cases, it is possible that some of the clinically diagnosed TB cases might not be true TB cases as there are other differential causes of chest x-ray abnormalities that mimic TB. Inmates in court or on the farms were not screened for TB which could have

introduced bias during data collection. Additionally, asymptomatic TB was not consistently screened for.

CONCLUSION

Despite significant progress over the last decade in controlling TB and HIV in Zambian correctional facilities, these continue to be disproportionately affected by both diseases. TB/HIV programs in correctional facilities need further strengthening including aspects of juvenile specific TB programming and gender responsive HIV programming. Additionally, there is need to consider use of more sensitive algorithms that include chest x-ray to minimize the risk of missing asymptomatic TB cases. Additional studies are required to determine the true prevalence of asymptomatic TB in correctional facilities, to better understand the reason for high HIV burden among females in correctional facilities and to determine the prevalence of TB and HIV using a sample whose results can be generalized to all the correctional facilities in Zambia.

ETHICS STATEMENT

Approval to use the programmatic data was obtained from the University of Zambia Biomedical Research Ethics Committee No: 018-11-18 and the London School of Hygiene and Tropical Medicine Ethics Committee No: 21332. Since data was collected under programmatic conditions, no consent was sought for TB screening and verbal consent and assent were obtained for HIV testing. The EJJOH project had obtained permission from the Zambia Correctional service and the Ministry of Community Development and Social services to

conduct the screening activities including testing of juveniles. When migrating data from the paper-based registers to the electronic database, participant identifying information was excluded.

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AUTHOR CONTRIBUTIONS

Conceived and designed the study: MK, SH, CNM, MM. Database design and data curation: PS, JB. Implemented the study: MK, SH, MT, TZ, CNM, MM. Data analysis: PS, MK, FB. Wrote the original draft: MK. Reviewed the manuscript: SH, MT, JB, PS, TZ, FB, CNM, MM. Approved the final version to be published: MK, SH, PS, MT, JB, TZ, FB, CNM, MM.

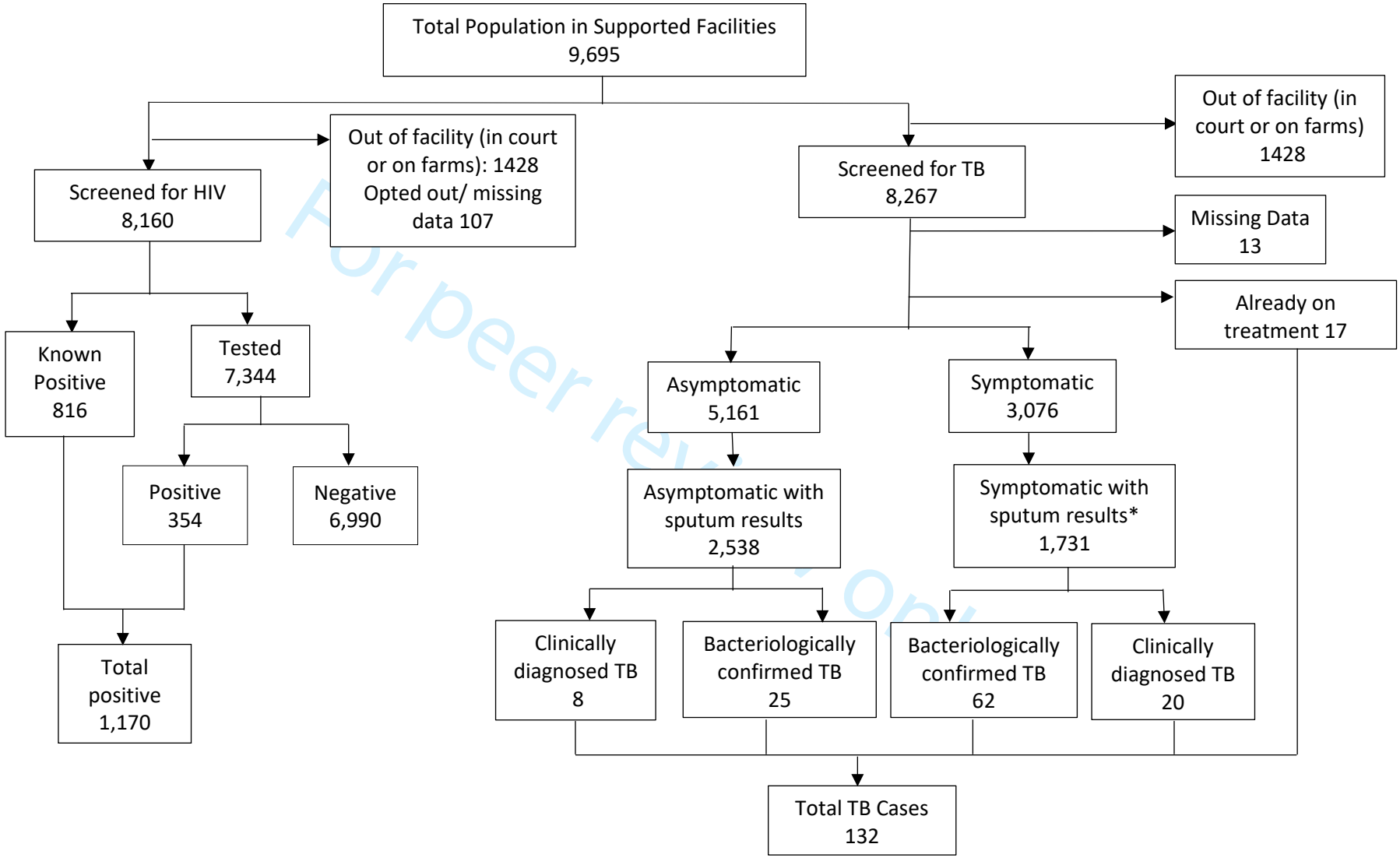
The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

