

Integrating Community-Based Interventions to Reverse the Convergent TB/HIV Epidemics in Rural South Africa

Technical Appendix

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Model Calibration and Validation

We calibrated the model to TB and HIV longitudinal data from South Africa [1,2]. A small subset of parameters that could not be estimated from the literature or prior studies were fit to the data: population growth, TB and HIV transmission, background and disease-specific mortality, and treatment coverage parameters (S1 Table). For these parameters only, values were independently randomly sampled from plausible ranges derived from the literature, then supplied to model simulations to generate putative outcomes for TB and HIV incidence and prevalence. Outcomes were evaluated by least sums of squared differences to assess the goodness of fit of the predicted TB and HIV incidence and prevalence relative to the longitudinal data. Standard score normalization was used to weight all data points equally: $z = \frac{x-\mu}{\sigma}$, where z is the normalized data point, x is the data point before normalization, μ is the mean of the data points, and σ is the standard deviation of the data points. To identify the best-fit parameter values, we randomly sampled fitted parameter values to generate 100,000 model outcomes, selecting the set of parameters that produced the lowest sum of squared differences. Ranges for fitted parameters (used in sensitivity and uncertainty analyses) were determined by restricting parameter values to only those combinations that produced model outcome estimates within the minimum and maximum of the TB incidence, prevalence, and case detection rate longitudinal data.

To validate our model, we compared our model outcome predictions to the longitudinal data to which parameters were fit (S1 Fig. and S2 Table). We additionally compared our model predictions to observed data that were not used in the model calibration: prevalence of MDR and XDR-TB and estimated ART coverage (S2 Table).

Uncertainty and Sensitivity Analyses

To account for uncertainty in parameter estimates, we specified probability distributions encompassing values ranging from the minimum to maximum estimate for each parameter (S1 Table), and then evaluated the model outcomes predicted from random samples of those distributions. We specified Beta distributions for all parameters whose ranges were constrained between zero and one (*i.e.*, probabilities and proportions). Gamma distributions were specified for rate parameters. The means of the Beta and Gamma distributions were set to the best-fit parameter estimates. The variances were calculated based on the uniform distributions between the minimum and maximum estimates from the literature ($variance = \frac{1}{12} (maximum - minimum)^2$; S1 Table), and distributions were truncated by the minimum and maximum estimates. To efficiently draw a collection of variates from the probability distributions, Latin hypercube sampling was applied. These variates were used to parameterize the model and generate outcomes. The central 95% of each outcome was identified as representing our uncertainty. This uncertainty was demarcated by the error bars in the figures of the main results. Partial rank correlation coefficients (PRCCs) were calculated for model outcomes when CICF was implemented at an annual screening rate. PRCCs are listed in S3 Table.

Model Equations

Our model consists of differential equations, characterizing joint TB and HIV transmission in a rural community in South Africa. The modeled disease states are listed in S4 Table. For clarity, here we describe TB and HIV transmission separately, where X corresponds to the TB disease state; Y corresponds to the HIV disease state; i = infectious or noninfectious TB; and j = DS ($j=1$), MDR ($j=2$), or XDR ($j=3$) TB; T = TB; H = HIV.

Drug Susceptible TB

$$\frac{dS^T X^H}{dt} = g \left(1 - \sum_j \text{latent}_j^{TB} \right) N + \psi P_S^T X^H - \left(\sum_j \lambda_j^{TB} + \text{age} \right) S^T X^H \quad (1)$$

$$\frac{dP_S^T X^H}{dt} = - \left(\sum_{j=2}^3 \lambda_j^{TB} + \psi + \text{age} \right) P_S^T X^H \quad (2)$$

$$\begin{aligned} \frac{dL_1^T X^H}{dt} = & g * \text{latent}_1^{TB} * N + (1 - p_H) \lambda_1^{TB} \left(S^T X^H + x_H^{TB} \sum_j (L_j^T X^H + E_j^T X^H + R_j^T X^H) \right) \\ & + \zeta (A_{i,1}^T S^H + D_{i,1}^T S^H) + \psi P_{L1}^T X^H - \left(\nu_H + x_H^{TB} \sum_j \lambda_j^{TB} + \text{age} \right) L_1^T X^H \end{aligned} \quad (3)$$

