



## Infection control in households of drug-resistant tuberculosis patients co-infected with HIV in Mumbai, India

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<http://dx.doi.org/10.5588/pha.13.0096>

**Background:** Mumbai has a population of 21 million, and an increasingly recognised epidemic of drug-resistant tuberculosis (DR-TB).

**Objective:** To describe TB infection control (IC) measures implemented in households of DR-TB patients co-infected with the human immunodeficiency virus (HIV) under a Médecins Sans Frontières programme.

**Methods:** IC assessments were carried out in patient households between May 2012 and March 2013. A simplified, standardised assessment tool was utilised to assess the risk of TB transmission and guide interventions. Administrative, environmental and personal protective measures were tailored to patient needs.

**Results:** IC assessments were carried out in 29 houses. Measures included health education, segregating sleeping areas of patients, improving natural ventilation by opening windows, removing curtains and obstacles to air flow, installing fans and air extractors and providing surgical masks to patients for limited periods. Environmental interventions were carried out in 22 houses.

**Conclusions:** TB IC could be a beneficial component of a comprehensive TB and HIV care programme in households and communities. Although particularly challenging in slum settings, IC measures that are feasible, affordable and acceptable can be implemented in such settings using simplified and standardised tools. Appropriate IC interventions at household level may prevent new cases of DR-TB, especially in households of patients with a lower chance of cure.

Greater Mumbai is a metropolitan area with a population of approximately 21 million, of which approximately 60% are slum-dwellers lacking basic household amenities, including running water and sanitation.<sup>1</sup> Poverty and poor living conditions have long been associated with the occurrence and transmission of infectious diseases, especially tuberculosis (TB).<sup>2</sup>

TB infection control (IC) measures aimed at reducing the risk of TB transmission are well recognised.<sup>3,4</sup> Although a number of initiatives have been adopted for IC in health care settings,<sup>5–8</sup> limited work has been done to reduce the risk in patients' households.<sup>9</sup> Similar to the situation seen in health care workers in direct contact with TB patients attending health care facilities,<sup>10</sup> the incidence of active TB disease among household contacts of TB patients also exceeds that reported in the general population.<sup>11–14</sup> Until a person

with pulmonary TB is on an adequate treatment regimen that is likely to make him/her no longer infectious, those living in the same household and neighbouring residents may be at constant risk of inhaling TB bacilli, including multidrug-resistant (MDR-TB) and extensively drug-resistant TB (XDR-TB).

The national guidelines on airborne IC in India briefly mention community IC, including a suggestion to counsel patients and family members on cough etiquette and respiratory hygiene.<sup>15</sup> However, as in most settings, there are delays in accessing prompt TB diagnosis and treatment,<sup>16</sup> which is the most effective way to prevent transmission of TB. Although the national TB programme conducts contact tracing to identify cases in the household, follow-up is inefficiently done.<sup>17</sup>

Despite the importance of the household environment in TB transmission, very few experiences have been documented, particularly in resource-limited settings. One challenge has been the lack of simple tools for assessing the risk of transmission in the household environment and a set of standardised, non-sophisticated and inexpensive interventions that could be implemented to reduce such an assumed risk.

In the present study, we aimed to describe our experience assessing the need for and implementing TB IC measures in households of MDR-TB and XDR-TB patients co-infected with the human immunodeficiency virus (HIV) enrolled in a Médecins Sans Frontières (MSF) programme in a slum setting in Mumbai, India.

### METHODS

#### Study design

This is a descriptive study of a routine programme model of TB IC measures implemented during 2012–2013 in the households of patients followed under a MSF TB-HIV programme in Mumbai, India.

#### Setting and study population

MSF started an HIV project in Mumbai, India, in 2006, under which treatment for MDR-TB patients co-infected with HIV has been available since 2007. More than 70% of the patients enrolled in the MSF programme are slum dwellers, as previously described.<sup>18,19</sup> TB IC assessments and interventions were carried out in households of DR-TB patients co-infected with HIV from May 2012 to March 2013, after patient consent had been obtained.

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*Conflict of interest:* none declared.

