ISSN: 3029-0716

*Research Article*

Journal of Infectious Diseases & Treatments

# Strategies For the Control of Tuberculosis in Bolivian Penitentiary Centres

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**Received:** April 17, 2025; **Accepted:** April 22, 2025; **Published:** April 30, 2025

**ABSTRACT**

Background: Tuberculosis (TB) remains a major global health concern, with incarcerated populations experiencing higher incidence due to overcrowding, poor living conditions, and limited healthcare access. This study evaluates the implementation of TB control strategies in Bolivian prisons from 2000 to 2024, emphasizing the role of nutritional interventions in treatment outcomes.

Objective: To assess the effectiveness of progressive tuberculosis control strategies in Bolivian prisons and analyze the impact of nutritional strategies on treatment outcomes.

Methods: A descriptive retro-prospective cohort study was conducted, evaluating the tuberculosis control strategies implemented in Bolivian prisons from 2000 to 2024. Data were collected through interviews with program officials, institutional records, and databases, with an emphasis on tuberculosis case incidence, treatment outcomes, and the effects of nutritional supplementation on patients' health.

Results: Between 2012 and 2018, the incidence of tuberculosis cases increased, though treatment success rates remained stable. The introduction of nutritional supplements and food rations between 2019 and 2023 demonstrated improvements in patients' body weight and body mass index, which correlated with higher treatment success rates. However, despite these improvements, cases of treatment failure and death persisted, indicating the complexity of tuberculosis treatment in the prison setting.

Conclusions: The gradual implementation of tuberculosis control strategies in Bolivian prisons has led to improvements in case detection and nutritional status. However, the increase in tuberculosis incidence and the challenges of ensuring treatment continuity underscore the need for further efforts in managing comorbidities, improving follow-up for released inmates, and enhancing adherence to treatment protocols.

**Keywords:** Tuberculosis, Strategies, Prisons, Treatment outcomes, Nutritional Intervention, Comorbidities, Prison Health

**Abbreviations**

| | | |
|---|---|---|
| BMI | : | Body Mass Index |
| DM | : | Diabetes Mellitus |
| DOTS | : | Directly Observed Treatment, Short-course |
| HIV | : | Human Immunodeficiency Virus |
| PAHO | : | Pan American Health Organization |
| SPSS | : | Statistical Package for the Social Sciences |
| TB | : | Tuberculosis |
| WHO | : | World Health Organization |

**Citation:** Rebeca Ledezma, Ruth Ramos, Amilcar Apaza, Igberto J Tordoya-Titichoca, Miguel Zambrana. Strategies For the Control of Tuberculosis in Bolivian Penitentiary Centres. J Infect Dise Treat. 2025. 3(2): 1-7. DOI: doi.org/10.61440/JIDT.2025.v3.29

## Introduction

Tuberculosis (TB) remains a major global public health issue, despite the implementation of various control strategies. It is estimated that in 2023, there were 10.8 million new TB cases worldwide, with approximately 342,000 new cases reported in the Americas during the same period [1]. However, in the context of incarcerated populations, the problem of tuberculosis presents greater complexity due to high population density, poor living conditions, and limited access to adequate healthcare services, which facilitate the spread of the disease [2].

Globally, TB incidence in prisons is significantly higher than in the general population, with rates often exceeding those in communities outside of the penitentiary environment [3,4]. According to the Pan American Health Organization (PAHO), in 2023, the notification rate of TB among incarcerated individuals in the Americas was estimated to be 53 times higher than that in the general population. The same report indicates that TB incidence in Bolivia's prisons was 2,234 per 100,000 inhabitants, 29 times higher than in the general population [5].

