



Trends in tuberculosis notification and treatment outcomes in prisons: a country-wide assessment in El Salvador from 2009–2014

Gilberto Ayala,¹ Julio Garay,¹ Miguel Aragon,² Tom Decroo,³ and Rony Zachariah³

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ABSTRACT

Objective. To describe trends in tuberculosis (TB) notification and treatment outcomes in 25 prisons in El Salvador from 2009–2014 and to determine if a set of interventions introduced in 2011 affected TB case finding and management.

Methods. This was operational research that utilized a retrospective cohort study of program data from 2009–2014. The package of interventions introduced in 2011 provides staff training, engages inmates in TB case finding, and offers diagnosis through mobile X-ray and Xpert[®] MTB/RIF.

Results. Case notification rates per 100 000 prisoners tripled, from 532 in 2009 to 1 688 in 2014—about 50 times that of the general population. Individual data were analyzed for 1 177 patients who started TB treatment, among whom 1 056 (89.7%) cases were bacteriologically-confirmed: 966 (92%) were diagnosed through smear microscopy; 42 (4%) with Xpert[®] MTB/RIF; and 48 (5%) through cultures. Cumulative treatment success and cure rates were over 95% and 90%, respectively. However, among 113 patients with previously-treated TB, drug sensitivity testing results were available for only 53 (47%). One patient was diagnosed with mono-drug resistant TB.

Conclusions. These findings show that TB notification increased exponentially since introduction of the intervention package and that excellent treatment outcomes were sustained. Both are of vital relevance to countries striving for TB elimination. Notification might be improved further by providing systematic TB screening upon prison entry and periodically thereafter. Furthermore, previously-treated TB patients should receive prioritized screening for drug resistance.

Key words

Tuberculosis; prisons; lung; radiography; molecular diagnostic techniques; social participation; operations research; El Salvador; Central America.

Tuberculosis (TB) incidence rates are 5–50 times higher in prisons than among the general population (1, 2). Acquisition and transmission of TB in prisons is exacerbated by overcrowding, insufficient infection control measures, limited access

to health care, and delays in TB diagnosis. Poor nutritional status, drug usage, and higher prevalence of human immunodeficiency virus (HIV) in prisons serve as additional risk-factors. Consequently, reactivation of latent TB infection and

rapid progression of newly-acquired TB infection to disease are both common in the prison setting (1–3). Prisons serve as a “reservoir” for spreading disease to the broader community; it has even been hypothesized that transmission dynamics between prisoners and the general population play a key role in driving overall population-level TB incidence, prevalence, and mortality (2, 4).

¹ National Tuberculosis Program and Lung Diseases, Ministry of Health, San Salvador, El Salvador. Send correspondence to Gilberto Ayala, email: dr.anibalayala@gmail.com

² Pan American Health Organization, San Salvador, El Salvador.

³ Médecins sans Frontières, Brussels Operational Center, Luxembourg City, Luxembourg.

Effective TB control in prisons is, therefore, of major importance to public health. The Government of El Salvador, in an effort to enhance early TB case finding and diagnosis in its prisons, introduced a new package of interventions in 2011. These interventions included medical staff training, a mobile X-ray unit to visit all prisons, sputum sample evaluation, and an inmate volunteer network to help identify those with presumptive TB. El Salvador, like many countries in the Region of the Americas, has achieved the Millennium Development Goal (MDG) targets of reducing TB incidence, prevalence, and mortality (5). In 2013, case detection for the general population of El Salvador was 87% (2 176 diagnosed of 2 501 estimated cases) and mortality was less than 10% for the different types of TB (5). However, to the authors' knowledge, there are no studies to date that have evaluated TB control interventions in prisons in El Salvador.

This study, therefore, aimed to describe trends in tuberculosis (TB) notification and treatment outcomes in 25 prisons in El Salvador from 2009–2014 and to determine if a set of interventions introduced in 2011 affected TB case finding and management.