#### KEY WORDS

infection control; drug-resistant tuberculosis; HIV; slums; Mumbai

Received 28 October 2013  
Accepted 30 January 2014

PHA 2014; 4(1): 35–41  
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**TABLE 1** Hierarchy of infection control measures<sup>4,15</sup>

- Administrative controls: the managerial and administrative measures taken in the patient's residence to reduce the risk of the transmission of infectious disease (TB) by minimising the generation of droplet nuclei and/or exposure by others
- Environmental controls: the mechanical and structural measures taken to reduce the transmission of infectious disease (TB) by minimising the concentration of infectious respiratory droplets and increasing air exchange
- Personal protective measures: these measures reduce the transmission of infectious disease (TB) by providing barriers to exhalation and inhalation of infectious droplet nuclei.

TB = tuberculosis.

### Infection control assessment and interventions

The hierarchy of TB IC measures used to design the tools utilised in the programme are presented in Table 1. The first visit to each patient household was made once the patient was registered in the programme and had given verbal consent for a TB IC assessment at their residence. Each visit was performed by a team consisting of a nurse, a social worker and an IC officer. The IC team was occupied part-time in the IC intervention at the household, and involved part-time in other programme activities.

A simple, standardised tool in the form of a checklist (Table 2) was used to assess the risk of TB transmission in the patient's home. Along with the IC assessment, a socio-economic assessment of the family was made by the assigned social worker. Based on the results of the risk assessment, and after obtaining consent from the patient and the family, IC interventions chosen from a list of standardised interventions (Table 3) were carried out, and tailored to the type of residence and the needs of the patient and the family.

Once the preparations were complete, a second visit to the patients' home was made to implement IC interventions recommended at the time of the assessment. Existing openings (i.e., doors and windows), fans and air extractors were used to improve the air exchange in the relevant room(s). Traditional incense sticks were used to assess the flow of air in the room/house and to guide the placement of extractors and mechanical fans. A supply of surgical masks was given to the patients, which they were advised to wear until the risk of infectivity had decreased (i.e., until the sputum smear and culture results had converted to negative).

At all stages of the intervention, a household report (Table 4) was maintained; the report included the location of residence, the number of household members living with the patient, the status of the patient's residence (whether owned or rented) and details of IC measures that needed to be implemented.

### Data collection and analysis

Data were compiled from the records of IC assessments of patient homes and the IC interventions carried out between May 2012 and March 2013. The data collected were recorded in electronic format and in hard copy. Records were cross-verified by the investigators for completeness and accuracy. A descriptive analysis was prepared on the basis of the findings and the interventions implemented.

### Ethics

The study satisfied the criteria for reports using routinely collected programme data on patients followed in a MSF TB-HIV programme and set by the independent MSF Ethics Review Board in Geneva, Switzerland. Informed verbal consent was obtained from patients before any home visit.

**TABLE 2** Checklist to assess infection control in the household

Criteria	
<b>Administrative requirements</b>	
Does the patient understand how TB is transmitted?	Yes/vaguely/no
Has the patient disclosed his/her TB status to their family?	Yes/no
Does the patient work outside the home?	Yes/occasionally/no
Does the patient travel outside the home apart from visits to the clinic?	Yes/occasionally/no
<b>Environmental situation</b>	
<b>Structure</b>	
Nature of accommodation	Slum/multistorey/rural
Rooms	One/>1 rooms
Doors	Number and dimensions
Windows	Number and dimensions
Fans	Number and position
<b>Facilities</b>	
Running water	Available/not available
Electricity	Available/not available
Toilet	Attached/public
<b>Hygiene</b>	
Sanitation and hygiene level	Poor/average/good
Water drainage	Clean/dirty/obstructed
Waste management	Daily/weekly/no collection
Awareness of hygiene behaviour	Poor/average/good

TB = tuberculosis.