The spread of tuberculosis in prisons is facilitated by delays in diagnosing and treating infectious cases, as well as by poor living conditions, such as overcrowding [6]. A key challenge in the fight against tuberculosis in these environments is non-adherence to supervised treatments. This issue is exacerbated by frequent transfers between prisons, which disrupt treatment continuity. Moreover, the release of inmates during treatment, particularly those from vulnerable or street environments, interrupts the treatment process and increases the likelihood of re-incarceration. Some of these patients return with drug-resistant tuberculosis, perpetuating the cycle of disease transmission. The World Health Organization (WHO) highlights that maintaining treatment continuity is one of the main challenges in the fight against tuberculosis, especially in mobile populations or those with difficulties accessing medical care post-release. Inadequate follow-up contributes to treatment failure and disease spread, emphasizing the need to strengthen referral and post-release follow-up mechanisms in prisons.

TB is one of the leading causes of illness and death in prisons, alongside HIV, malnutrition, mental illness, and violence. HIV further exacerbates the already high risk of TB in the incarcerated population. Comparisons between the prevalence of HIV in the general population and that in prisoners have shown that prevalence in prisons can be up to 75 times higher [7-9].

Regarding treatment outcomes in penitentiary facilities, WHO notes that deaths may be related to malnutrition. Additionally, treatment abandonment could be influenced by malnutrition, which can contribute to the development of adverse drug reactions to anti-tuberculosis medications, potentially leading patients to abandon their treatment. In this context, WHO recommends improving nutrition and living conditions in prisons, as such improvements could have a more significant impact on TB control, even surpassing the effects of medical interventions [7].

Since 2000, several strategies have been implemented in the Cochabamba region of Bolivia to control tuberculosis in penitentiary facilities, following WHO recommendations. Directly Observed Treatment (DOTS) began in 2000 with the involvement of health professionals, and since 2008, with support from the Global Fund, nurses were hired and prison health units were equipped. This integration enabled the inclusion of health units into the TB surveillance system, with doctors hired by the Ministry of Government starting in 2010. In 2008, HIV screening was also initiated. Since 2012, health promoters have been trained, organizing health fairs and self-help meetings, funded by the Global Fund. In 2015, TB screening was implemented upon prison entry, along with clinical records. In 2017, molecular TB diagnosis was introduced. Between 2019 and 2023, a pilot strategy for providing food rations and nutritional supplements was carried out, funded by the Damián Foundation. In 2024, health promoters were trained, and informational talks were offered to police personnel.

This study, focused on the implementation of strategies for controlling tuberculosis in prisons, aims to answer the following questions: What is the relationship between the progressive implementation of tuberculosis control strategies and the incidence of TB case notifications in prisons? And, what is the impact of implementing nutritional strategies on tuberculosis treatment outcomes in the prisons of Cochabamba, Bolivia?

## Methods and Materials

### Study Design

This descriptive retro-prospective cohort study focuses on the evaluation of the strategies implemented for the management of tuberculosis in prisons between 2000 and 2024.

### Data Collection

Data was collected in two key periods. The first, corresponding to 2000-2018, involved interviews with those responsible for the Tuberculosis Program and the Penitentiary Regime. Additionally, information was obtained from updated records, institutional reports, and databases from the Regional Tuberculosis Program, which included epidemiological and operational indicators related to tuberculosis cases in prisons. For the period 2019-2023, the data came from a pilot intervention study conducted between the Tuberculosis Program and the Damián Foundation, which included 190 cases of active pulmonary and extrapulmonary tuberculosis, as well as TB/HIV co-infection and TB/DM comorbidity cases.

### Study Variables and Data Analysis

The variables included for the evaluation of the implementation of different strategies to contribute to the control of tuberculosis in penitentiary centers, correspond to incidence, presumptive tuberculosis cases, pulmonary and extrapulmonary cases; in addition, those related to the results after anti-tuberculosis treatment identified as Successful treatment (cured and treatment completed); Therapeutic failure; Deceases; Lost to Follow-up; Transferred, not evaluated. Also, those referring to body weight and body mass index and demographic variables.

The statistical analysis of the data was conducted using SPSS software. The Spearman correlation coefficient was used to assess the relationships between the variables studied, particularly between the implementation of strategies and the incidence of cases, as well as treatment success. Changes in weight and BMI were also analyzed, along with their relationship to treatment outcomes based on age.

