Brief for GSDR – 2016 Update

Mobilizing Big Data and Microsimulation for SDGs: Forecasting the Impact of a Conditional Cash Transfer Programme on Tuberculosis in Brazil

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Background

Retrospective impact evaluations are often not compatible - mainly in terms of time required to obtain results - with policy making processes of implementation of an intervention.[1] In order to overcome these limitations prospective, or ex-antes, impact evaluations have recently gained importance, with the aim of forecasting the impact of interventions and estimate the effects of different policy implementations or policy scenarios.[2] Microsimulation models are promising methods which are able to analyze the impact of an intervention at the individual and sub-population level and to incorporate changing behavioral responses and institutional attributes.[3,4,5] Few studies have applied MSMs in developing countries [6,7,8] because of the lack of expertise and - in some cases – lack of microdata for the estimation of the parameters of the models. Brazil is a middle-income country that has undergone great improvements in terms of socioeconomic conditions and population health in the last decade. However, poverty still remains high in rural areas, in city slums, and in the North-East Region in general. Several retrospective impact evaluations have demonstrated the role of the recent implementation of social and health policies on the decrease of child mortality, especially from malnutrition and diarrhea [11,12,13], but none has evaluated their effects on infectious diseases related to poverty. Among these diseases, tuberculosis (TB) imposes one of the highest burdens in the country (71,123 new cases in 2013, an incidence of 34.5/100,000inh) [14] and its cure rate is still at 71%, far below the 85% recommended by the World Health Organization. The impact of cash transfer policies on morbidity and mortality from tuberculosis has been already hypothesized [15] and a recent study has shown a 7% increase of tuberculosis cure rate among the Brazilian conditional cash transfer program (BolsaFamilia Program - BFP) beneficiaries in comparison with families eligible for BFP but not receiving the benefits [16]. The objective of the present study was to forecast the impact of the BolsaFamilia Program on the prevalence of tuberculosis in Brazil in the period 2015-2025, analyzing trends on different sub-populations according to their different socio-economic and demographic conditions and differential BFP coverage.

Methods

This study uses discrete-time dynamic microsimulation models of Tuberculosis prevalence based on subpopulations with no cluster effects [4,5]. The estimates of BFP effects have been obtained from a previous retrospective study which performed the record linkage between the administrative dataset of all BFP beneficiaries and all TB patients of Brazil in the same year, allowing the evaluation of the differential effectiveness of the BFP according to different subpopulations characteristics[16].

The population under study was composed of individuals who were TB cases and were eligible for the BFP, e.g. they received BFP benefits at least once, during (exposed) or - due to random administrative delays - after the treatment (control), resulting in 9,126 cases. All the effect estimates obtained from the ex-post evaluation analysis have been used to develop dynamic

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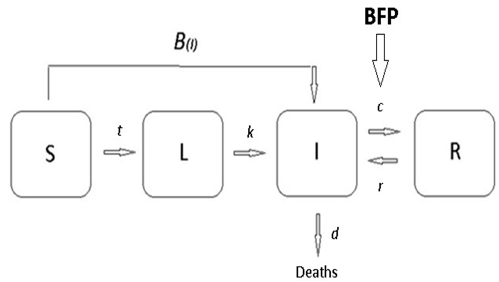
microsimulation models, and analyses using these models allowed estimation of the overall and subpopulation-specific forecasts. Microsimulations (1000 for each model) of a population of 10^6 individuals using models with 4 compartments (Figure 1) and 8 different subpopulations have been performed. The subpopulations were originated by the combination of the values of 3 dichotomous variables that, according to the ex-post evaluation regression models, had the stronger effect on tuberculosis cure rate: age (under and above 15y), extreme poverty (under and above 20$ pc), Directly Observed Treatment (DOT: with or without). Each subpopulation had different starting prevalence, incidence and different cure rate, estimated from the retrospective analysis of the dataset. The compartmental model used to simulate the stages of illness for each subpopulation was based on a slight simplification of existing models [17], which did not compromise its validity but allowed a greater complexity in modeling the population structure, as it is usually done in microsimulations (Figure 1).

Estimates of initial prevalence and incidence as well as mortality rates were obtained from the estimates of the World Health Organization and were complemented by the estimates of the National Tuberculosis Control Program of the Ministry of Health [18,19]. Considered the long study period some parameters were estimated and used in a dynamic way, i.e. with values that change in time according to a linear extrapolation of the trend identified in the previous period, in particular the Transmission Rate and Case-Fatality Rate. A Secular Trend of poverty reduction was also introduced in the model.

The model was calibrated and validated using the estimates of the prevalence of TB of the World Health Organization for Brazil along the period 2000-2010, and compared with the case notifications from the National Tuberculosis Control Program of the Ministry of Health along the same period [18,19].

All the models were implemented in the R statistical program v.3.2.2.

Figure 1. Compartmental Model Used for the Microsimulation, BolsaFamilia is increasing the cure rate (c).

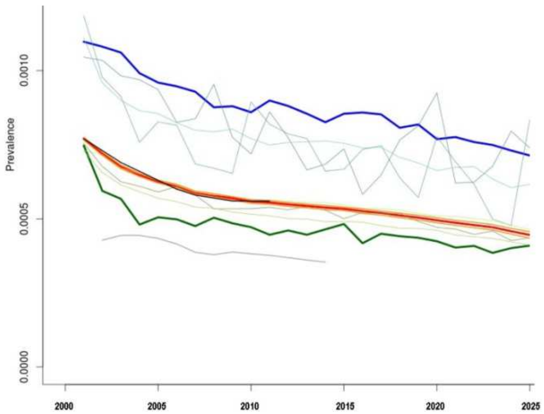


S= Susceptibles; L= Latent TB; I= Infectious TB; R= Recovered TB; BFP= BolsaFamilia Program; t,k,c,r,d: rates for the transition from one compartment to another.