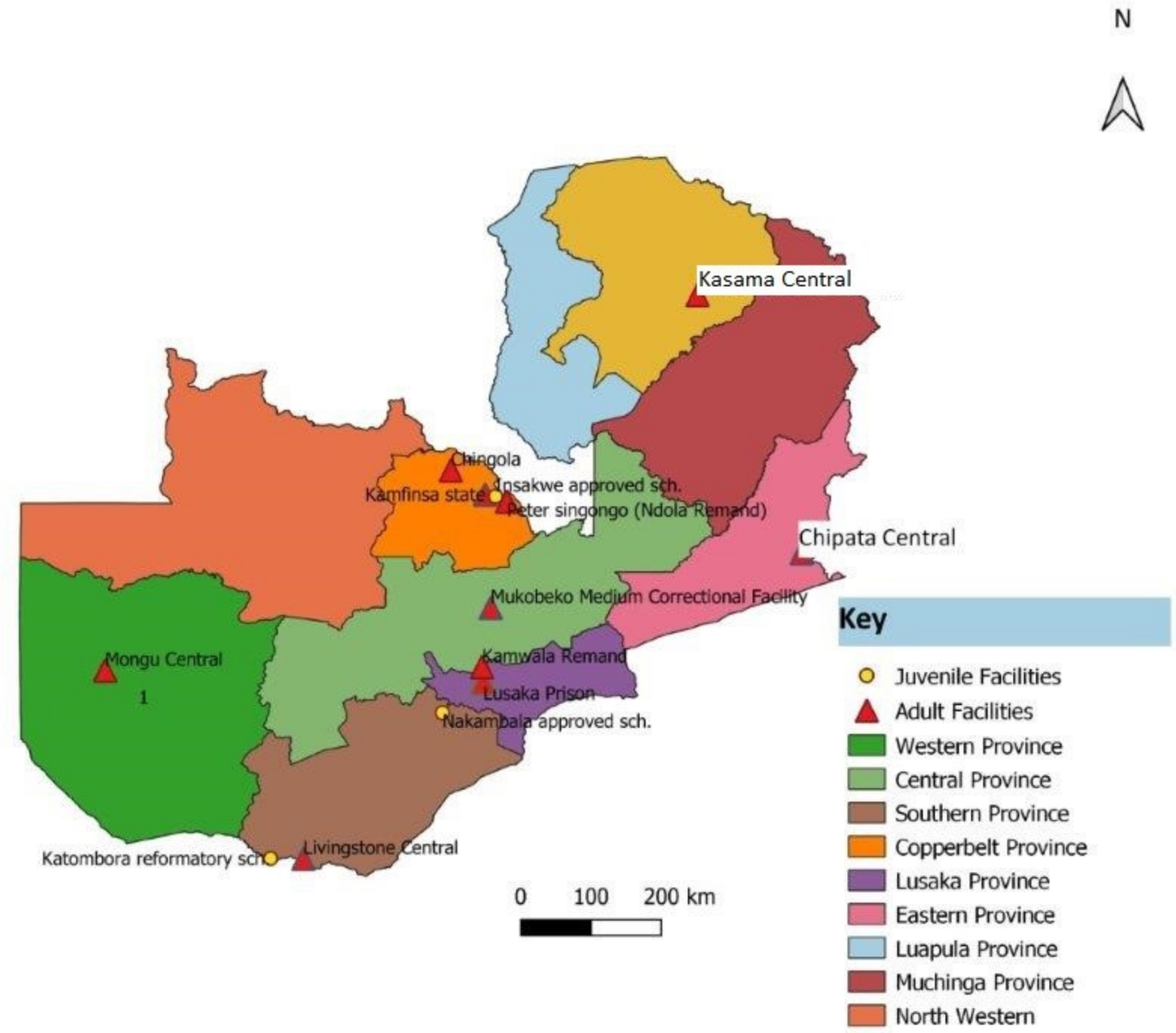
DATA SHARING STATEMENT

Additional data is available upon request by emailing Monde.Muyoyeta@cidrz.org



HIV- Human Immunodeficiency Virus, TB- Tuberculosis

**All symptomatic patients submitted sputum, however, some correctional facilities only documented results of patients with positive results.*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Chingola
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Insakwe approved sch.
Peter singongo (Ndola Remand)
Chipata Central
Mukobeko Medium Correctional Facility
Mongu Central
1
Kamwala Remand
Lusaka Prison
Nakambala approved sch.
Katombora reformatory sch
Livingstone Central
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Key
Juvenile Facilities
Adult Facilities
Western Province
Central Province
Southern Province
Copperbelt Province
Lusaka Province
Eastern Province
Luapula Province
Muchinga Province
North Western

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5,6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6,7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6,7
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7,8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7,8
		(*b*) Describe any methods used to examine subgroups and interactions	7,8
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8, 9
		(b) Give reasons for non-participation at each stage	8,9
		(c) Consider use of a flow diagram	9
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9,10
		(b) Indicate number of participants with missing data for each variable of interest	10-13
Outcome data	15*	Report numbers of outcome events or summary measures	10-13

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	10-13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A cross sectional assessment of Tuberculosis and Human Immunodeficiency Virus prevalence in 13 correctional facilities in Zambia

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A cross sectional assessment of Tuberculosis and Human Immunodeficiency Virus prevalence in 13 correctional facilities in Zambia

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Key words: Correctional facilities, Tuberculosis, HIV, incarcerated population, Zambia

ABSTRACT

Objective: To determine the prevalence of Tuberculosis (TB) and Human Immunodeficiency virus (HIV) in 13 Zambian correctional facilities.