The timeline of the implementation of the different strategies for the management of tuberculosis in prisons is summarized graphically in Figure 1.

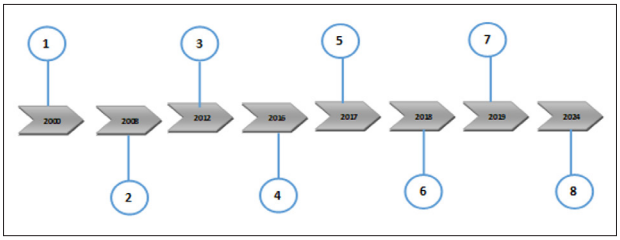


**Figure 1:** Chronology of strategies implemented for tuberculosis control in Bolivian prisons. (1) =DOTs.; (2) =Integration of prison health areas with the health services network.; (3) =Training of health promoters, Self-help meetings among patients with tuberculosis, health fairs focused on tuberculosis; (4) =Tuberculosis screening upon entry to prison.; (5) =Tuberculosis diagnosis using GenExpert.; (6) =Diabetes control with capillary glucometers.; (7) =Pilot experience of delivery of food rations and nutritional supplements; (8) =Training of promoters using the problem tree methodology.

## Results

The different strategies implemented to contribute to the control of tuberculosis in prisons, summarized in Figure 1, were performed progressively. The impact of these strategies is reflected in different metrics, such as the incidence of tuberculosis cases, which was, on average, 463.3 (+/- 155.5) per 100,000 inhabitants for the period 2012-2015, and 910 (+/- 207.2) per 100,000 inhabitants for the period 2016-2018. The same occurred with the identification of new cases, which was 12 (+/- 3.9) and 25 (+/- 6.2), for the same periods. Although the progressive strategies implemented since 2000 show no evident changes in the average treatment success percentages during the periods 2012-20215; 2016-2018, nor in the period 2019-2024 [83.8 (+/- 13.2); 89.6 (+/- 0.7); 84.7 (+/- 3.6) respectively].

Capillary glucose measurement began in 2018, which facilitated the diagnosis of diabetes, reaching 4.7% (9/190 cases) during the period 2019-2023, highlighting the importance of controlling comorbidities in TB patients, as diabetes can complicate its progression. Similarly, the systematic implementation of rapid HIV tests in 2012 allowed for the diagnosis of HIV-TB coinfection in the same period, with 4.2% (8/190 cases), this coinfection represents an additional challenge, as the interaction of both diseases can complicate treatment and worsen health outcomes, emphasizing the need for early detection and proper management of coinfections. Additionally, the identification of new tuberculosis cases in this period increased to 37 (+/- 11.4) cases representing a 32% increase compared to the previous period [2016 - 2018; 25 (+/- 6.2) cases]. A similar situation was observed for the incidence which reached 1201.9 (+/- 256.04) cases per 100,000 inhabitants.

The results from the Spearman correlation coefficient matrix (Table 1) show several significant relationships between the studied variables. First, there is a strong positive correlation between the year and the implemented strategies ($r = 0.949$, $p < 0.001$), indicating that as the years progressed, the strategies applied have been strengthening. This correlation with the implemented strategies also extends to the incidence and the increase in new cases detected ($r = 0.863$; $0.765$, $p < 0.001$, respectively), suggesting that the detection of new tuberculosis cases is closely linked to the evolution of strategies over time.