$$\begin{aligned} \frac{dE_1^T X^H}{dt} = & p_H \lambda_1^{TB} \left(S^T X^H + x_H^{TB} \sum_j (L_j^T X^H + E_j^T X^H + R_j^T X^H) \right) \\ & - \left(\tau_H + x_H^{TB} \sum_j \lambda_j^{TB} + \text{age} \right) E_1^T X^H \end{aligned} \quad (4)$$

$$\frac{dF_{L1}^T X^H}{dt} = - \left(x_H^{TB} \sum_{j=2}^3 \lambda_j^{TB} + \psi + \text{age} \right) F_{L1}^T X^H \quad (5)$$

$$\begin{aligned} \frac{dA_{i1}^T X^H}{dt} = & f_H (\nu_H L_1^T X^H + \tau_H E_1^T X^H + \nu R_1^T X^H) + w_i A_{01}^T X^H + (1 - \omega_1) d_1^{TB} (1 - q_{11H}) \delta A_{i1}^T X^H \\ & + ((1 - s_{xH}) + s_{xH} (1 - s_{m_i}) \text{nocul} + s_{xH} * s_{m_i} * l_1^{TB}) \iota A_{i1}^T X^H \\ & + s_{xH} * s_{m_i} (1 - l_1^{TB}) (1 - \omega_1) d_1^{TB} (1 - q_{11H}) \iota A_{i1}^T X^H \\ & + ((1 - c_i) + l_1^{TB} c_i + (1 - l_1^{TB}) (1 - \omega_1) d_1^{TB} (1 - q_{11H}) c_i) \sigma_{DS} D_1^T X^H \\ & - (\delta + \iota + \zeta + \mu_{TB} + w_i + \text{age}) A_{i1}^T X^H \end{aligned} \quad (6)$$

$$\begin{aligned} \frac{dT_{i11}^T X^H}{dt} = & q_{11H} \delta A_{i1}^T X^H + q_{11H} \delta D_{i1}^T X^H + s_{xH} * s_{m_i} (1 - l_1^{TB}) q_{11H} \iota A_{i1}^T X^H + (1 - l_1^{TB}) q_{11H} c_i \sigma_{DS} D_{i1}^T X^H \\ & + q_{11H} \kappa F_{i11}^T X^H - (\rho_{DS} + \text{age}) T_{i11}^T X^H \end{aligned} \quad (7)$$

$$\begin{aligned} \frac{dF_{i11}^T X^H}{dt} = & (1 - \omega_1) (1 - d_1^{TB}) ((1 - q_{11H}) \delta A_{i1}^T X^H + (1 - q_{11H}) \delta D_{i1}^T X^H + s_{xH} * s_{m_i} (1 - l_1^{TB}) (1 - q_{11H}) \iota A_{i1}^T X^H) \\ & + (1 - \omega_1) (1 - d_1^{TB}) (1 - l_1^{TB}) (1 - q_{11H}) c_i \sigma_{DS} D_{i1}^T X^H + (1 - q_{11H}) \kappa F_{i11}^T X^H \\ & - (\mu_{TB} + \kappa + \text{age}) F_{i11}^T X^H \end{aligned} \quad (8)$$

$$\frac{dD_{i1}^T X^H}{dt} = s_{xH} (1 - s_{m_i}) \text{cul} \iota A_{i1}^T X^H + (1 - \omega_1) d_1^{TB} (1 - q_{11H}) \delta D_{i1}^T X^H - (\mu_{TB} + \sigma_{DS} + \delta + \zeta + \text{age}) D_{i1}^T X^H \quad (9)$$

$$\frac{dR_1^T X^H}{dt} = \rho_{DS} T_{i11}^T X^H - \left(\nu + x_H^{TB} \sum_j \lambda_j^{TB} + \text{age} \right) R_1^T X^H \quad (10)$$

$$\frac{dF_{R1}^T X^H}{dt} = - \left(x_H^{TB} \sum_{j=2}^3 \lambda_j^{TB} + \psi + \text{age} \right) F_{R1}^T X^H \quad (11)$$