Methods: Cross sectional study

Setting: 13 correctional facilities in 7 of the 10 provinces in Zambia.

Participants: All incarcerated individuals were eligible for TB and HIV screening and testing. Of the total study population of 9,695 individuals, which represent 46.2% of total correctional population at the beginning of the study, 8,267 and 8,160 were screened for TB and HIV respectively.

Interventions: TB and HIV screening and testing was done between July 2018 and February 2019.

Primary outcome measures: All forms of TB, bacteriologically confirmed TB, drug resistant TB, HIV

Results: Prevalence of all forms of TB and bacteriologically confirmed TB was 1598(1340-1894) per 100,000 population and 1056(847-1301) per 100,000 population, respectively. Among those with bacteriologically confirmed TB, 4.6% (1.3%-11.4%) had drug resistant TB. There was no statistically significant difference in the prevalence of different forms of TB between adults and juveniles: (p= 0.82), (p= 0.23), (p=0.68). Of the bacteriologically confirmed TB cases, 28.7% were asymptomatic. The prevalence of HIV was 14.3% (13.6%-15.1%). The prevalence of HIV among females was 1.8 times the prevalence of HIV among males (p=0.01).

Conclusion: Compared to the study in 2011 which screened inmates representing 30% of the country's inmate population then, the prevalence of all forms of TB and HIV in correctional

facilities has reduced by about 75% and 37.6% respectively. However, compared to the general population, the prevalence of all forms of TB and HIV was 3.5 and 1.3 times higher, respectively. TB/HIV programs in correctional facilities need further strengthening to include aspects of juvenile specific TB programming and gender responsive HIV programming.

ARTICLE SUMMARY

Strengths and limitations of this study

- This is the only study on prevalence of TB and HIV in Zambian correctional facilities in the past 8 years.
- Results are generalisable to the 13 correctional facilities as a large sample was screened for TB and HIV.
- Data disaggregates can inform targeted interventions to reduce the burden of both diseases.
- Variations in TB screening algorithms could have underestimated TB prevalence.
- Asymptomatic TB was not consistently screened for.

INTRODUCTION

Globally, correctional facilities are disproportionately affected by tuberculosis (TB) and the Human Immunodeficiency Virus (HIV). (1-3) In some correctional facilities: the prevalence of TB has been reported to be up to 100 times higher than the prevalence in the general population (1) while the prevalence of HIV has been reported to be up to 23 times higher than the prevalence in the general population(3). The poor living conditions in correctional facilities perpetuate TB and HIV. While overcrowding, poor ventilation, HIV, poor nutrition and late case detection perpetuate TB; sexual violence, sharing of sharp objects and lack of access to condoms perpetuate HIV. (4, 5) Additionally, incarcerated people often come from socio-economically disadvantaged backgrounds where the burden of TB and HIV is already high. (1, 3)

In 2011, the prevalence of all forms of TB in 6 Zambian correctional facilities representing 30% of the total incarcerated population was 6,428 per 100,000 population, which was 18 times higher than the national estimates. (6) In the same study, 0.6% of those with bacteriologically confirmed TB had rifampicin-resistant TB and the overall prevalence of HIV was 22.9%, which was 1.5 times the national prevalence.

Since the last documented prevalence survey, several interventions including test and treat for HIV, health systems strengthening, nutritional support, TB and HIV entry screening, among others, have been put in place to control the burden of TB and its associated risk factors in Zambia correctional facilities. (7-10)

This study aimed to determine current prevalence of all forms of TB, bacteriologically confirmed TB, and drug resistant (DR) TB and the prevalence of HIV in 13 Zambian correctional facilities.

METHODS

Study design

We present an analysis of cross-sectional data collected under programmatic conditions by the Elton John Juvenile Offenders' health (EJJOH) project. The EJJOH project was a health system strengthening project aimed at supporting provision of holistic and integrated health services to juvenile offenders. While the project primarily targeted juveniles, its support was extended to adults being held in the same facility with the juveniles so as to improve infectious disease control. The project screened the incarcerated population as part of its baseline assessment.

Study setting and population

Zambia has 87 correctional facilities with a total capacity of 9,150 incarcerated individuals. (11) However, the total incarcerated population in Zambia was slightly over 21,000 in 2018 and 22,823 in 2019. In 2019, almost one in five individuals detained was in pre-trial detention. (11) The data was collected between July 2018 and February 2019 in 13 correctional facilities with a combined population of 9,695, representing 46.2% of the total correctional facility population in Zambia in 2018. The 13 correctional facilities had been purposefully selected by the EJJOH project because they held a significant number of juveniles. The facilities include

Lusaka Central, Kamwala Remand, Livingstone Central, Katombora Reformatory School, Nakambala Approved school, Mukobeko Medium, Ndola remand, Kamfinsa State, Chingola, Insakwe Approved School, Chipata Central, Mongu Central and Kasama Central (locations shown in Supplementary Figure 1). The Reformatory and approved schools hold ordered (convicted) juveniles (persons less than 19 years old)(12); the other facilities are intended only for adults and circumstantial children(13) but also hold juveniles who are still undergoing trial.