MATERIALS AND METHODS

Study design and setting

This was a retrospective cohort study using data from the national prison TB program of El Salvador. All of the country's 25 prisons were included. In 2013, the 21 adult correctional facilities were reported to have 27 038 inmates, greatly exceeding the maximum capacity of 8 328 (325% saturation). Many of the prison facilities lack adequate sanitation, clean water, and ventilation (6).

Study participants were all convicted prisoners diagnosed with TB in January 2009–December 2014 in 25 prisons (including the four juvenile prisons).

Prison TB control background

Prior to 2011, TB management in the prisons followed the national guidelines (7, 8). Patients were managed in each prison by a general practitioner and a nurse employed by the National Directorate of Prisons. The Directorate

collaborated with the National Tuberculosis Program (NTP). Presumptive TB was considered if an individual manifested a cough for 3 weeks or more, had chest-pain, was coughing-up blood or sputum, and had other symptoms, such as weakness or fatigue, weight loss, lack of appetite, and/or chills and fever. Sputum of patients with presumptive TB was sent to the closest laboratory in the national health system for smear microscopy. All prisoners diagnosed with TB received treatment within the prison; a national TB register was completed and outcomes were reported to the NTP. All TB patients were also offered HIV testing and those who were positive were offered antiretroviral treatment (ART). If a prisoner's term ended and TB treatment was incomplete, the patient was referred to the health facility closest to home.

Prison TB control after intervention

In 2011, the intervention package was introduced. It incrementally implemented health staff training on Directly Observed Treatment, Short-course (DOTS); a visiting mobile X-ray unit; sputum sample evaluation; and an inmate volunteer network. Prison health staff was trained on TB case finding and management. Sputum of patients with presumptive TB was still sent for smear microscopy to a nearby laboratory within the national health system. In 2012, a mobile radiological unit began to screen patients with presumptive TB at all the prisons at least twice per year, visiting each facility according to a fixed schedule.

In addition, Xpert[®] MTB/RIF (Cepheid Incorporated, Sunnyvale, California, United States) testing was performed for all patients with an X-ray suggestive for pulmonary TB, or for any patient with presumptive TB, but who had three negative sputum smears. The Xpert[®] machine is a fully automated and commercially available nucleic acid amplification test that provides results in less than 2 hours. The test has high sensitivity and specificity for the diagnosis of TB and gives information on susceptibility to rifampicin (9). During the study period, there were four Xpert[®] MTB/RIF machines available. If cases of presumptive TB were seen in between the scheduled visits of the mobile team, the same services were offered by sending sputum specimens and/or the patient to the closest diagnostic facility. By 2014, Xpert[®] MTB/RIF became a first-line test for all patients with presumptive TB and provided a unique opportunity to evaluate the emergence of drug resistant TB in prisons.

Lastly, a volunteer network was enacted inside the prisons to detect and refer patients with presumptive TB and to support treatment adherence. Volunteers included mainly prison leaders, who were trained on TB symptoms, referral criteria, and adherence support. The differences in TB diagnosis and treatment before and after 2011 are shown in Table 1.

Data sources and variables

Data related to the study objectives were collected from November 2014–March 2015 and included: gender (male/female); age (in years); start date of TB treatment; number of prisoners

TABLE 1. Differences in tuberculosis (TB) diagnosis and treatment before and after the intervention package introduced in 2011 in 25 prisons, El Salvador

	Before 2011	Progressive implementations of activities since 2011
TB diagnosis	Sputum of patients with presumptive TB sent for smear microscopy to a laboratory within the national health system. Patients with presumptive TB and negative smears referred for X-ray to an external clinic in the national health system.	2011–prison health staff trained on TB prevention and treatment March 2012–mobile X-ray unit begins biannual visits to each prison. Prisoners with presumptive TB have a X-ray (independent of smear results) April 2012–sputum sent for Xpert [®] MTB/RIF testing following three negative smears or a suggestive X-ray May 2013–activation of volunteer network to detect patients with presumptive TB
TB treatment	Adherence support by health care workers	Training on Directly Observed Treatment, Short Course (DOTS) for clinicians Adherence support of volunteers recruited among the prisoners