## RESULTS

IC assessments were carried out between May 2012 and March 2013 in the households of 29 DR-TB patients, 23 of whom were co-infected with HIV. All 29 patients were diagnosed during the study period and none of the patients refused IC assessments. The general characteristics of the patients in the programme have been reported elsewhere.<sup>18</sup> The mean patient age was 34 years (standard deviation 9.4), and the majority (62%) were male. The median number of adult members per household was 2.5 (interquartile range [IQR] 1–5), and approximately half of the households (14/29) included children, including two with one child aged <5 years. Of the 29 study patients, 6 (21%) lived in rented accommodation, and only 10% (3/29) were employed. In four of the households, there was another HIV-infected member apart from the index case.

Administrative measures included health education for all 29 patients and their families on the mode of TB transmission and how to reduce its risk (e.g., the need to sleep in separate rooms). Patients were educated about cough hygiene (e.g., how to dispose of sputum), which was accompanied by the distribution of surgical masks and information on how and when they should be worn by the patients.

Environmental TB IC interventions were carried out in 22/29 (75.9%) households. The following electrical devices were installed in the 22 households: 30 air extractors, 23 standing fans, 5 ceiling fans, 2 table fans and 2 wall fans. The average number of devices installed per household was 2.8, at an average cost of 4500 Indian rupees (70 USD) per household. Seven households did not require any environmental TB IC interventions.

Household contacts of all 29 patients were not given personal protective devices (e.g., N95 respirators) due to logistic and financial constraints. Figure 1 details the different IC interventions car-

**TABLE 3** List of standardised tuberculosis infection control interventions

Type of patient residence	Potential infection control interventions
Two rooms/one big room on the same level in the house	Isolation (administrative interventions): patient stays in separate room or stays in one part of a room separated by a fixed/mobile separator. Surgical mask worn and cough hygiene measures practised by patient Environmental interventions: application of standing fans and air extractor for appropriate air exchange to reduce the infectious air in room(s) Protective interventions: respirators if acceptable and available
Two-level house	Administrative intervention: patient should stay in the upper level of the house Environmental intervention: patient should stay near window or application of air extractor is required to improve air exchange Protective interventions: respirators if acceptable and available
Toilet/bathroom (public or attached to patient's residence)	Environmental intervention: keeping the door wide open for a long duration to improve air exchange before being used by others Protective interventions: respirators if acceptable and available
Multi-storey apartment	Environmental intervention: advice on keeping the windows open and mechanical fans on Use of 'direction fan' to direct the air out from the toilet/bathroom Ensure air exchange in relevant rooms Protective interventions: respirators, if acceptable and available
Rural house	Environmental intervention: keeping doors and windows open Ensure air exchange, including by cross-ventilation measures Protective interventions: respirators if acceptable and available.

**TABLE 4** Infection control report

Patient details:
Address:
Description of patient's residence:
Number of household members:
Patient's home ownership status:
Infection control assessment results:
Infection control measures proposed:
Remarks:

ried out in the households of the 29 patients. Figure 2 illustrates a case study showing the situation before and after the introduction of environmental TB IC interventions in one patient's household, including the arrangement of fans and air extractors in the different parts of the house, as well as the patient's sleeping arrangements.

## DISCUSSION

To our knowledge this is the first description of a TB IC intervention conducted in households of DR-TB-HIV co-infected patients in a slum setting in India, and probably among the first descriptions of TB IC interventions at household level in resource-limited settings. A number of studies have investigated aspects of TB IC in health facilities, but few have been carried out in patients' homes.<sup>5-9</sup>

Early case detection followed by prompt initiation of a robust treatment regimen and good adherence support remain the most effective IC measures to prevent TB transmission to household contacts and the community. The World Health Organization (WHO) recommends that patients with MDR-TB be treated using mainly ambulatory care rather than models of care based principally on hospitalisation.<sup>20</sup> This implies that implementation of TB IC measures is necessary early during the course of treatment to