Across Zambia, routinely, incarcerated people should undergo universal TB screening and HIV testing at entry or within 7 days of admission into correctional facilities. However, in some facilities entry screening is not done due to various constraints. Depending on availability of logistics, periodic TB and HIV mass screening are carried out, with freedom to opt out of HIV testing but not TB screening and testing. TB screening is mandatory to increase early TB detection and treatment so as to protect other inmates from TB.

Study Procedures

A project specific register was used; it was a modification of the National Presumptive TB register with additional data elements on entry point, category of individual and previous history of TB. All inmates were screened for TB; those who did not opt out were tested for HIV. The screening point was documented under one of the following categories: mass screening, entry screening from the community or entry screening transfer from other correctional facility. The categories of individuals included adults and juveniles. Those already on anti-TB treatment at the time of screening were documented as TB cases and those on

anti-retroviral therapy (ART) were recorded as HIV positive and were not retested. Those with cough, fever, weight loss, night sweats, chest pain and shortness of breath, irrespective of duration, were considered presumptive TB patients and submitted sputum for testing using GeneXpert (Xpert MTB/Rif Assay. Cepheid, Sunnyvale, California, USA). Symptomatic individuals with a negative GeneXpert were referred for Chest x-ray (CXR) depending on the clinician's discretion. There were 3 variations to this algorithm: 1) In Lusaka central, a random proportion of the incarcerated population received CXR in addition to symptoms screening and those with either abnormal CXR or symptoms submitted sputum for GeneXpert; 2) at Ndola remand, all except those already on TB treatment submitted sputum irrespective of symptoms; and 3) in Kabwe medium, Fluorescent Microscopy (FM) was used for sputum examination instead of GeneXpert.

Alere Determine™ HIV-1/2 test (AlereHIV-1/2; Abbott, Chicago, IL, USA) was used for HIV screening and SD-Bioline HIV-1/2 (SD-Bioline HIV-1/2; Abbott, Chicago, IL, USA) for confirmation of positive screening test, following the standard Zambian HIV testing algorithm. All individuals received pre- and post-test HIV counselling. HIV positive inmates were commenced on ART within 1-2 days.

Data analysis

STATA Statistical Software (Stata Corporation Version 14. College Station, Texas 77845, USA) was used for data analysis. A descriptive analysis was done to determine the characteristics of the population screened and the prevalence of TB and HIV; overall prevalence and prevalence among subgroups was determined. The prevalence of all forms of TB included bacteriologically confirmed TB and clinically diagnosed TB. Bacteriologically confirmed TB

prevalence included those who had a positive GeneXpert or FM result, while patients already on TB treatment at time of screening were excluded from this analysis since data on the type of TB had not been collected. DR TB prevalence included incarcerated people with rifampicin resistance on GeneXpert. Missing data was excluded from the analysis.

Additionally, a chi-square test was done to determine if there was a statistically significant difference in prevalence of TB and HIV between residents and new entrants into correctional facilities. New entrants were defined as incarcerated people whose entry point was entry screening from community while residents were defined as those whose entry point was either mass screening or entry screening transfer from other correctional facility.

Patient and Public involvement

The development of the research questions was intended to inform priority setting by the EJJOH project based on the disease burden in correctional facilities. The incarcerated population were not involved in the design of the project. The correctional health committees constituting of the incarcerated persons, correctional officers and health care workers were involved in the data collection. A representative of the correctional health committee at each correctional facility participated in the dissemination meeting on project findings.

RESULTS

Flow diagram and participant characteristics

Of the total adult and juvenile population of 9,695 in the 13 correctional facilities, 8160 (84.2%) were screened for HIV and 8,267(85.3%) were screened for TB (Figure 1). Individuals not screened were 1,428 (14.7%) and they constituted those either in court or the farms. Of those screened for HIV, 1170(14.3%) were HIV positive, of which 816 were known positive and 354 were new positives, while 6,990 (85.7%) were HIV negative. Of those screened for TB, 17(0.2%) were already on treatment, 3,076 (37.3%) individuals had symptoms of TB, 5,161 (62.5%) were asymptomatic while 13 (0.2%) had missing data. A total of 4,269 individuals had documented sputum results. Eighty seven (87) bacteriologically confirmed TB cases were reported including 25(28.7%) asymptomatic individuals 62(71.3%) symptomatic individuals. A total of 132 TB cases were identified including 87 (65.9%) bacteriologically confirmed TB cases, 28 (21.2%) clinically diagnosed TB cases and the 17 (12.9%) that were already on TB treatment at the time of screening.

Figure 1: Flow diagram of TB screening and diagnosis

Of those screened, 7,805 (94.41%) were adults and 462 (5.58%) were juveniles (Table 1). The overall median age (interquartile range (IQR)) of the participants was 32 years (IQR 10-93); the median ages for the adults and juveniles were 33(IQR 19-93) and 17(IQR 10-18) respectively. The males were 8,167 (98.79%), participants with a history of previous TB were 467 (5.65%), resident inmates were 7,767 (93.95%) while new entrants were 497 (6.01%).