Source: created by the authors from the study data.

by year; number registered with TB (cumulative by type and category of TB); TB regimen (Category I for new patients, Category II for retreatment, Category III for patients less than 10 years of age [not applicable], Category IV for multi-drug resistant TB [MDR-TB]); microscopy result at diagnosis; result of culture at diagnosis; results of the Xpert[®] MTB/RIF; HIV test result; and TB treatment outcomes. The data sources included the annual report of the National Directorate of Prisons, the national TB reports for the years 2009 and 2010, and the national TB program registers for the years 2011, 2012, 2013, and 2014. Notified patients were all those had been diagnosed on bacteriological or clinical grounds and had started TB treatment from 1 January 2009–31 December 2014. Treatment outcomes were assessed for the cohort starting TB treatment between 1 January 2009–31 December 2013 and appraised on 31 November 2014. Treatment outcomes were standardized and were categorized as either: success, failure, death, lost-to-follow-up, or not recorded (8).

Data analysis

Prison TB notification rates were calculated using the number of inmates (prison population) retrieved from the Directorate of Prisons for December of each study year. For validation, the data were compared with the aggregate numbers of the NTP.

EpiData software was used for data entry and analysis (version 3.1 for entry and version 2.2.2.183 for analysis, EpiData Association, Odense, Denmark). Descriptive statistics were used to summarize the findings and the chi-square for trend to assess linear trends.

Ethics

The study was approved by the Ethics Advisory Group of the International Union Against Tuberculosis and Lung Disease (Paris, France) and the National Ethics Committee for Clinical Research (San Salvador, El Salvador). Permission for the study was granted by the Ministry of Health of El Salvador. Since the study evaluated only routine program data without patient identifiers, informed consent was not necessary.

RESULTS

Trend in TB notification

A total of 1 679 prisoners were diagnosed with TB in 2009–2014. Figure 1 shows the 6-year trend. During this period, the intervention package was introduced progressively and the TB notification rate per 100 000 increased from 532 (118/22 189) in 2009 to 1 688 (503/29 803) in 2014 (a three-fold increase, chi-square for trend = 798; $P < 0.001$). The prison population increased from 22 189 in 2009 to 29 803 in 2014 (a 34% increase). After the 2011 intervention package, a total of 1 800 chest X-rays were done with 179 (10%) being suggestive of TB. There were also 301 Xpert[®] MTB/RIF tests done, of which 42 (14%) were positive for TB.

Characteristics of prisoners with TB

Individual data were analyzed for all 1 177 prisoners who started TB treatment in 2009–2013. Of the total, 1 166 (99%) were male. The median age was 28 years of age, ranging from 14–73 years; the interquartile range (IQR) was 24–33 years of age. HIV testing was

done in 99.4% of the cohort ($n = 1 177$), with 75 (6.4%) patients found to be HIV-positive. Of the latter, 44 (59%) started ART. Prior to introduction of the intervention package (2009–2011), the proportion of HIV/TB co-infected patients was 8.7% (45/517), but dropped thereafter to 4.6% (30/655) (chi-square for trend = 8.2; $P = 0.004$).