In contrast, treatment success showed a null and non-significant correlation with the implementation of strategies ($r = 0.040$, $p = 0.903$), indicating that there is no clear direct relationship between the two variables. This finding suggests that, although the strategies have been progressively intensified, they have not had a measurable impact on therapeutic success rates. Likewise, none of the evaluated comorbidities showed a significant correlation with treatment outcomes

Additionally, the introduction in the period 2019-2023 of the delivery of food rations and nutritional supplements, although as a pilot experience, made it possible to identify the evident changes in weight and body mass index (BMI) as summarized in Figure 2. In terms of body weight, the positive change was 5.2 (+/- 3.8) kg and 1.9 (+/- 1.4) for BMI; on the contrary, the negative changes were: in body weight - 3.5 (+/- 5.1) and -1.4 (+/- 2.1) in BMI. There were also 31 cases in which no changes were evident in body weight or BMI and 34 cases with no data recorded in this regard.

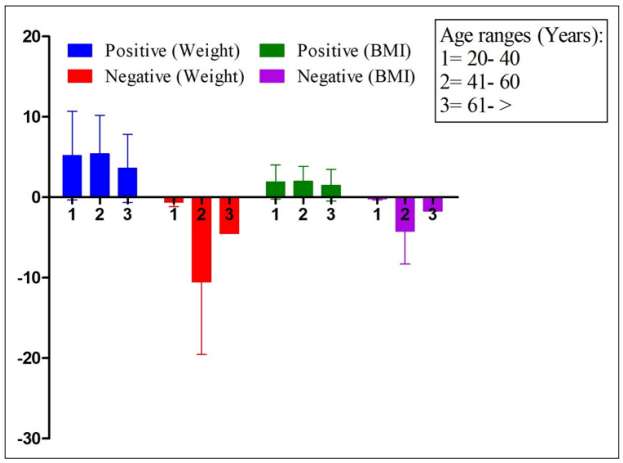


**Figure 2:** changes in weight and BMI, after delivery of food rations and nutritional supplements as pilot strategy to improve the detection of new cases and also the adherence to antituberculosis treatment. Data are expressed as mean (SD). n=190 cases.

The evaluation of the potential impact of the pilot delivery of food and nutritional supplements on the outcomes of tuberculosis treatment is summarized in Table 1. Cases with successful treatment following a positive change in body weight represented 56.3% (107/190), while those with a negative change in weight who achieved successful treatment accounted for 3.7% (7/190).

A case of therapeutic failure (0.5%) was identified among patients with a positive change in body weight. A similar situation was observed among deceased cases, regardless of the change in body weight (positive or negative) following the provision of food and supplements (Table 1). However, it is important to note that, in the deceased cases, weight gain could not be tracked, as many of these patients passed away before completing treatment. The same issue occurred with those lost to follow-up.

**Table 1: Spearman correlation matrix between the implemented strategies and the variables related to the epidemiological and operational evolution of tuberculosis control in prisons during the period 2000-2024**

| Spearman's Rho | | Results | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Epidemiological | | Operating | | | | comorbidty | |
| | | Year | Incidence | Presumptive Tuberculosis cases | Pulmonary Tuberculosis cases | Pulmonary and Extrapulmonary Tuberculosis cases | Successful Treatment | TB/DM | TB/HIV |
| Strategies | Correlation Coefficient | 0.949** | 0.863** | 0.679* | 0.767** | 0.765** | 0.040 | 0.620 | 0.309 |
| | Significance (Bilateral) | <0.001 | <0.001 | 0.011 | 0.002 | 0.002 | 0.903 | 0.138 | 0.329 |
| | N (Years) | 13 | 13 | 13 | 13 | 13 | 12 | 7 | 12 |

**. The correlation is significant at the 0.01 level (bilateral).
*. The correlation is significant at the 0.05 level (bilateral).