Table 1: Characteristics of population screened

Variable	**Participants (n= 8267)**
Category of individual	n (%)
Adults	7,805 (94.41%)
Juveniles	462 (5.58%)

Median Age (IQR)	
Overall	32(10-93)
Adults (≥19 years)	33 (19-93)
Juveniles (<19 years)	17 (10-18)
Sex	n (%)
Male	8,167 (98.79%)
Female	89 (1.08%)
Missing	11 (0.13%)
History of previous TB	n (%)
Yes	467 (5.65%)
No	7,786 (94.18%)
Missing	14 (0.17%)
Type of screening visit	n (%)
Mass screening	7,602 (91.92%)
Entry screening other correctional facility	165 (2.00%)
Entry screening community	497 (6.01%)
Missing	3 (0.04%)

Abbreviations: IQR- Interquartile range, TB- Tuberculosis

Prevalence of all forms of TB and bacteriologically confirmed TB

The overall prevalence of all forms of TB was 1,598 (1339-1892) per 100,000 population while the overall prevalence of bacteriologically confirmed TB was 1,056 (844-1301) per 100,000 population (Table 2). There was no statistically significant difference in the prevalence of both all forms of TB and bacteriologically confirmed TB between males and females, (p=0.51) and (p=1.00) respectively. It was the same for adults and juveniles (p= 0.82) and (p= 0.23) respectively and the new entrants and residents (p=0.25) and (p=0.21) respectively.

Table 2: Prevalence of all forms of TB and bacteriologically confirmed TB

	Cases/ Participants (n/N)	**Prevalence of all forms of TB per 100,000 (CI)**	**p-value**	**Cases/ Participants (n/N)**	**Prevalence of Bacteriologically confirmed TB per 100,000 (CI)**	**p-value**

Overall	132/8,254[1]	1599 (1340-1894)		87/8,237[1,2]	1056 (847-1301)	
Sex						
Male	129/8,154	1582 (1322-1877)	0.60	84/8,137	1032 (824-1276)	0.79
Female	1/89	1124 (28- 6102)		1/89	1124 (28- 6102)	
Missing gender	2/11			2/11		
Category of individual						
Adult (≥19 years)	124/7,792	1591 (1325- 1894)	0.82	79/7,775	1016 (805-1265)	0.23
Juvenile (<19 years)	8/462	1732 (750-3383)		8/462	1732 (750-3383)	
Entry point[1,3]						
Residents	121/ 7757	1560 (1296- 1861)	0.25	79/7740	1020 (809-1270)	0.21
New entrants	11/494	2227 (1117-3949)		8/494	1619 (702-3166)	

Abbreviations: CI- Confidence interval, TB- Tuberculosis

Residents include those screened through mass screening and those under entry screening as a transfer from other correctional facility.

New entrants include those screened under entry screening from the community (police cells).

[1] Thirteen (13) participants had missing values on TB.

[2] Seventeen participants were already on TB treatment, bacteriological status unknown

[3] Three (3) participants had missing values on entry point

Prevalence of DR TB

Among the bacteriologically confirmed TB cases, the overall prevalence of DR TB was 4.6% (1.3%-11.4%) (Table 3). There was no statistically significant difference in prevalence of DR TB between males and females (p=0.95), between adults and juveniles (p=0.68), between those with and those without previous history of TB (p=0.72) and between the new entrants and residents(p=0.26).

Table 3: Prevalence of drug resistant TB

	Cases/ Participants (n/N)	Prevalence of DR TB % (CI)	p-value
Overall	4/87	4.6 (1.3-11.4)	
Sex			
Male	4/84	4.8 (1.3-11.7)	0.95
Female	0/1	0 (0- 97.5) *	
Missing	0/2		
Category of individual			
Adults (≥19 years)	4/79	5.1 (1.4- 12.5)	0.68
Juveniles (<19 years)	0/8	0 (0-3.7) *	
Previous History of TB			
No	3/64	4.7 (1.0-13.1)	0.72
Yes	1/23	4.3 (0.1- 21.9)	
Entry point			
Residents	3/76	3.8 (0.8-10.7)	0.26
New entrants	1/8	12.5 (0.3-52.7)	

Abbreviations: DR TB- Drug Resistant Tuberculosis CI- Confidence interval
Residents include those screened through mass screening and those under entry screening as a transfer from other correctional facility.
New incarcerated individuals include those screened under entry screening from the community (police cells).
* one-sided, 97.5% confidence interval

Prevalence of HIV

The overall HIV prevalence was 14.3% (13.6%-15.1%) (Table 4). The prevalence of HIV among males was 14.1% (13.4%-14.9%) and among females 25.8% (16.6%-35.1%) (p=0.01). The prevalence of HIV among adults and juveniles was 15.0% (14.1%-15.7%) and 3.9% (2.3%-6.2%) (p<0.01) respectively. There was no statistically significant differences in prevalence of HIV between residents and new entrants (*p*=0.05).

Table 4: Prevalence of HIV

	Cases/ Participants (n/N)	Prevalence of HIV % (CI)	p-value

Overall	1,170/8,160[1]	14.3 (13.6-15.1)	
Sex			
Male	1,139/8,061	14.1 (13.4-14.9)	0.00
Female	23/89	25.8 (17.4-36.2)	
Missing sex	8/10		
Category of individual			
Adults (≥19 years)	1,153/7,727	15.0 (14.1-15.7)	0.00
Juveniles (<19 years)	17/433	3.9 (2.3- 6.2)	
Entry point[1,2]			
Residents	1,118/7699	14.5(13.7-15.3)	0.06
New entrants	52/460	11.3 (8.6-14.6)	

Abbreviations: CI- Confidence interval, HIV- Human Immunodeficiency virus
Residents include those screened through mass screening and those under entry screening as a transfer from other correctional facility. New incarcerated individuals include those screened under entry screening from the community (police cells).
[1]One hundred and seven (107) participants either opted out of HIV testing or had missing data
[2]Three (3) participants had missing entry point, 2 of which also had missing HIV status
(*) one-sided, 97.5% confidence interval.
** not determined.