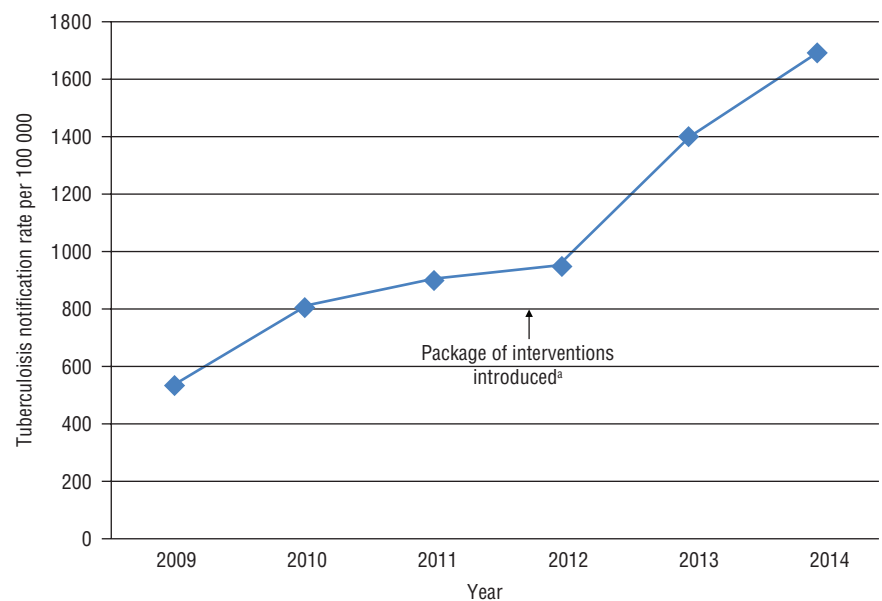
Confirmed cases

Of the 1 177 individuals that had started TB treatment, 1 056 (89.6%) had bacteriologically confirmed TB; of these, 966 (91.5%) were confirmed by smear microscopy, 42 (4%) with Xpert[®] MTB/RIF, and 48 (4.5%) through Löwenstein-Jensen medium cultures. Of the 42 patients who tested positive with Xpert[®] MTB/RIF, one was resistant to rifampicin.

Treatment outcomes

Outcomes for TB patients who started treatment in 2009–2013 in relation to the intervention package of enhanced case finding and management is shown in Table 2. Overall, treatment success was consistently over 95% (1 130/1 173).

FIGURE 1. Increase in tuberculosis notification rates following introduction of an intervention package, per 100 000 prisoners in 25 prisons in El Salvador, 2009–2014



Source: created by the authors from the study data.

^a Intervention package comprising: TB management training for medical staff; mobile X-ray unit visits to each prison at least twice a year; X-rays for all prisoners with presumptive TB symptoms (independent of sputum smear results); Xpert[®] MTB/RIF testing in case of three negative smears or a suggestive X-ray; volunteer network to identify patients with presumptive TB.

The treatment outcomes for 920 smear-positive, confirmed, new pulmonary TB patients for the same period are shown in Table 3. Overall, treatment success was again consistently over 95% and “cure” rate was 90% or above.

Among 113 patients with previously treated TB (106 recurrent; 4 retreated after failure; 3 retreated after lost to follow up), Xpert® MTB/RIF was offered to 5 patients. Culture was done in 72 (63.7%), while in 41 (36.3%) culture was either not done or not recorded. Drug sensitivity testing results were available for 53 individuals and one patient was found with mono-drug resistant TB. Treatment outcomes ($n = 113$) included 108 (95.6%) cured, 4 (3.6%) treatment completed, and 1 death. Therefore, overall treatment success was 99.1%.

DISCUSSION

This first study of TB in prisons in El Salvador shows encouraging TB program performance. Following introduction of

a three-pronged intervention package that combined staff training, mobile diagnostic technology, and inmate participation, TB case finding and management improved markedly in prison. TB case notification rates tripled, and despite the increase in TB caseload, excellent treatment outcomes exceeded the 90% success target set by WHO (5). In a country aiming to eliminate TB, this is of particular operational importance.

The 2014 case notification of 1 687.7 per 100 000 prisoners compares well with the estimated annual incidence in prisons of 1 942.8 per 100 000 (IQR: 1 045.3–2 777.8) in low- and middle-income countries (10). In El Salvador, TB incidence among the general population is estimated to be 34 per 100 000 (5). This implies that case notification rates in El Salvador’s prisons is 50 times that of the general population. However, the TB case detection rate (number detected out of the number expected per year) remains unknown, since no TB incidence

surveys were conducted in El Salvador’s prisons. Thus, we do not know if there are still missing cases (11).

