Tuberculosis control in a socially vulnerable area: a community intervention beyond DOT in a Brazilian favela


*City of Rio de Janeiro Health Secretariat, Rio de Janeiro, Brazil; †Kaiser Permanente Center for Health Research, Portland, OR, USA; ‡IPEC-Fiocruz, Rio de Janeiro, Brazil; §Johns Hopkins University, Center for Tuberculosis Research, Baltimore, MD, USA

OBJECTIVES: To evaluate the population-based impact of a comprehensive intervention to strengthen tuberculosis (TB) control in Rocinha, the largest urban slum in Rio de Janeiro, Brazil.

DESIGN: In July 2003, 40 lay persons were hired and trained as community health workers to supervise treatment, implement educational activities and establish a supportive social network for anti-tuberculosis treatment. Between July 2005 and June 2008, a door-to-door active case finding campaign was conducted. Data were obtained from the Brazilian National Reporting System, which collects information from the TB notification form for every reported case.

RESULTS: Between January 2001 and December 2008, 2623 TB cases were reported, 852 before and 1771 after the start of the program. Following the intervention, treatment success rates increased (67.6% vs. 83.2%, \( P < 0.001 \)) and default rates dropped (17.8% vs. 5.5%, \( P < 0.001 \)). Compared to the pre-intervention period, the TB case rate declined by an average of 39 cases per 100,000 population per 6 months (\( P = 0.003 \)) in the post-intervention period, although this may have been due to secular trends already in place at the start of the intervention. Case rates declined from 591/100,000 in 2001 to 496/100,000 in 2008.

CONCLUSION: With proper planning and effective community involvement, a successful intervention can lead to high cure rates and may contribute to a decrease in TB notification rates.

KEY WORDS: TB case notification rate; slum; community health workers; incidence rate

IN 2008, for the first time in history, the world’s urban population exceeded its rural population.¹ This trend has been most dramatic in developing countries, where high rates of population growth have resulted in the establishment of informal settlements or slums in most urban settings.² Rio de Janeiro is a city with a population of 6 million located in south-east Brazil. It is the second largest city in the country and the fourteenth largest in the world. Nineteen per cent of Rio’s population lives in favelas, poor, overcrowded slums with few basic public services.³ These conditions pose significant challenges to human health and create a breeding ground for social problems as well as communicable diseases such as tuberculosis (TB).⁴–⁸

Rocinha is a densely populated favela where residents have low levels of literacy, high rates of poverty and inadequate access to basic sanitation.³ Compounding the poor living conditions, Rocinha has a large and lucrative illegal drug trade which creates a violent environment. Poverty and the gap between rich and poor are important factors contributing to a high incidence of TB in many countries,⁹ and the Rocinha favela is a clear example of this. Rocinha comprises 1% of the city population, but accounts for a disproportionate 5% of TB cases in the city. With a population of more than 56,000, from the year 2000 to 2002 the reported annual TB case notification rate was more than 500 per 100,000 population, which is five times higher than that for the city as a whole.¹⁰

Despite successful clinic-based implementation of TB control in selected areas of Rio de Janeiro, the city has not yet reached the World Health Organization goal of curing 85% of incident cases,¹¹ indicating that a clinic-based DOTS model alone, at least in cities such as Rio, will not suffice to achieve the 2015 TB-related Millennium Development Goals.¹²,¹³

In June 2003, the city’s TB Control Program began the implementation of a comprehensive community intervention in the favela, where the annual TB notification rate was estimated to be 570/100,000. The intervention began with supervised treatment in the community, followed by a door-to-door active case finding campaign.
finding campaign from July 2005 to June 2008. Prior descriptions of community-based TB programs have generally centered on rural areas or refugee camps and have focused on immediate treatment outcomes. Very little has been reported on the implementation of community-involved interventions in densely crowded, violent, urban slums.

To address this issue we conducted a population-based assessment of the intervention in Rocinha. We describe the implementation of the program and examine the changes in treatment outcomes and trends in TB notification rates over time.