DISCUSSION

Statement of principal findings

This study found that in Zambian correctional facilities, the prevalence of all forms of TB, bacteriologically confirmed TB and DR TB were 3.5 times higher(14), 1.7 times higher(14) and 3.5 times higher(15) than the respective prevalence in the general population. Additionally, the overall prevalence of HIV was 1.3 times higher than the prevalence in the general population (16) and the prevalence of HIV among females was 1.8 times higher than the prevalence of HIV among males within correctional facilities. Of the bacteriologically confirmed TB cases, 28.7% were asymptomatic.

Study findings in relation to other studies

It is noteworthy that there is no statistically significant difference in prevalence of all forms TB and bacteriologically confirmed TB between juveniles and adults and that in fact the point estimates for TB in juveniles were higher; generally older adults have a higher TB burden than adolescents. (17, 18) This suggests that the disproportionate access to TB services and health services in general among juveniles in Zambian correctional facilities reported between 2009-2010 has persisted. (19) Another significant contrast relative to the general population is the absence of a statistically significant difference in prevalence of bacteriologically confirmed TB between males and females. (14) This could be due to absence of gender related differences in exposure to risk factors for TB infection and disease but could also be due to the small sample size and very wide confidence intervals among females.

In comparison to the 2010-2011 study, the prevalence of all forms of TB has reduced by about 75% while the prevalence of bacteriologically confirmed TB has reduced by 50%. (6) The reduction in prevalence of all forms of TB and bacteriologically confirmed TB could be a result of the TB interventions being implemented within the Zambian correctional facilities since 2011. This explanation is supported by findings from an observational and modelling study done in Brazil: entry screening, active screening for TB among inmates, TB preventive therapy and annual mass screening independently reduce the incidence of TB in correctional facilities by 10.3%, 35%, 23.5% and 47.5% respectively after a period of 10 years and a combination of these interventions reduces the TB incidence by 79.2% after a period of 10 years. (20) However, it is worth mentioning that though the previous study used a more sensitive algorithm involving x-ray and culture(21, 22) for all inmates, the reduction is so large that it cannot simply be explained by use of different algorithms. Other countries in sub-Saharan

Africa with results involving multiple correctional facilities report TB prevalence ranging from 457 - 888 per 100,000 population. (23-25) However, a direct comparison to the prevalence reported in the other countries can't be done due to differences in definitions of TB used and differences in prevalence in the general population.

The prevalence of DR TB among people with no history of TB is similar to the prevalence among people with previous history of TB, suggesting significant transmission of DR TB either in correctional facilities or in the communities where the incarcerated people come from, or both. Strengthening TB infection control can reduce transmission of DR TB. (26) In comparison to the 2010-2011 study, the prevalence of DR TB has increased by 667%. (6) The increasing trend of DR TB in the Zambian correctional facility setting is also seen at the global and national levels.(27) The prevalence of DR TB in this study can't be directly compared to other correctional facility settings since the forms of drug resistance reported are different. (28-30)

Similar to the national picture, the prevalence of HIV was higher among adults than juveniles and was higher among females than males. (16) However, the prevalence of HIV in women relative to the prevalence of HIV in men is much higher in the incarcerated population than the general population because women with HIV risk factors like sex worker status, intimate partner violence, drug and substance abuse are overrepresented in this population. (31) Additionally, women are exposed to sexual abuse while in custody and they have more access barriers to HIV prevention, testing and treatment services compared to men. (32) Despite the very high rates of HIV in this group, relative to the study done by Simooya et al in 1999 which showed a prevalence of 33% in females, the prevalence of HIV has reduced.(33) There has been a 37.6% reduction in overall prevalence of HIV since the study in 2010-2011. (6) The

reduction in prevalence of HIV in correctional facilities is attributable to the reduction of HIV prevalence in the general population(16), the implementation of test and treat across Zambia(34), entry HIV testing and treatment(6) and use of correctional health committees to strengthen TB/HIV service delivery at facility level(9). Among African countries with studies involving several correctional facilities, Zambia's prevalence is lower than South Africa's (25) but higher than Burkina Faso and Uganda.

The difference in prevalence of TB and HIV between residents and new entrants into correctional facilities was not statistically significant. This is possibly due to the following reasons: a) individuals entering correctional facilities come from socio-economically disadvantaged backgrounds where prevalence of TB and HIV are already high (1); b) there are high rates of recidivism (35); and c) detainees spend long periods in police cells, which have similar conditions to the correctional facilities (36, 37). However, the small sample size and wide confidence intervals especially for the new entrants is a limiting factor for drawing any inferences from this comparison. This finding highlights the contribution of imported TB and HIV cases to the burden of disease in correctional facilities and underscores the importance of entry screening within this setting.

Strengths and limitations

This study provides the most recent evidence on prevalence of TB and HIV in Zambian correctional facilities. The results of this study are generalizable to the 13 correctional facilities, as a large sample representing 85% and 84% of the 13 correctional facility population, was screened for TB and HIV respectively. By virtue of the data being disaggregated, it provides an opportunity for targeting of interventions that can reduce the

burden of both diseases. However, there were variations in the strength of screening algorithms for TB, hence the prevalence of TB could have been underestimated in some correctional facilities. That said, among all forms TB cases, it is possible that some of the clinically diagnosed TB cases might not be true TB cases as there are other differential causes of chest x-ray abnormalities that mimic TB. Inmates in court or on the farms were not screened for TB which could have introduced bias during data collection. Additionally, asymptomatic TB was not consistently screened for.