MDR-TB

$$\frac{dL_2^T X^H}{dt} = g * latent_2^{TB} * N \quad (12)$$

$$+ (1 - p_H) \lambda_2^{TB} \left(S^T X^H + P_S^T X^H + x_H^{TB} \sum_j (L_j^T X^H + E_j^T X^H + R_j^T X^H + P_{L_j}^T X^H + P_{R_j}^T X^H) \right) \\ + \zeta (A_{i,2}^T S^H + D_{i,2}^T S^H) + \psi P_{L_2}^T X^H - \left(\nu_H + x_H^{TB} \sum_j \lambda_j^{TB} + age \right) L_2^T X^H$$

$$\frac{dE_2^T X^H}{dt} = p_H \lambda_2^{TB} \left(S^T X^H + P_S^T X^H + x_H^{TB} \sum_j (L_j^T X^H + E_j^T X^H + R_j^T X^H + P_{L_j}^T X^H + P_{R_j}^T X^H) \right) \quad (13)$$

$$- \left(\tau_H + x_H^{TB} \sum_j \lambda_j^{TB} + age \right) E_2^T X^H$$

$$\frac{dP_{L_2}^T X^H}{dt} = - \left(\nu_H + x_H^{TB} \sum_{j=2}^3 \lambda_j^{TB} + \psi + age \right) P_{L_2}^T X^H \quad (14)$$

$$\frac{dA_{i2}^T X^H}{dt} = f_H (\nu_H (L_2^T X^H + P_{L_2}^T X^H) + \tau_H E_2^T X^H + v (R_2^T X^H + P_{R_2}^T X^H)) + w_i A_{i2}^T X^H \quad (15)$$

$$+ \omega_1 d_1^{TB} ((1 - q_{11H}) \delta A_{i1}^T X^H + s_{xH} * sm_i (1 - l_1^{TB}) (1 - q_{11H}) \iota A_{i1}^T X^H + (1 - l_1^{TB}) (1 - q_{11H}) c_i \sigma_{DS} D_{i1}^T X^H) \\ + ((1 - r_{tx}) d_1^{TB} (1 - q_{12H}) + r_{tx} (1 - x_{pt}) d_1^{TB} (1 - q_{12H}) + r_{tx} * x_{pt} (1 - \omega_2) d_2^{TB} (1 - q_{22H})) \delta A_{i2}^T X^H \\ ((1 - s_{xH}) + s_{xH} (1 - sm_i) nocul + s_{xH} * sm_i (1 - x_{pt}) nocul (l_1^{TB} + (1 - l_1^{TB}) d_1^{TB} (1 - q_{12H}))) \iota A_{i2}^T X^H \\ + (s_{xH} * sm_i * x_{pt} (l_2^{TB} + (1 - l_2^{TB}) (1 - \omega_2) d_2^{TB} (1 - q_{22H}))) \iota A_{i2}^T X^H + (1 - c_i) \sigma_{DR} D_{i2}^T X^H \\ + l_2^{TB} (c_i \sigma_{DR} D_{i2}^T X^H + c_i \sigma_{DR} D_{T_{i2}}^T X^H) \\ + (1 - l_2^{TB}) (1 - \omega_2) d_2^{TB} (c_i (1 - q_{22H}) \sigma_{DR} D_{i2}^T X^H + c_i (1 - q_{22H}) \sigma_{DR} D_{T_{i2}}^T X^H) \\ + (1 - c_i) d_1^{TB} (1 - q_{12H}) \sigma_{DR} D_{T_{i2}}^T X^H \\ + (x_{pt} * l_2^{TB} + x_{pt} (1 - l_2^{TB}) (1 - \omega_2) d_2^{TB} (1 - q_{22H})) \kappa F_{i12}^T X^H + r_{tx} * x_{pt} * l_2^{TB} * \delta * A_{i2}^T X^H \\ - (\delta + \iota + \zeta + \mu_{TB} + w_i + age) A_{i2}^T X^H \quad (16)$$