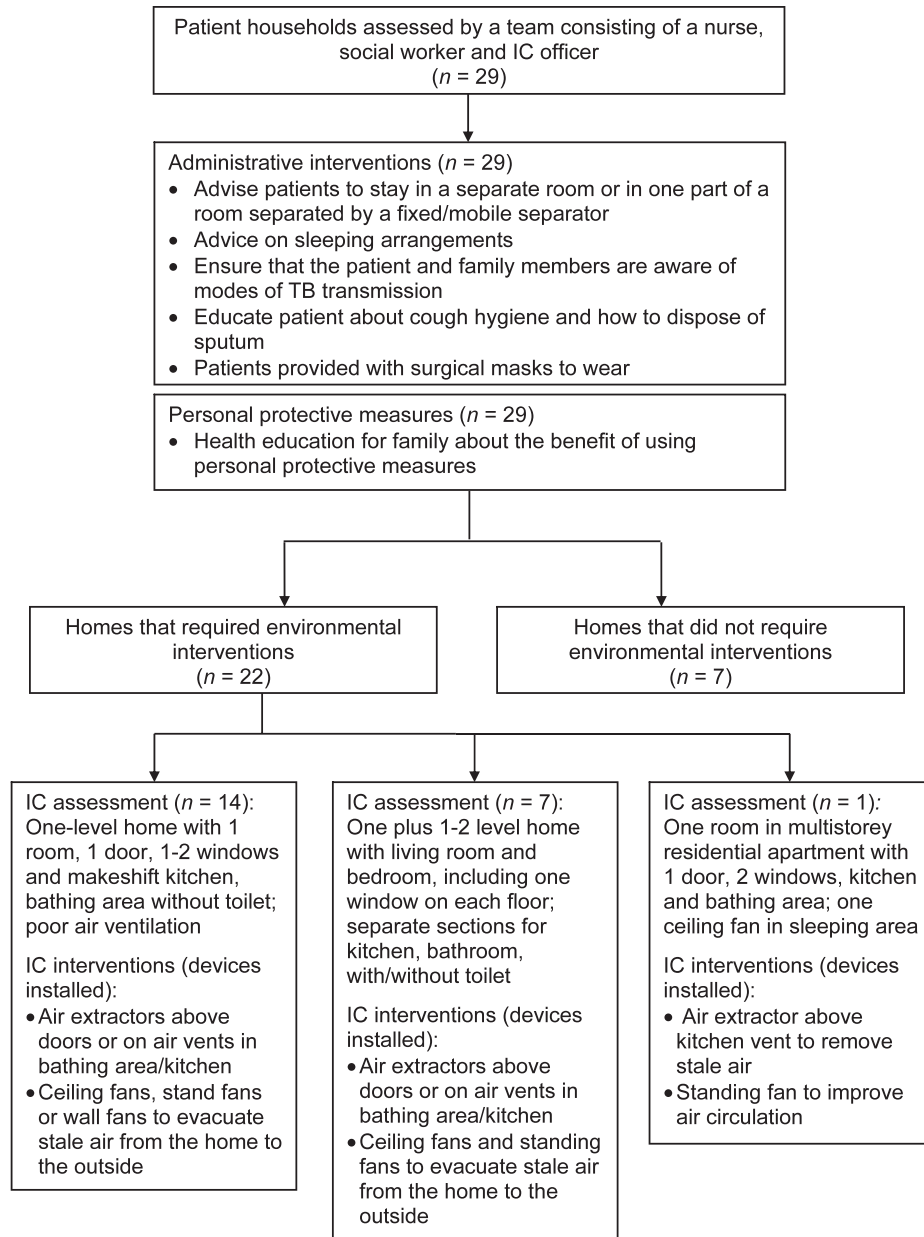
reduce the risk of transmission to household members and the community until the patient is no longer infectious.<sup>4</sup>

According to the WHO, 'MDR-TB increases the risk of morbidity and mortality, particularly in people living with HIV. Additional infection control measures should therefore be implemented for the management of MDR-TB patients at home.'<sup>4</sup>

Directing resources to improving IC in homes of patients can be questioned, given the evidence that infectiousness decreases soon after appropriate treatment is initiated. However, designing appropriate treatment for patients in settings with a high prevalence of fluoroquinolone resistance may not be feasible.