The evaluation of the outcome obtained after anti-tuberculosis treatment of prisoners, according to the categories "cured", "completed", "failed", etc. indicated in Table 2, takes into account body weight changes after the pilot administration of food and nutritional supplements, reveals a tendency towards higher percentages for the cured category in those who presented positive body weight changes independently of the age range group in which was grouped the cases. Even so, among these groups with positive changes in body weight, one case of treatment failure and another of death were found. (Table 2)

**Table 2: Relationship of the patient's status after antituberculosis treatment with changes in body weight as a result of nutritional supplementation and food delivery. Data are presented as frequencies (%), n=190**

| Age Ranges (Years) | Weight changes (Kg) | Patient's Status after Completion of Antituberculosis Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cured | Completed | Failure | Deceased | Lost to Follow-up | Transferred | Not Evaluated | No data |
| 20-40 | No Changes | 14(7.4) | 1(0.5) | - | 1(0.5) | 2(1.1) | 1(0.5) | | 2(1.1) |
| | Positive | 84(44.2) | 4(2.1) | 2(0.5) | - | 5(2.6) | - | 1(0.5) | 1(0.5) |
| | Change | 5(2.6) | - | - | - | - | - | - | - |
| | No data | 15(7.9) | - | - | 3(1.6) | 3(1.6) | - | - | - |
| 41-60 | No Changes | 2(3.4) | - | - | - | 1(0.5) | 1(0.5) | - | - |
| | Positive | 8(4.2) | 4(2.1) | - | 1(0.5) | - | - | 2(1.1) | - |
| | Change | 1(0.5) | - | - | 1(0.5) | - | - | - | - |
| | No data | 8(4.2) | - | - | 4(2.1) | 1(0.5) | - | - | - |
| 61-> | No Changes | 1(0.5) | - | - | - | - | - | - | - |
| | Positive | 6(3.2) | 1(0.5) | - | - | - | - | - | - |
| | Change | 1(0.5) | - | - | - | - | - | - | - |
| | No data | 1(0.5) | - | - | - | - | - | - | - |

**Discussion**

The results obtained in this study highlight a complex scenario in the management of tuberculosis within correctional facilities, despite the progress made in the strategies implemented between 2000 and 2024. The evolution of incidence rates and the identification of new cases suggest that the interventions have had a positive impact on the detection of the disease. However, this progress has not translated into comparable success in treatment outcomes. It is important to emphasize that early detection alone is not sufficient; it is crucial to ensure appropriate treatment and guarantee its effectiveness throughout the process. A significant challenge in the Bolivian context is the loss of follow-up for released individuals, an issue that is also observed in other countries with similar situations [10-12].

On the other hand, the progressive increase in incidence may be related to both improvements in case detection and a possible rise in the circulation of the bacillus within correctional facilities [13]. This underscores the need to strengthen preventive measures and early diagnosis. The positive correlation observed between the passage of years and the implementation of strategies suggests that the adopted measures have had a favorable impact on the identification of new cases, which also reflects an increased capacity to detect the disease, a key factor in controlling the epidemic. However, it is important to note that these values may be underestimated due to limitations in the methodology used for calculation, as the prison population is fluctuating, especially in preventive detention facilities, which aligns with findings from other studies [14,15].

The management of comorbidities, such as diabetes and HIV coinfection, is an important factor in the treatment of tuberculosis [16-19]. The implementation of systematic HIV-TB coinfection screening since 2012 has allowed for the identification of 5% of coinfected cases during the period 2012-2024, which presents an additional challenge for achieving successful treatment. HIV-TB coinfection is widely recognized as a factor that increases treatment complexity and reduces therapeutic success rates due to the immunosuppression induced by HIV [20-22]. Additionally, the introduction of capillary glucose monitoring since 2018 has facilitated the identification of a diabetes prevalence of 3.6% during the period 2018-2024. These findings highlight the importance of adopting an integrated approach that addresses not only tuberculosis but also associated comorbidities, in order to prevent them from exacerbating the progression of the disease [18-23]. especially in such a vulnerable setting as prisons.

It is important to highlight that once tuberculosis sets in, it causes an increase in metabolism and a decrease in appetite [24], which negatively impacts the patient's nutritional status. This nutritional deterioration can further complicate treatment and recovery. For this reason, between 2019 and 2023, a pilot nutritional intervention strategy was implemented, consisting of the provision of food rations and nutritional supplements. The findings of this study indicate that nutrition plays a key role in treatment response. Previous studies support that good nutritional status contributes to patients' ability to tolerate the side effects of medication, which may improve clinical outcomes [25-26].