**METHODS**

The study was approved by the ethics committee of the Rio de Janeiro Health Secretariat, Rio de Janeiro, Brazil.

**Study population**

This intervention was implemented in the Rocinha favela, an urban settlement with high TB notification rates. The estimated population of Rocinha grew from approximately 57,000 to 67,000 during the study period (2001–2008).

**Pre-intervention program**

Pre-intervention, patients underwent self-administered treatment, which included monthly evaluations at a regional clinic, where they received a 1-month supply of drugs. New cases received 2 months of rifampin (R, RMP), isoniazid (H, INH) and pyrazinamide (Z, PZA), followed by 4 months of RMP and INH (2RHZE/4RHE). Retreatment cases received the same regimen, with ethambutol in addition (E, EMB) (2RHZE/4RHE).

**Post-intervention program**

The intervention started in June 2003 and consisted of directly observed therapy (DOT) implementation as well as community involvement to strengthen local TB control. A health team led by two nurses was established in a local church, and 40 lay persons from the community were hired as community health workers (CHWs) to provide TB care. The team established a supportive social network in the community and carried out educational activities to enhance TB awareness. The CHWs also collected sputum at home, monitored medical appointment attendance, sent contacts for evaluation and made home visits to supervise treatment.

The regimen used for the DOT intervention was the same as employed before, although it was intermittent for the last 4 months (2RHZE/4R3H2E2). Human immunodeficiency virus (HIV) positive patients received a daily regimen throughout treatment. All doses were supervised by CHWs, and medical consultation was provided on a monthly basis as before.

To increase case detection, the team launched an active case finding campaign from July 2005 to June 2008 that consisted of a standardized door-to-door symptom screen and spot sputum collection for symptomatic individuals.

**Data collection**

All patients with pulmonary or extra-pulmonary TB who started treatment between 2001 and 2008 were included in the analysis. Cases were classified according to national Brazilian guidelines. Case data were obtained from the Sistema de Informação de Agravos de Notificação (SINAN; the Brazilian national reporting system); population estimates were provided by the Rio de Janeiro Municipality. Treatment outcomes were defined as follows: successful treatment (completed), default (missed treatment for ≥30 consecutive days), death (died during treatment of any cause), failure (remained smear-positive at month 5), transferred to another health unit and unknown.

**Statistical analysis**

For a formal modeling of the intervention effect, we divided the timeframe into 16 semi-annual intervals (5 before and 11 after the start of the intervention) and fit a series of Poisson regression models using generalized estimating equations with an autoregressive error structure.

As an initial unadjusted comparison of TB case rates before and after the intervention rollout, we fit a simple model of the form:

\[
\ln(I_i) = \beta_0 + \beta_1 \exp(t),
\]

where \( \exp(t) \) is an indicator of the post-intervention period. Under this model, \( \beta_1 \) represents the ln(incidence rate ratio), ln(IRR), for the post- vs. pre-intervention period. To adjust for possible secular trends, we next fit a piecewise continuous regression model with separate time trends pre- and post-intervention, and compared it to a reference model that assumed no intervention effect. Under the reference model, the log incidence at time interval \( i, \ln(I_i) \) may be expressed as:

\[
\ln(I_i) = \beta_0 + \beta_1 \text{time},
\]

where \( \text{time} = 1, 2, \ldots, 16 \) indicates the time period, while the intervention model may be expressed as follows:

\[
\ln(I_i) = \beta_0 + \beta_1 \text{time} + \beta_2 \exp(t) \text{time} - 5.
\]

In both models (2) and (3), the coefficient \( \beta_1 \) represents the underlying secular trend in ln(incidence), while \( \beta_2 \) is the incremental impact on that trend.
associated with the intervention. We also fit a fourth model that assumed a fixed intervention effect, which may be expressed as follows:

\[
\ln(I_t) = \beta_0 + \beta_1 \text{time} + \beta_2 \text{exp} \tag{4}
\]

The models were fit using the xtgee procedure in Stata (version 10.0; StataCorp, College Station, TX, USA). All other analyses were performed using R for Windows, version 2.4.1.23

RESULTS

Demographics and clinical characteristics

From 1 January 2001 to 31 December 2008, TB was diagnosed in 2623 Rocinha residents. Of these, 852 (32.5%) were treated in the period before the intervention and 1771 (67.5%) after the intervention had been established.