Studies have shown that good household ventilation is an essential component for TB IC.<sup>9,21</sup> Overcrowding in households has been found to be related to TB mortality.<sup>22</sup> As reported by Chamie et al., improving household ventilation thus reduces TB transmission and enhances TB prevention efforts in TB-endemic areas.<sup>9</sup> Natural ventilation can undoubtedly produce high rates of air exchange as long as the windows are of sufficient size and situated to allow cross-ventilation; unfortunately, this was often not possible in the households of patients in this Mumbai cohort. The majority of these DR-TB patients lived in rented homes in slum settings; major structural changes (e.g., the creation of new windows to allow for cross-ventilation) were often not possible, especially as household structures often shared walls with neighbouring houses. Wind-driven roof turbines were also not installed, as many of the homes occupied the basement of a two-storey dwelling; moreover, there were concerns regarding possible water leakage during the monsoon season. Basic mechanical ventilation was the best option for improving air exchange in most households (ceiling fans, standing fans and air extractors). Optimal placement of these devices was tested with the help of incense sticks, which were used to determine the direction of air flow.

All TB IC interventions in resource-limited settings should be as simple as possible, culturally acceptable, and feasible for TB



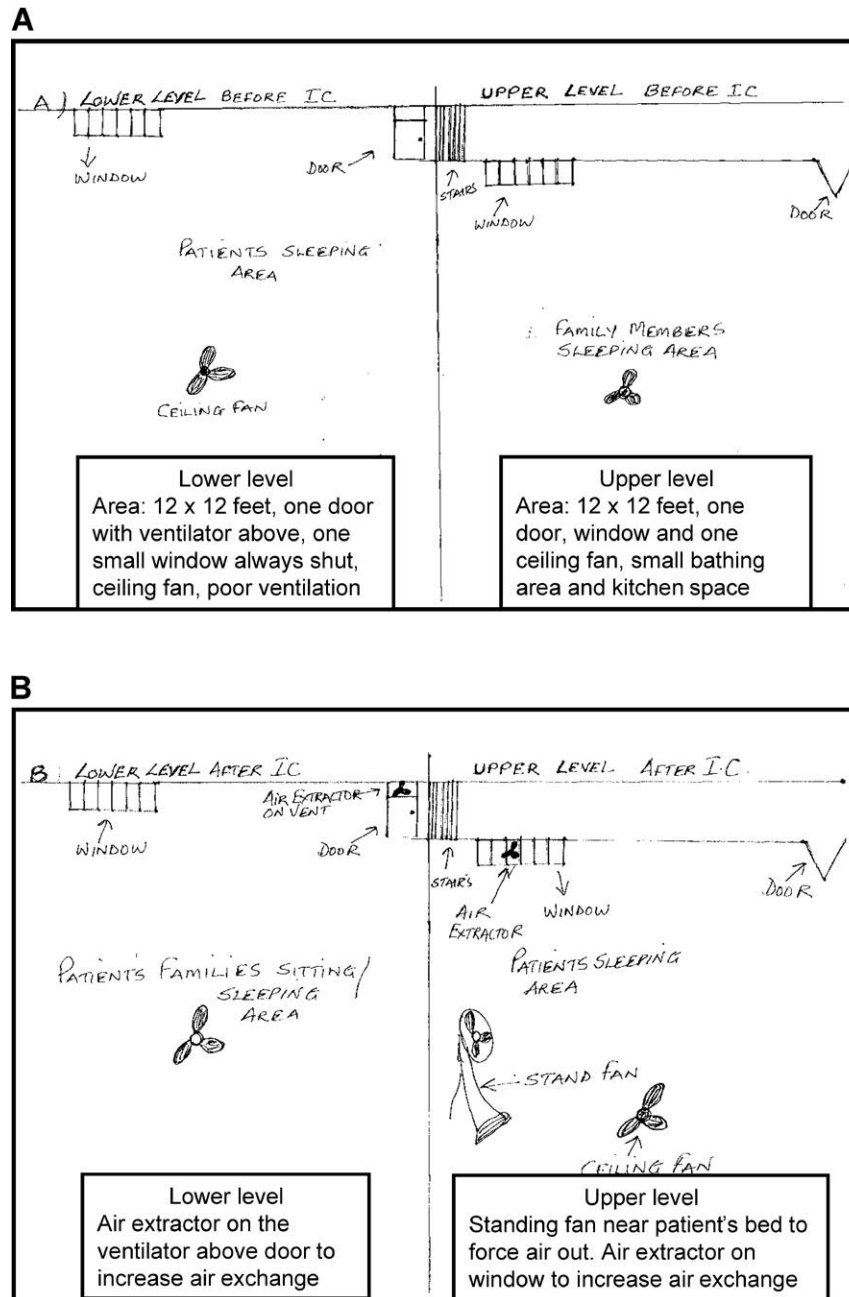
**FIGURE 1** IC interventions carried out in patient households. IC = infection control; TB = tuberculosis.