The improvement in nutritional status observed in patients treated with nutritional supplementation and food rations aligns with previous studies highlighting the importance of a comprehensive approach that combines both pharmacological treatment and nutritional support [27,28]. However, despite the evident benefits in increased body weight and body mass index, cases of therapeutic failure and death, even in those with nutritional improvements, underscore the complexity of tuberculosis treatment. This suggests that, in addition to nutrition, factors such as treatment adherence, socioeconomic conditions, and the overall health of the inmates must be carefully considered to improve outcomes.

Meanwhile, antituberculosis treatment has a positive impact on the overall health status of patients, not only by resolving respiratory symptoms but also by improving appetite and, consequently, nutritional status [28]. The study by Schwenk et al. showed that, after six months of treatment, tuberculosis patients gained body weight [29]. This weight gain is crucial, as better nutrition strengthens the immune system, facilitating treatment tolerance and improving therapeutic response [25,26]. The scientific literature also points out that malnutrition is a significant risk factor for the failure of antituberculosis treatment, as it can reduce the effectiveness of drugs and increase mortality [30,31].

**Conclusions and Recommendations**

The implementation of tuberculosis control strategies in Cochabamba, Bolivia, has progressed gradually and in line with the recommendations of the WHO and PAHO, with notable achievements such as the integration of penitentiary health services into the public health network, the use of rapid diagnostic tests, and the early identification of comorbidities such as diabetes and HIV co-infection. Despite these advances, the incidence of cases and the identification of new cases have increased, reflecting the complexity of treating tuberculosis in a penitentiary setting.

Although interventions such as the provision of food rations and nutritional supplements have shown improvements in nutritional status and treatment tolerance, the lack of adequate follow-up for released patients, the need for ongoing staff training, and the efficiency of resource management remain key areas for improving outcomes.

It is recommended to continue strengthening early diagnosis and treatment strategies, with an emphasis on managing comorbidities, ensuring treatment adherence, and implementing more effective patient follow-up. Furthermore, it is essential to ensure proper resource allocation and keep treatment strategies up to date to prevent the spread of tuberculosis, especially as incidence rates continue to rise. Finally, priority should be given to strengthening follow-up and referral mechanisms for released patients, as this group represents a critical challenge for disease control within prisons.

**Strength And Limitations of The Study**

The strengths of the study include the detailed evaluation of progressive strategies implemented to control tuberculosis in the penitentiary centers of Cochabamba between 2000 and 2024, with a focus on the impact of interventions such as early detection of comorbidities and nutritional monitoring. The use of both quantitative and qualitative data, along with statistical analysis using the Spearman correlation coefficient, provided valuable information on the evolution of case incidence and treatment outcomes. Additionally, collaboration with institutions like the Damián Foundation allowed for the assessment of pilot interventions with a significant sample size.

However, the study has limitations, such as the lack of proper follow-up for released patients, which may have affected the results. Furthermore, the increase in incidence could reflect both improved detection and a rise in the spread of the bacillus. The fluctuation of the prison population also presents challenges in accurately measuring the data.

**Acknowledgements**
The authors express they're thanks to Dr. Miguel Guzman-Rivero for your suggestions to organize the manuscript and also for the exhaustive revision. Also, to Programa Regional de lucha contra la tuberculosis Cochabamba, for provide additional information to complete data obtained in prisons regarding some not complete data. And to Dirección regional del régimen penitenciario, for allowing access to the prisons in Cochabamba for the follow-up of the cases. Finally, the authors express they're thanks to the patients that participate for the pilot experience for nutritional supplementation.

**Contributions**
RL; obtention, systematization and analyses of data; Redaction of manuscript. RR; manuscript review. AA; manuscript review. IT-T; manuscript review. MZ; manuscript review. NO-G; manuscript review.

**Funding**
Fundacion Damian, Bolivia

**Competing Interest**
The authors declare no competing interest

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