$$\frac{dT_{i12}^T X^H}{dt} = (r_{tx} (1 - x_{pt}) + (1 - r_{tx})) q_{12H} \delta A_{i2}^T X^H + s_{xH} * sm_i (1 - x_{pt}) nocul (1 - l_1^{TB}) q_{12H} \iota A_{i2}^T X^H \quad (17)$$

$$+ (1 - c_i) q_{12H} \sigma_{DR} D_{T_{i2}}^T X^H - (\rho_{DS} + age) T_{i12}^T X^H$$

$$\frac{dT_{i22}^T X^H}{dt} = r_{tx} * x_{pt} * q_{22H} \delta A_{i2}^T X^H + (1 - l_2^{TB}) q_{22H} c_i \sigma_{DR} D_{i2}^T X^H + (1 - l_2^{TB}) q_{22H} c_i \sigma_{DR} D_{T_{i2}}^T X^H \quad (18)$$

$$+ x_{pt} (1 - l_2^{TB}) q_{22H} \kappa F_{i12}^T X^H + s_{xH} * sm_i * x_{pt} (1 - l_2^{TB}) q_{22H} \iota A_{i2}^T X^H + q_{22H} \kappa F_{i22}^T X^H$$

$$- (\rho_{DR} + age) T_{i22}^T X^H$$

$$\frac{dF_{i12}^T X^H}{dt} = \omega_1 (1 - d_1^{TB}) ((1 - q_{11H}) \delta A_{i1}^T X^H + (1 - q_{11H}) \delta D_{i1}^T X^H + s_{xH} * sm_i (1 - l_1^{TB}) (1 - q_{11H}) \iota A_{i1}^T X^H) \quad (19)$$

$$+ \omega_1 (1 - d_1^{TB}) (1 - l_1^{TB}) (1 - q_{11H}) c_i \sigma_{DS} D_{i1}^T X^H + (r_{tx} (1 - x_{pt}) + (1 - r_{tx})) (1 - q_{12H}) (1 - d_1^{TB}) \delta A_{i2}^T X^H$$

$$+ s_{xH} * sm_i (1 - x_{pt}) nocul (1 - l_1^{TB}) (1 - d_1^{TB}) (1 - q_{12H}) \iota A_{i2}^T X^H$$

$$+ (1 - c_i) (1 - d_1^{TB}) (1 - q_{12H}) \sigma_{DR} D_{T_{i2}}^T X^H + (1 - x_{pt}) nocul \kappa F_{i12}^T X^H$$

$$- (\mu_{TB} + \kappa + age) F_{i12}^T X^H$$

$$\frac{dF_{i22}^T X^H}{dt} = r_{tx} * x_{pt} * (1 - \omega_2) (1 - d_2^{TB}) (1 - q_{22H}) \delta A_{i2}^T X^H \quad (20)$$

$$+ (1 - \omega_2) (1 - d_2^{TB}) (1 - l_2^{TB}) ((1 - q_{22H}) c_i \sigma_{DR} D_{i2}^T X^H + (1 - q_{22H}) c_i \sigma_{DR} D_{T_{i2}}^T X^H + x_{pt} (1 - q_{22H}) \kappa F_{i12}^T X^H)$$

$$+ s_{xH} * sm_i * x_{pt} (1 - l_2^{TB}) (1 - \omega_2) (1 - d_2^{TB}) (1 - q_{22H}) \iota A_{i2}^T X^H + (1 - q_{22H}) \kappa F_{i22}^T X^H$$

$$- (\mu_{TB} + \kappa + age) F_{i22}^T X^H$$

$$\frac{dD_{i2}^T X^H}{dt} = s_{xH} (1 - sm_i) cul \iota A_{i2}^T X^H + s_{xH} * sm_i (1 - x_{pt}) cul * l_1^{TB} \iota A_{i2}^T X^H \quad (21)$$