patients and household members. An earlier qualitative study carried out in 2011 among HIV patients followed in this MSF clinic revealed a widespread fear of forced disclosure during home visits.<sup>23</sup> A determined effort was therefore made not only to seek the consent of patients before any visit, but also to minimise the number of subsequent home visits. Socio-economic assessments were carried out to ascertain the economic conditions of the patients and the need for support with food rations for patients and their families. Psychosocial assessments were also performed, and were useful in assessing the level of acceptance to the TB IC intervention being planned. We created awareness of the need for TB prevention by involving other household members. An important part of the process involved preliminary counselling for the TB patients and their family members about TB and HIV disclosure. As the TB patients had the right to decide whether or not to allow visits for a TB IC assessment and inter-

vention, the role of the counsellor in explaining about TB prevention became crucial.

IC interventions should also be considered at the community level, including community involvement in the early detection of TB and DR-TB, and provision of information on access to diagnosis and treatment. Another step involves creating awareness about cough hygiene, sanitation and good home ventilation across communities. Community models should be explored to understand how to optimise effective community participation and implementation of such measures.

The study had several limitations. First, the numbers in our study are small and we collected a limited set of data. Nevertheless, this Mumbai cohort of HIV-co-infected DR-TB patients is among the largest cohorts reported, as the global cohort of patients on second-line anti-tuberculosis treatment is still relatively small.<sup>24</sup> Second, as this is a descriptive study, we did not measure



**FIGURE 2** Case study showing the situation before and after the introduction of environmental tuberculosis IC interventions in one patient's household. A) Patient's home before environmental IC interventions. B) Patient's home after environmental IC interventions. IC = infection control.

the effectiveness of the interventions implemented. We were therefore not able to determine final outcomes, such as reduced TB transmission, at the family and household levels, nor were we able to report surrogate endpoints such as increased ventilation measured in air changes per hour. We were also not able to ascertain whether or not the proposed interventions were consistently followed by the patients. However, we used existing guidelines to assess the risk of transmission and to implement simple but affordable administrative and environmental measures for TB IC. Lastly, we acknowledge that any reduction in the risk of DR-TB transmission after a patient has been diagnosed and started on appropriate second-line treatment will be directly proportional to

the duration of infectiousness. TB IC measures in the household can be assumed to have the greatest impact on the rate of DR-TB among household contacts when the pattern of drug resistance is complicated and where limited treatment options make it difficult to prescribe a robust anti-tuberculosis regimen with high chance of cure.

IC at the household level could be beneficial in protecting family members, particularly children and the elderly, from becoming infected with drug-susceptible and drug-resistant strains of TB. The importance of TB IC to those living with HIV is well recognised and documented.<sup>25,26</sup> In resource-limited settings, low-cost interventions such as the opening of windows to allow air



exchange through natural ventilation (or at least keeping the existing openings clear from obstacles) or the use of very basic mechanical ventilation (e.g., fans and air extractors) should be adopted, as these may reduce the risk of TB transmission and are certainly more feasible than costly, high-maintenance mechanical ventilation systems. One of a number of current research opportunities related to TB IC would be household transmission after initiating DR-TB treatment in settings with fluoroquinolone resistance and among HIV-infected adults and children.