CONCLUSION

Despite significant progress over the last decade in controlling TB and HIV in Zambian correctional facilities, these continue to be disproportionately affected by both diseases. TB/HIV programs in correctional facilities need further strengthening to include aspects of juvenile specific TB programming, gender responsive HIV programming and holistic integrated service delivery as TB and HIV are not exclusive health concerns of incarcerated individuals. Additionally, there is need to consider use of more sensitive algorithms that include chest x-ray to minimize the risk of missing asymptomatic TB cases. Additional studies are required to determine the true prevalence of asymptomatic TB in correctional facilities, to better understand the reason for high HIV burden among females in correctional facilities and to determine the prevalence of TB and HIV using a sample whose results can be generalized to all the correctional facilities in Zambia.

ETHICS STATEMENT

Approval to use the programmatic data was obtained from the University of Zambia Biomedical Research Ethics Committee No: 018-11-18 and the London School of Hygiene and Tropical Medicine Ethics Committee No: 21332. Since data was collected under programmatic conditions, no consent was sought for TB screening and verbal consent and assent were obtained for HIV testing. The EJJOH project had obtained permission from the Zambia Correctional service and the Ministry of Community Development and Social services to conduct the screening activities including testing of juveniles. When migrating data from the paper-based registers to the electronic database, participant identifying information was excluded.

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AUTHOR CONTRIBUTIONS

Conceived and designed the study: MK, SH, CNM, MM. Database design and data curation: PS, JB. Implemented the study: MK, SH, MT, TZ, CNM, MM. Data analysis: PS, MK, FB. Wrote the original draft: MK. Reviewed the manuscript: SH, MT, JB, PS, TZ, FB, CNM, MM. Approved the final version to be published: MK, SH, PS, MT, JB, TZ, FB, CNM, MM.

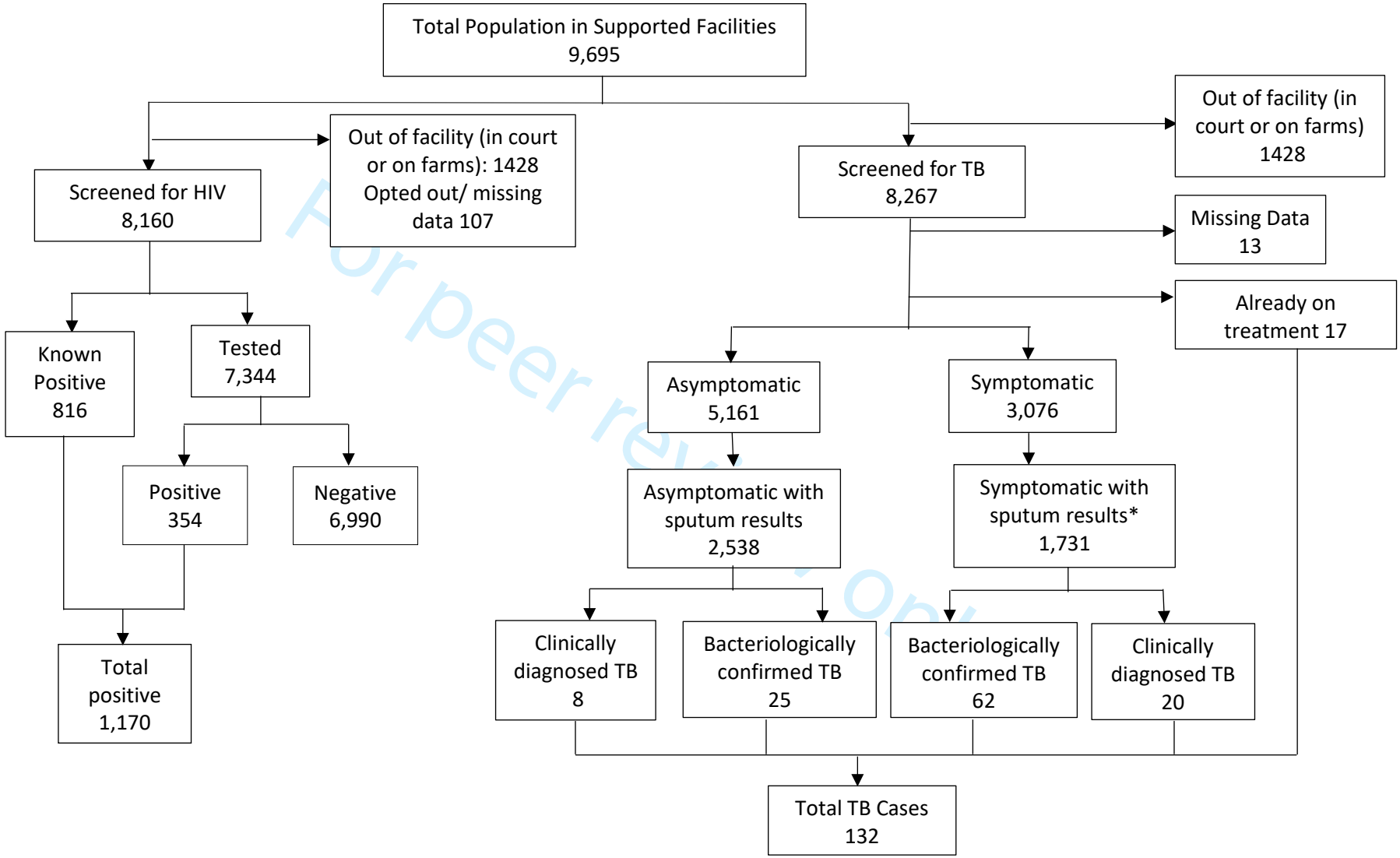
The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