Results

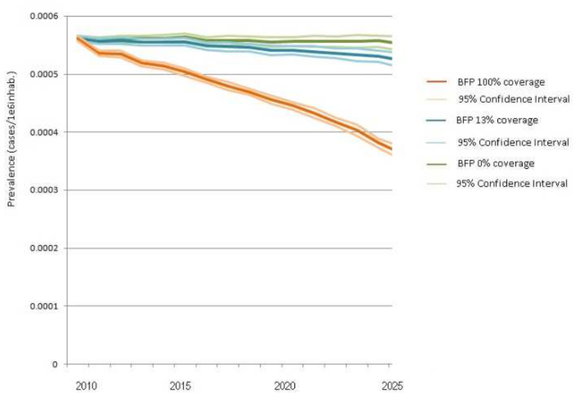
The findings of this study indicate an overall decrease of tuberculosis prevalence during the period 2010-2025, but with different levels of prevalence for each subpopulation (Figure 2). An overall expansion of BFP coverage to 100% in all subpopulations, which according to our assumptions has an effect only on the increase of cure rates, could greatly decrease TB prevalence - overall and for each specific subpopulation (Figure 3). On the contrary, the cancellation of the BFP could affect the ongoing reduction trend due to the actual coverage of the program on Tuberculosis cases, estimated at 13%. Even a BFP expansion on specific subpopulations, such as in the extremely poor and in the ones not covered by DOT, could influence the overall prevalence in the period (Figure 4). It has to be considered that in the population under study the extremely poor are 7%, while the TB cases without DOT are 53%.

FIG 2.Simulated prevalence of Tuberculosis for the different 8 subpopulations in the period 2000-2025 and comparison of the main prevalence with the WHO estimates and MoH new cases notifications.



Blue lines: 4 poorest subpopulations; Red line: overall prevalence in the population with 95%CI (Orange lines); Green lines: 4 richest subpopulations; Black line: WHO prevalence estimates 2000-2010; Grey line: yearly notified cases of TB by the MoH, which are a proxy of the TB incidence (and not prevalence, but should have a similar trend).

FIG 3.Simulated prevalence of Tuberculosis according to different BFP coverage - homogeneous for all subpopulations in the period 2010-2025.



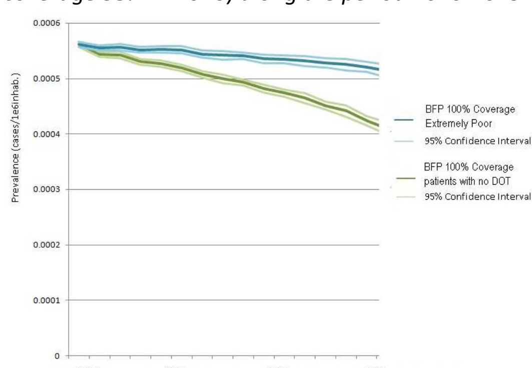
Discussion

The microsimulation models used in this study suggest that an expansion of the coverage of the BolsaFamilia Program - through the increase of Tuberculosis cure rate - could contribute to the reduction of the burden of Tuberculosis in Brazil within the next 10 years. This reduction can occur, in a lower extent, even if this expansion is targeted to specific groups, in particular TB cases not receiving DOT and the extremely poor. These findings are plausible according to the models of social determination of TB [20] and in agreement with articles which suggest that the poverty-reduction policies should be an important element of the TB control strategy [15].

The main limitation of this study is that we have used cure-rate estimates from a subsample of the overall TB cases of the country, corresponding to the study population of the ex-post evaluation, and we have assumed that the effect of the BFP was similar for the rest of TB cases.

Considering that this study population - composed only of individuals eligible for the BFP- has a lower socioeconomic status than the rest of the population, and that the BFP could have a weaker effect in non-poor TB cases, our impact of the BFP on the overall population could be overestimated.

FIG 4.Simulated prevalence of Tuberculosis according to different BFP coverage in the different subpopulations (Extremely Poor 7% in 2010; No DOT coverage 53% in 2010) along the period 2010-2025.



However it has to be considered that, except for the cure rate, all other parameters - including the subpopulation structure, are representative of the overall Brazilian population. Another limitation of the study is that the cure rate was the only subpopulation-specific parameter available from the dataset, incidence and prevalence ratio between extremely poor and the rest of the population has been chosen by calibration, and case-fatality rates has been considered identical for all the TB cases. In order to have these subpopulation-specific parameters a more complete dataset, from record linkages with other database, would have been necessary. Another limitation is that improvement in diagnostics and medical treatments has not been modeled, as well as TB Multi-drug resistant cases and the epidemic of HIV/AIDS.

The main strength of the study is the choice of modeling subpopulations instead of the average population. This is particularly relevant because it allows better understanding of which groups are more vulnerable to TB and which subpopulations should be prioritized in the expansion of the BFP – or any money allowance – coverage.

Embedded with the R script of the microsimulation models it has been also developed a Shiny interface [21], which is a user-friendly application which allow policy-makers and others not familiars with the programming language to interact with the models and project scenarios according to different parameters values.

Conclusions

The results of this study suggest that the expansion of cash transfer programs could greatly contribute - in the future years- to the reduction of the burden of a poverty-related disease such as tuberculosis in developing countries.

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