Sex, age, TB site and type distributions were similar before and after the intervention (Table 1). However, TB cases occurring after the intervention were more likely to have undergone HIV testing (44.2% vs. 15.5%, \(P < 0.001\)), and were less likely to be seropositive (12.4% vs. 33.3%, \(P < 0.001\)) than those occurring before the intervention. Although similar proportions (89%) of cases were diagnosed as having pulmonary disease in both groups, acid-fast bacilli (AFB) smear testing was more likely to be performed during the intervention phase than before (63% vs. 58%, \(P = 0.019\)). Among pulmonary cases who underwent AFB smear testing, positivity was similar for both groups (76% pre-intervention vs. 78% during the intervention, \(P = 0.37\)).

Treatment outcomes

Treatment outcomes improved significantly following the intervention (Table 2). Success rates increased by 23%, from 67.6% to 83.2% (\(P < 0.001\)), while default rates dropped by 69%, from 17.8% to 5.5% (\(P < 0.001\)). These changes occurred within the first year of the intervention and remained fairly stable thereafter (Figure). Although treatment outcomes improved significantly for both new and retreatment cases, the improvements were particularly notable among retreatment cases, for whom treatment success increased from 53.2% to 76.4% (Table 2).

Changes in tuberculosis notification rates

As shown in the Figure, TB notification rates declined over the course of the study period, from 591/100 000 in 2001 to 496/100 000 in 2008. This reflected a 13% reduction, on average, in case rates post-intervention compared to pre-intervention (IRR 0.87, 95% confidence interval for relative risk 0.79–0.96). We also observed a highly significant overall downward linear trend (Model 2). After adjusting for this trend, the intervention effect, whether expressed as a trend or a constant effect, was no longer significant (Table 3). Interestingly, in both of these latter models the secular trend was also no longer statistically significant, although collectively both of these models significantly improved the fit relative to a null model with no coefficients.

Table 2 Treatment outcomes by intervention status

<table>
<thead>
<tr>
<th>Treatment outcomes</th>
<th>Before the intervention ((n = 852))</th>
<th>During the intervention ((n = 1771))</th>
<th>(P) value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>All cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>576 (67.6)</td>
<td>1473 (83.2)</td>
<td>0.001</td>
</tr>
<tr>
<td>Default</td>
<td>152 (17.8)</td>
<td>98 (5.5)</td>
<td></td>
</tr>
<tr>
<td>Death</td>
<td>11 (1.3)</td>
<td>53 (3.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Failure</td>
<td>0</td>
<td>1 (0.1)</td>
<td></td>
</tr>
<tr>
<td>Transfer out</td>
<td>32 (3.8)</td>
<td>70 (4.0)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>81 (9.5)</td>
<td>76 (4.2)</td>
<td></td>
</tr>
<tr>
<td>New cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>476 (71.7)</td>
<td>1208 (84.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Default</td>
<td>99 (14.9)</td>
<td>65 (4.6)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>89 (13.4)</td>
<td>151 (10.6)</td>
<td></td>
</tr>
<tr>
<td>Retreatment cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>100 (53.2)</td>
<td>265 (76.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Default</td>
<td>52 (28.2)</td>
<td>33 (9.5)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>35 (18.6)</td>
<td>49 (14.1)</td>
<td></td>
</tr>
</tbody>
</table>

* Two-tailed \(P\) values based on Pearson’s \(\chi^2\) test; all \(P\) values based on the collapsed categories.

**Figure** Annual tuberculosis case notification (per 100 000 population), cure and default rates (%), Rocinha, Brazil.
DISCUSSION

Our study shows that, with proper planning and effective community involvement, a community-based program aimed at improving TB care and control can be implemented even under very difficult circumstances.