## CONCLUSIONS

TB IC could be a beneficial component of a comprehensive TB and HIV care programme in households and communities. Although particularly challenging in slum settings, IC measures that are feasible, affordable and acceptable can be implemented in such settings using simplified and standardised tools. While early diagnosis and prompt treatment of DR-TB patients remain the most important IC measures, appropriate IC interventions at the household level may still prevent new cases of DR-TB, particularly in households of patients with lower chance of cure, for example when the regimen does not contain four drugs likely to be effective and/or the patient has not improved on treatment. Moreover, IC measures may play a role in households in which members are children and/or immunocompromised as a result of HIV infection.

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**Contexte :** A Mumbai, population 21 millions, on voit une épidémie de plus en plus reconnue de tuberculose pharmacorésistante (TB-DR).

**Objectif :** Décrire les mesures de lutte contre l'infection (IC) pour la TB mises en place dans les foyers de patients DR-TB coinfectés par le virus de l'immunodéficience humaine (VIH) dans le cadre d'un programme de Médecins Sans Frontières à Mumbai.

**Méthodes :** L'évaluation des mesures de lutte a été réalisée dans les foyers des patients entre mai 2012 et mars 2013. Un outil d'évaluation simplifié a permis d'évaluer le risque de transmission de la TB et de guider les interventions. Les mesures de protection administratives, environnementales et personnelles ont été adaptées aux besoins de chaque patient.

**Résultats :** Ces évaluations ont été réalisées dans 29 foyers. Les mesures mises en œuvre incluaient l'éducation sanitaire, le couchage

séparé des patients, une amélioration de la ventilation naturelle par l'ouverture des fenêtres et l'enlèvement des rideaux et autres obstacles à la circulation de l'air, l'installation de ventilateurs et d'extracteurs d'air et la fourniture de masques chirurgicaux pour une durée limitée. Les interventions environnementales ont été réalisées dans 22 maisons.

**Conclusions :** Les mesures IC pour la TB pourraient constituer un élément bénéfique d'un programme intégré de soins de la TB et du VIH dans les foyers et les communautés. Bien qu'il s'agisse d'un défi particulier dans les bidonvilles, des mesures faisables, abordables et acceptables peuvent être mis en œuvre dans ce contexte grâce à des outils simplifiés et standardisés. Des mesures appropriées à domicile peuvent contribuer à éviter de nouveaux cas, surtout dans les foyers des patients qui ont moins de chances de guérison.

**Marco de referencia:** Mumbai cuenta con una población de 21 millones de habitantes, y presenta una epidemia cada vez más reconocida de tuberculosis farmacorresistente (TB-DR).

**Objetivo:** Describir las medidas de control de la infección (IC) para la TB que se aplican en los hogares de los pacientes coinfectados por el virus de la inmunodeficiencia humana (VIH) y la TB-DR, en el marco del programa de Médicos Sin Fronteras en Mumbai.

**Métodos:** De mayo del 2012 a marzo del 2013 se evaluaron las medidas de IC de la TB en los hogares de los pacientes. Se aplicó un instrumento simplificado normalizado, con el fin de evaluar el riesgo de transmisión de la TB y orientar las intervenciones. Las medidas administrativas, ambientales y de protección personal se adaptaron a las necesidades de los pacientes.

**Resultados:** Se practicaron evaluaciones del IC en 29 casas. Las medidas comportaron educación sanitaria, separación de los espacios donde

duermen los pacientes, optimización de la ventilación natural mediante la abertura de las ventanas, la eliminación de las cortinas y los obstáculos al flujo del aire, la instalación de ventiladores y extractores de aire y el suministro de mascarillas de quirófano a los pacientes durante un período limitado. Se llevaron a cabo intervenciones ambientales en 22 casas.

**Conclusiones:** El IC para la TB puede constituir un componente útil de un programa integral de atención de la TB y la infección por el VIH en los hogares y las comunidades. Aunque las intervenciones plantean dificultades en el contexto de las viviendas precarias, se pueden introducir medidas de IC que sean factibles, abordables y aceptables en estos entornos, mediante la utilización de instrumentos sencillos y normalizados. Las intervenciones adecuadas a escala de los hogares también pueden prevenir la aparición de nuevos casos de TB-DR, sobre todo en los hogares de los pacientes con menos probabilidades de curación.