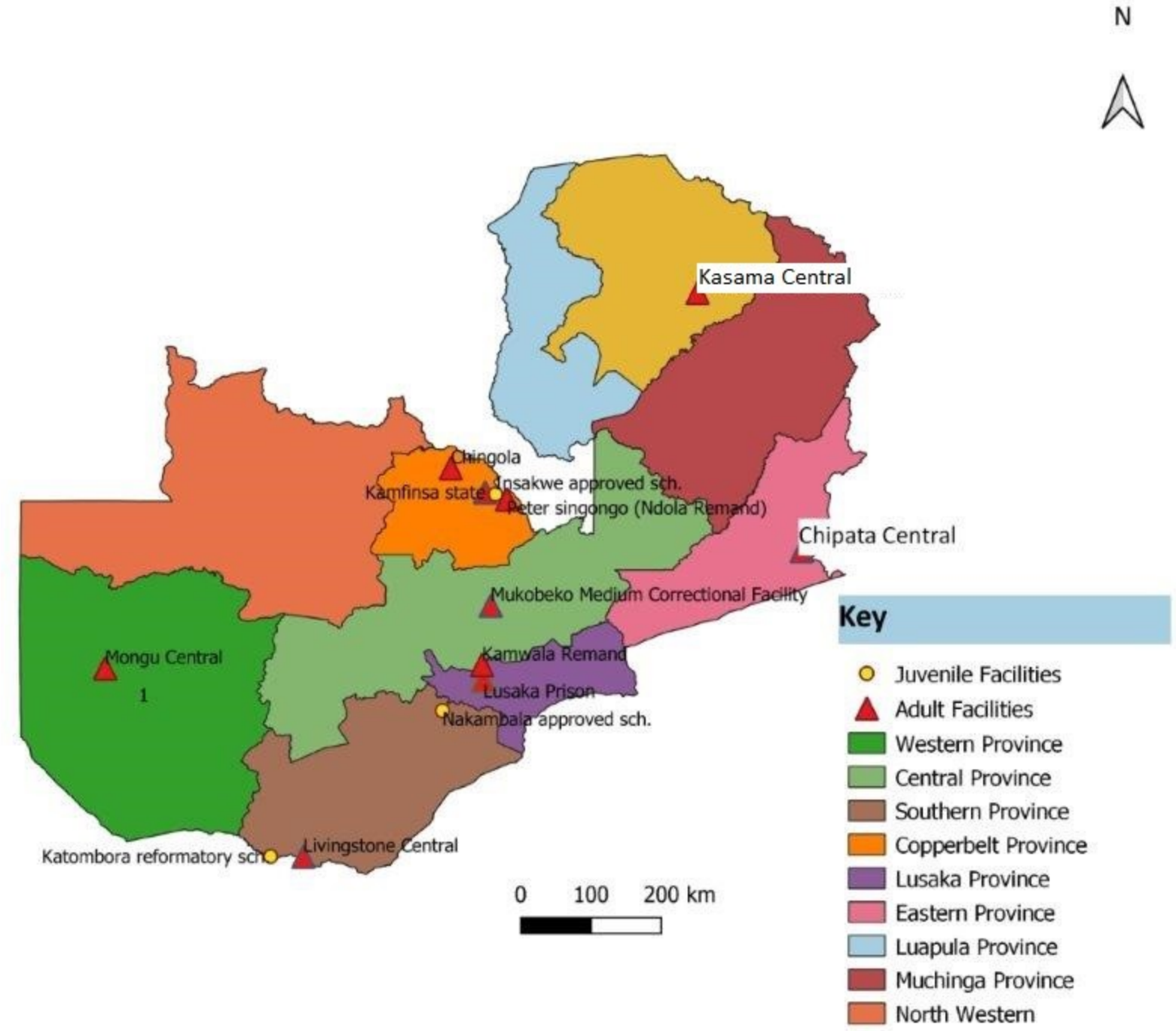
DATA SHARING STATEMENT

Additional data is available upon request by emailing Monde.Muyoyeta@cidrz.org



HIV- Human Immunodeficiency Virus, TB- Tuberculosis

**All symptomatic patients submitted sputum, however, some correctional facilities only documented results of patients with positive results.*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Chipata Central
Mukobeko Medium Correctional Facility
Mongu Central
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Lusaka Prison
Nakambala approved sch.
Katombora reformatory sch
Livingstone Central
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Key
Juvenile Facilities
Adult Facilities
Western Province
Central Province
Southern Province
Copperbelt Province
Lusaka Province
Eastern Province
Luapula Province
Muchinga Province
North Western

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5,6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6,7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7,8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8,9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8,9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8,9
		(*b*) Describe any methods used to examine subgroups and interactions	8,9
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9, 10
		(b) Give reasons for non-participation at each stage	9,10
		(c) Consider use of a flow diagram	10
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10,11
		(b) Indicate number of participants with missing data for each variable of interest	11-14
Outcome data	15*	Report numbers of outcome events or summary measures	11-14

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	11-14
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-14
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.