The Rocinha intervention used a patient-centered approach and was designed to improve access to health services, increase community awareness and reduce the duration of infectiousness in the community. Factors contributing to the success of this program included the motivation of CHWs, an ongoing training program, regular feedback of the results to the local team and an on-site supervision scheme implemented by the City TB Program staff. Another important strength is that the CHWs have a signed contract with the municipal government, which minimizes employee turnover, making the team stable and avoiding the need for constant training.

Contrary to the experience of Suárez et al. with the implementation of the DOTS strategy in Peru,23 we did not observe an immediate increase in case detection rates after the implementation of the intervention. The most likely explanation for this difference is that Peru likely had a large number of prevalent cases who had not been detected until the program was improved. In Rio, the cases had been notified all along, but had not been followed up with care. Before the intervention, treatment was not supervised and the program was unable to minimize default rates. Even with the intensification of the case-finding process, which lasted from July 2005 to June 2008, case notifications did not increase, suggesting that there were few undetected TB cases in this community. Although TB case rates in Rio took a similar trajectory over this period of time (from 109/100,000 in 2001 to 95.2/100,000 in 2008), the decline in notification rates in Rocinha was considerably faster. Our findings parallel those reported by New York City,24,25 where a comprehensive intervention including an extensive DOTS program resulted in a decrease in incidence.

It is, however, difficult to be certain whether or not the intervention reduced TB case rates. We observed a significant decline in the average case rate following the implementation of the intervention, but this did not persist after adjusting for secular trends that may have been in place before the start of the intervention. As the significant overall linear trend did not persist after adjustment for the intervention, it is difficult to determine the dominant factor. Was the drop in case rates post-intervention just a reflection of an ongoing secular trend, or was the overall secular trend in part just reflecting the effect of the intervention? When assessed only during the pre-intervention phase, we found no evidence of a significant secular trend (P = 0.64).

In Rio, favelas are growing at a dramatically fast pace. While the city’s formal sector presents an annual growth rate of 0.4%, the annual growth rate of favelas is 2.2%, or the equivalent of almost 6 years of growth in the formal sector.26 Moreover, Rocinha, like many other favelas in Rio, is under the control of criminal factions and the entire community suffers from associated criminal activity and violence. Although we have achieved good treatment outcomes that are in line with findings in other conflict-affected areas,27,28 the escalated level of violence observed in Rocinha since April 2004 has hampered TB control. CHWs are frequently questioned by the police and also by drug dealers, some have been caught in cross-fires between gangs and others have been threatened by heavily armed drug dealers while working.

Although proven to be cost-effective,29 DOTS in Rio has so far been evaluated as a clinic-based model, where incentives, such as bus tokens, are given to patients. Other community-based models showing good cost-effectiveness have been described, such as in Bangladesh30 and in Cape Town;31 however, further analyses are needed to determine if our model shows similar cost-effectiveness.

Our study has some limitations. First, our analysis was an uncontrolled pre- vs. post-analysis, and any differences observed could be due to unmeasured factors that are confounded with the intervention effect. We attempted to account for this, at least partially, by dividing time into 6-month increments and fitting piecewise linear regression models that permitted us to adjust for secular trends that were in place before the start of the intervention. Second, diagnosis was based on microscopy, as culture was not routinely available in Rio de Janeiro until 2010. Third, the Brazilian National Reporting System is not linked to the
laboratory system. However, as TB drugs are not available in the open market, everyone in need of treatment must access the public health system, which requires each case to be notified to receive the medication. Furthermore, the City TB Program is able to link all TB death certificates to the TB Reporting System. Also compensating for these limitations is the fact that this study represents true operational research, carried out under real program conditions in the field.32 This greatly enhances the generalizability of our findings to other real-world settings.