$$- (\mu_{TB} + \sigma_{DR} + \zeta + age) D_{i2}^T X^H$$

$$\frac{dD_{T_{i2}}^T X^H}{dt} = s_{xH} * sm_i (1 - x_{pt}) cul (1 - l_2^{TB}) \iota A_{i2}^T X^H + (1 - x_{pt}) cul \kappa F_{i12}^T X^H \quad (22)$$

$$- (\mu_{TB} + \sigma_{DR} + age) D_{T_{i2}}^T X^H$$

$$\frac{dR_2^T X^H}{dt} = \rho_{DS} T_{i12}^T X^H + \rho_{DR} T_{i22}^T X^H + \psi P_{R_2}^T X^H - \left(v + x_H^{TB} \sum_j \lambda_j^{TB} + age \right) R_2^T X^H \quad (23)$$

$$\frac{dP_{R_2}^T X^H}{dt} = - \left(v + x_H^{TB} \sum_{j=2}^3 \lambda_j^{TB} + \psi + age \right) P_{R_2}^T X^H \quad (24)$$

XDR-TB

$$\frac{dL_3^T X^H}{dt} = g * latent_3^{TB} * N \quad (25)$$

$$+ (1 - p_H) \lambda_3^{TB} \left(S^T X^H + P_S^T X^H + x_H^{TB} \sum_j (L_j^T X^H + E_j^T X^H + R_j^T X^H + P_{L_j}^T X^H + P_{R_j}^T X^H) \right) \\ + \zeta (A_{i,3}^T S^H + D_{i,3}^T S^H) + \psi P_{L_3}^T X^H - \left(\nu_H + x_H^{TB} \sum_j \lambda_j^{TB} + age \right) L_3^T X^H$$

$$\frac{dE_3^T X^H}{dt} = p_H \lambda_3^{TB} \left(S^T X^H + P_S^T X^H + x_H^{TB} \sum_j (L_j^T X^H + E_j^T X^H + R_j^T X^H + P_{L_j}^T X^H + P_{R_j}^T X^H) \right) \\ - \left(\tau_H + x_H^{TB} \sum_j \lambda_j^{TB} + age \right) E_3^T X^H \quad (26)$$

$$\frac{dP_{L_3}^T X^H}{dt} = - \left(\nu_H + x_H^{TB} \sum_{j=2}^3 \lambda_j^{TB} + \psi + age \right) P_{L_3}^T X^H \quad (27)$$