We also found that the proportion of patients with bacteriologically-confirmed TB was high (89.6%), indicating a well-functioning laboratory system and motivated staff. Furthermore, the cure rate among bacteriologically-confirmed cases was high (91.8%), which is important to limit TB transmission. This is particularly relevant in our setting where the number of TB cases has increased within a growing and overcrowded prison population.

Interestingly, HIV prevalence among TB patients decreased as case notification increased. A possible explanation for this is that active case finding and management meant earlier diagnoses of TB patients, and therefore patients had less-advanced disease; whereas, prior to the 2011 interventions, passive case finding detected HIV-positive individuals who were more likely to be clinically ill.

There are a number of study implications. First, what drove the exponential increase of notification in El Salvador’s prisons, while maintaining excellent treatment outcomes? We attribute this unique finding to the addition of the intervention package to an already robust TB program (12). Although we do not know what impact each specific component had, it makes iterative sense that training of medical staff, use of both X-ray and Xpert® MTB/RIF for screening presumptive TB, and participation of an inmate network in TB control (community engagement and participation) would be beneficial (13, 14). Other studies have confirmed the benefits of each component, which when offered in

TABLE 2. Tuberculosis (TB) treatment outcomes in 25 prisons in relation to interventions to improve case finding and management, El Salvador, 2009–2013

Year	TB treatment started	Treatment success (completed/cured)		Failure		Death		LTFU ^a		Not recorded	
		No.	%	No.	%	No.	%	No.	%	No.	%
Treatment outcomes											
2009	118	115	97.5	1	0.8	1	0.8	1	0.8	0	0
2010	174	169	97.1	2	1.1	2	1.1	1	0.6	0	0
2011	225	215	95.6	1	0.4	5	2.2	4	1.8	0	0
Intervention package to improve TB case finding and management											
2012	266	258	97.0	1	0.4	4	1.5	3	1.1	0	0
2013	390	373	95.6	1	0.3	6	1.5	7	1.8	1	0.8
Total	1 173	1 130	96.3	6	0.5	18	1.5	16	1.4	3	0.26

Source: created by the authors from the study data.

^aLost to follow-up.

TABLE 3. Tuberculosis (TB) treatment outcomes in new bacteriologically-confirmed pulmonary TB cases in 25 prisons in relation to interventions introduced in 2011 to improve case finding and management, El Salvador, 2009–2013

Year	TB treatment started	Cured		Completed		Treatment success (completed/cured)		Failure		Death		LTFU ^a		Not recorded	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Treatment outcomes															
2009	95	90	94.7	2	2.1	92	96.8	1	1.1	1	1.1	1	1.1	0	0
2010	138	124	89.9	9	6.5	133	96.4	2	1.5	2	1.5	1	0.7	0	0
2011	193	173	89.6	12	6.2	185	95.8	0	0	5	2.6	3	1.6	0	0
Intervention package to improve TB case finding and management															
2012	185	168	90.8	12	6.5	180	97.3	0	0	3	1.6	2	1.1	0	0
2013	304	285	93.8	8	2.6	293	95.4	1	0.3	5	1.6	4	1.3	1	0.3
Total	920	840	91.8	43	4.7	883	96.5	4	0.4	16	1.8	11	1.2	1	0.1

Source: created by the authors from the study data.

^aLost to follow-up.

a comprehensive manner might have had an added effect. An earlier study in El Salvador showed that thorough refresher courses can successfully improve the ability of clinicians to suspect TB and adhere to the NTP guidelines (15).

Second, involving prison inmates as volunteers is likely to have enhanced communication with prisoners, which may have overcome barriers such as lack of knowledge and stigma among inmates and prison staff. Better communication fosters favorable TB health-seeking behavior (16).

Third, the diagnostic algorithm maximized yield by combining chest X-ray, a test with good sensitivity but poor specificity, with Xpert® MTB/RIF, a test with high sensitivity and specificity (17).