Communities play an important role in TB care in a variety of settings,33 and the experience in Rocinha demonstrates that it is feasible to implement an effective program in a violent, overcrowded urban slum in a sustainable way. Nevertheless, considerable challenges that directly interfere in TB control but are completely outside the purview of TB program governance already exist, particularly those concerning the environment, poor living conditions, violence and level of poverty in this community.34,35 The lessons learned with this experience have in turn been employed in other favelas where the program was subsequently scaled up.

In conclusion, with proper planning and effective community involvement, a successful intervention can bring about high cure rates and may contribute to a decrease in TB notification rates.

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Conflict of interest: none declared.

References

24 Frieden T R, Fujisawa P I, Washko R M, Hamburg M A. Tu-
OBJECTIFS : Evaluer l’impact sur la population d’une intervention exhaustive pour renforcer la lutte contre la tuberculose (TB) à Rocinha, le plus important quartier pauvre de Rio de Janeiro.

SCHEMA : En juillet 2003, on a engagé et formé comme travailleurs de santé de la collectivité 40 personnes non diplômées pour superviser le traitement, mettre en œuvre des activités de formation et constituer un réseau social de soutien pour le traitement de la TB. Entre juillet 2005 et juin 2008, une campagne de dépistage actif a été menée de porte à porte. Les données ont été obtenues dans le Système National de Déclaration qui recueille l’information pour chaque cas déclaré dans les formulaires de déclaration de TB.

RÉSULTATS : Entre janvier 2001 et décembre 2008, on a déclaré 2623 cas de TB, 852 avant et 1771 après la mise en route du programme. À la suite de l’intervention, les taux de succès du traitement ont augmenté de 67,6% à 83,2% (P < 0,001) et les taux d’abandon ont chuté de 17,8% à 5,5% (P < 0,001). Par comparaison avec la période avant l’intervention, le taux de cas de TB a diminué en moyenne de 39 cas pour 100000 habitants par 6 mois (P = 0,003) dans la période post-intervention ; ceci pourrait être attribué à des tendances temporelles déjà en route au début de l’intervention. Les taux de cas sont passés de 591/100000 en 2001 à 496 en 2008.

CONCLUSION : Grâce à une planification et à une implémentation effective de la collectivité, une intervention couronnée de succès peut entraîner des taux de guérison élevés et contribuer à une diminution des taux de déclaration de la TB.

RESUMEN

OBJETIVOS: Evaluar la repercusión a escala comunitaria de una intervención exhaustiva de refuerzo del control de la tuberculosis (TB) en Rocinha, la zona más extensa de viviendas precarias en Río de Janeiro, Brasil.

MÉTODO: En julio del 2003, se contrataron 40 personas sin formación técnica y se capacitaron como agentes sanitarios de la comunidad con el fin de supervisar el tratamiento, impartir actividades educativas y crear una red social de apoyo dentro del marco del tratamiento de la TB. Entre julio del 2005 y junio del 2008 se puso en práctica una campaña de puerta a puerta de búsqueda activa de casos de TB. Se obtuvieron datos del Sistema Nacional de Registro de Datos de TB, el cual recoge la información de cada caso a partir de los formularios de notificación.

RESULTADOS: Entre enero del 2001 y diciembre del 2008 se notificaron 2623 casos de TB, de los cuales 852 antes del programa y 1771 después de haberlo comenzado. Después de la intervención aumentaron las tasas de éxito terapéutico (de 67,6% a 83,2%; P < 0,001) y disminuyeron las tasas de abandono (de 17,8% a 5,5%; P < 0,001). En comparación con el periodo previo, la ejecución del programa disminuyó la tasa de casos de TB en promedio de 39 casos por 100 000 habitantes en 6 meses (P = 0,003), aunque esto podría corresponder a las tendencias temporales en curso al comienzo de la intervención. Las tasas de casos disminuyeron de 591 por 100 000 habitantes en el 2001 a 496 en el 2008.

CONCLUSIÓN: Una intervención eficaz, planificada de manera adecuada y con la participación efectiva de la comunidad puede lograr altas tasas de curación y contribuir a la disminución de las tasas de notificación de casos de TB.