$$\frac{dA_{i,3}^T X^H}{dt} = f_H (\nu_H (L_3^T X^H + P_{L_3}^T X^H) + \tau_H E_3^T X^H + v (R_3^T X^H + P_{R_3}^T X^H)) + w_i A_{0,3}^T X^H \\ + rtx * xpt * \omega_2 d_2^{TB} (1 - q_{22H}) \delta A_{i,2}^T X^H \\ + \omega_2 d_2^{TB} (1 - l_2^{TB}) ((1 - q_{22H}) c_i \sigma_{DR} D_{i,2}^T X^H + (1 - q_{22H}) c_i \sigma_{DR} D_{T,2}^T X^H + xpt (1 - q_{22H}) \kappa F_{i,2}^T X^H) \\ + s_{xH} * sm_i * xpt (1 - l_2^{TB}) \omega_2 d_2^{TB} (1 - q_{22H}) \iota A_{i,2}^T X^H \\ + (rtx * xpt * nocul (l_2^{TB} + (1 - l_2^{TB}) d_2^{TB}) + rtx (1 - xpt) (l_1^{TB} + (1 - l_1^{TB}) d_1^{TB}) + (1 - rtx) (l_1^{TB} + (1 - l_1^{TB}) d_1^{TB})) \delta A_{i,3}^T X^H \\ + ((1 - s_{xH}) + s_{xH} (1 - sm_i) nocul + s_{xH} * sm_i (1 - xpt) nocul (l_1^{TB} + (1 - l_1^{TB}) d_1^{TB})) \iota A_{i,3}^T X^H \\ + (s_{xH} * sm_i * xpt * nocul (l_2^{TB} + (1 - l_2^{TB}) d_2^{TB})) \iota A_{i,3}^T X^H \\ + (1 - l_3^{TB}) d_3^{TB} ((1 - q_{33H}) c_i \sigma_{DR} D_{i,3}^T X^H + (1 - q_{33H}) c_i \sigma_{DR} D_{T,i,3}^T X^H + (1 - q_{33H}) c_i \sigma_{DR} D_{T,i,2,3}^T X^H) \\ + \iota_3^{TB} (c_i \sigma_{DR} D_{i,3}^T X^H + c_i \sigma_{DR} D_{T,i,3}^T X^H + c_i \sigma_{DR} D_{T,i,2,3}^T X^H) \\ + (1 - c_i) \sigma_{DR} D_{i,3}^T X^H + (1 - c_i) d_1^{TB} \sigma_{DR} D_{T,i,3}^T X^H + (1 - c_i) d_1^{TB} \sigma_{DR} D_{T,i,2,3}^T X^H + xpt * nocul (l_2^{TB} + (1 - l_2^{TB}) d_2^{TB}) \kappa F_{i,3}^T X^H \\ + rtx * xpt * l_2^{TB} \delta A_{i,3}^T X^H - (\delta + \iota + \zeta + \mu_{TB} + w_i + age) A_{i,3}^T X^H \quad (28)$$

$$\frac{dT_{i,3}^T X^H}{dt} = (1 - l_3^{TB}) q_{33H} c_i \sigma_{DR} D_{i,3}^T X^H + (1 - l_3^{TB}) q_{33H} c_i \sigma_{DR} D_{T,i,3}^T X^H + (1 - l_3^{TB}) q_{33H} c_i \sigma_{DR} D_{T,i,2,3}^T X^H + q_{33H} \kappa F_{i,3}^T X^H \\ - (\rho_{DR} + age) T_{i,3}^T X^H \quad (29)$$

$$\frac{dF_{i,3}^T X^H}{dt} = (rtx (1 - xpt) + (1 - rtx)) (1 - l_1^{TB}) (1 - d_1^{TB}) \delta A_{i,3}^T X^H + s_{xH} * sm_i (1 - xpt) nocul (1 - l_1^{TB}) (1 - d_1^{TB}) \iota A_{i,3}^T X^H \\ + (1 - c_i) (1 - d_1^{TB}) \sigma_{DR} D_{T,i,3}^T X^H + (1 - xpt) nocul \kappa F_{i,3}^T X^H \\ - (\mu_{TB} + \kappa + age) F_{i,3}^T X^H \quad (30)$$

$$\frac{dF_{i,2,3}^T X^H}{dt} = rtx * xpt * \omega_2 (1 - d_2^{TB}) (1 - q_{22H}) \delta A_{i,2}^T X^H \\ + (1 - l_2^{TB}) (1 - d_2^{TB}) \omega_2 ((1 - q_{22H}) c_i \sigma_{DR} D_{i,2}^T X^H + (1 - q_{22H}) c_i \sigma_{DR} D_{T,i,2}^T X^H + xpt (1 - q_{22H}) \kappa F_{i,2}^T X^H) \\ + s_{xH} * sm_i * xpt (1 - l_2^{TB}) \omega_2 (1 - d_2^{TB}) (1 - q_{22H}) \iota A_{i,2}^T X^H + rtx * xpt * nocul (1 - l_2^{TB}) (1 - d_2^{TB}) \delta A_{i,3}^T X^H \\ + s_{xH} * sm_i * xpt * nocul (1 - l_2^{TB}) (1 - d_2^{TB}) \iota A_{i,3}^T X^H + (1 - c_i) (1 - d_2^{TB}) \sigma_{DR} D_{T,i,2,3}^T X^H \\ + xpt * nocul (1 - l_2^{TB}) (1 - d_2^{TB}) \kappa F_{i,3}^T X^H + nocul \kappa F_{i,2,3}^T X^H \\ - (\mu_{TB} + \kappa + age) F_{i,2,3}^T X^H \quad (31)$$