Finally, the intervention package needs to be capitalized on by systematically offering TB testing to all prisoners upon prison entry and on a scheduled basis. A study from Brazil showed that such systematic screening increased TB notification by a factor of 5, when compared with restricted screening of presumptive TB (18). Another modelling study estimated that annual screening of the general prison population with Xpert® MTB/RIF would more effectively reduce overall TB prevalence and be cost effective compared to other screening methods (19). An operational caveat is that the increased numbers of detected TB cases would need to be matched with increased resources to cope with the burden. Furthermore, since the prison population continues to rise, a dedicated focus on environmental control of TB transmission is also vital.

The strengths of this study are that it was country-wide, likely to represent the operational reality; outcomes were available for all patients; and data on prison populations by year was available

allowing calculation of trends in case notification. The study also adhered to STROBE guidelines (14).

Limitations

An important limitation is that the study had no data on the trend of prisoners with respiratory symptoms or suspected cases of TB. Another limitation was that Xpert® MTB/RIF was used in only 5 previously-treated TB patients and culture was missing for 41 patients. Therefore, it is possible that some drug-resistant TB cases were missed. Despite this limitation, it is reassuring that treatment cure in this group was over 95%—which is a proxy for favorably low drug-resistance, as confirmed by other publications in El Salvador (13, 20). This notwithstanding, the NTP needs to ensure that henceforth, all previously-treated TB patients are offered Xpert® MTB/RIF testing. In 2014, a decision to this effect was made.

Conclusions

In conclusion, the findings from this study show an exponential increase in TB notification since the introduction of the intervention package. Excellent treatment outcomes were sustained. This is of considerable public health importance—boosting TB control among high risk groups such as prisoners—especially for countries striving for TB elimination.

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RESUMEN

Tendencias de la notificación de la tuberculosis y el resultado del tratamiento antituberculoso en prisiones: evaluación nacional en El Salvador del 2009 al 2014

Objetivo. Describir las tendencias de la notificación de casos de tuberculosis y los desenlaces terapéuticos en 25 prisiones de El Salvador del 2009 al 2014 y determinar si un conjunto de intervenciones introducidas en el 2011 ha modificado la búsqueda de casos y el tratamiento de la enfermedad.

Métodos. Investigación operativa con un estudio retrospectivo de cohortes a partir de los datos del programa del 2009 al 2014. El conjunto de intervenciones introducidas en el 2011 aportaba capacitación de personal, fomentaba la participación de los presidiarios en la búsqueda de casos de tuberculosis y ofrecía medios diagnósticos como la radiografía móvil y la prueba Xpert MTB/RIF®.

Resultados. La tasa de notificación de casos se triplicó de 532 por 100 000 reclusos en el 2009 a 1 688 en el 2014, una tasa alrededor de 50 veces más alta que en la población general. Se analizaron los datos individuales de 1 177 pacientes que comenzaron el tratamiento antituberculoso, de los cuales 1 056 (89,7%) obtuvieron confirmación bacteriológica: se diagnosticaron 966 casos (92%) mediante baciloscopia, 42 casos (4%) con la prueba Xpert MTB/RIF®, y 48 casos (5%) mediante cultivo. La tasa acumulada de éxito terapéutico fue 95% y la de curación fue 90%. Sin embargo, solo en 53 de los 113 pacientes (47%) con antecedente de tratamiento antituberculoso se contaba con resultados de las pruebas de sensibilidad a los medicamentos. En un paciente se diagnosticó tuberculosis monorresistente.

Conclusiones. Los resultados del presente estudio revelan que desde la introducción del módulo de intervenciones, la notificación de la tuberculosis ha aumentado de manera exponencial y se han mantenido excelentes desenlaces terapéuticos. Ambos aspectos son de gran importancia en los países que se esfuerzan por alcanzar la eliminación de la tuberculosis. Si la detección sistemática de la tuberculosis se lleva a cabo en el momento de la entrada en prisión y en adelante de manera periódica es posible mejorar aún más la notificación. Además, en los pacientes previamente tratados se debe priorizar la detección sistemática de farmacorresistencia.

Palabras clave

Tuberculosis; prisiones; pulmón, radiografía; técnicas de diagnóstico molecular; participación social; investigación operativa; El Salvador; América Central.