$$\frac{dF_{i,3}^T X^H}{dt} = (1 - l_3^{TB}) (1 - d_3^{TB}) ((1 - q_{33H}) c_i \sigma_{DR} D_{i,3}^T X^H + (1 - q_{33H}) c_i \sigma_{DR} D_{T,i,3}^T X^H + (1 - q_{33H}) c_i \sigma_{DR} D_{T,i,2,3}^T X^H) \\ + (1 - q_{33H}) \kappa F_{i,3}^T X^H - (\mu_{TB} + \kappa + age) F_{i,3}^T X^H \quad (32)$$

$$\frac{dD_{i,3}^T X^H}{dt} = s_{xH} (1 - sm_i) cul \iota A_{i,3}^T X^H + s_{xH} * sm_i * xpt * cul * l_2^{TB} \iota A_{i,3}^T X^H + s_{xH} * sm_i (1 - xpt) cul * l_1^{TB} \iota A_{i,3}^T X^H \\ - (\mu_{TB} + \sigma_{DR} + \zeta + age) D_{i,3}^T X^H \quad (33)$$

$$\frac{dD_{T,i,3}^T X^H}{dt} = s_{xH} * sm_i (1 - xpt) cul (1 - l_1^{TB}) \iota A_{i,3}^T X^H + (1 - xpt) cul \kappa F_{i,3}^T X^H \\ - (\mu_{TB} + \sigma_{DR} + age) D_{T,i,3}^T X^H \quad (34)$$

$$\frac{dD_{T,i,2,3}^T X^H}{dt} = s_{xH} * sm_i * xpt * cul (1 - l_2^{TB}) \iota A_{i,3}^T X^H + rtx * xpt * cul * (1 - l_2^{TB}) \delta A_{i,3}^T X^H \\ + cul \kappa F_{i,2,3}^T X^H + xpt * cul \kappa F_{i,3}^T X^H - (\mu_{TB} + \sigma_{DR} + age) D_{T,i,2,3}^T X^H \quad (35)$$

$$\frac{dR_3^T X^H}{dt} = \rho_{DR} T_{i,3}^T X^H + \psi P_{R_3}^T X^H - \left(v + x_H^{TB} \sum_j \lambda_j^{TB} + age \right) R_3^T X^H \quad (36)$$

$$\frac{dP_{R_3}^T X^H}{dt} = - \left(v + x_H^{TB} \sum_{j=2}^3 \lambda_j^{TB} + \psi + age \right) P_{R_3}^T X^H \quad (37)$$

HIV

$$\frac{dY^T S^H}{dt} = -(\mu_H + \lambda_{HIV})Y^T S^H \quad (38)$$

$$\frac{dY^T I^H}{dt} = \lambda_{HIV}Y^T S^H + (l_{HIV} * r + (1-r))\epsilon Y^T I^H + d_{HIV}Y^T I_{ART}^H - (\mu_H + \gamma + \eta + \epsilon)Y^T I^H \quad (39)$$

$$\frac{dY^T E^H}{dt} = \gamma Y^T I^H + (l_{HIV} * r + (1-r))\epsilon Y^T E^H + d_{HIV}Y^T E_{ART}^H - (\mu_H + \eta + \epsilon)Y^T E^H \quad (40)$$

$$\frac{dY^T I_{ART}^H}{dt} = \eta Y^T I^H + (1-l_{HIV})r\epsilon Y^T I^H - (\mu_H + d_{HIV})Y^T I_{ART}^H \quad (41)$$

$$\frac{dY^T E_{ART}^H}{dt} = \eta Y^T E^H + (1-l_{HIV})r\epsilon Y^T E^H - (\mu_H + d_{HIV})Y^T E_{ART}^H \quad (42)$$

Other

$$\lambda_j^{TB} = \beta_{TB}(1 - fit_j)(A_{ij}^T X^H + F_{ij}^T X^H + D_{ij}^T X^H + D_{Tij}^T X^H) \quad (43)$$

$$\lambda^{HIV} = \beta_{HIV}e^{\left(-\alpha \frac{Y^T I^H + \gamma Y^T E^H + \gamma Y^T I_{ART}^H + \gamma Y^T E_{ART}^H}{N}\right)}(Y^T I^H + \nu Y^T E^H + x_{HIV}Y^T I_{ART}^H + \nu l * x_{HIV}Y^T E_{ART}^H) \quad (44)$$

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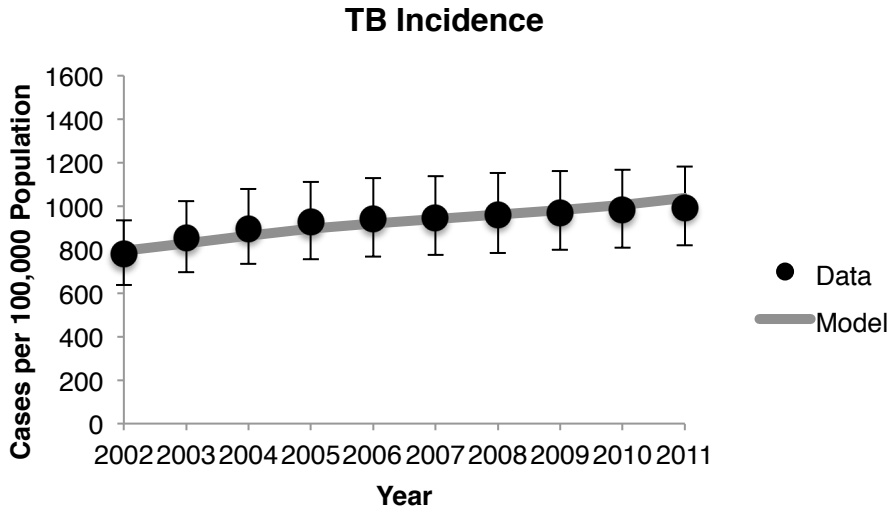
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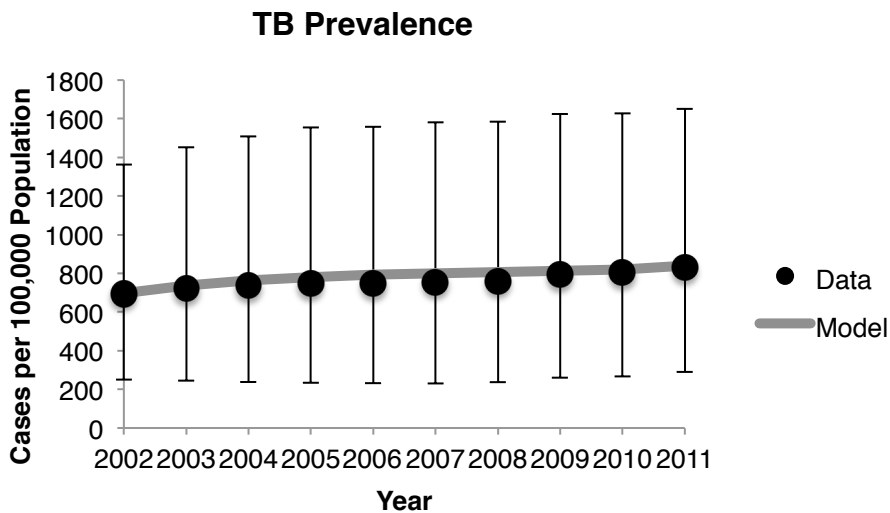
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S1 Fig. Model Calibration and Validation. Model calibration and validation using (A) TB incidence, (B) TB prevalence, and (C) HIV prevalence data. Error bars indicate available minimum and maximum values in data.

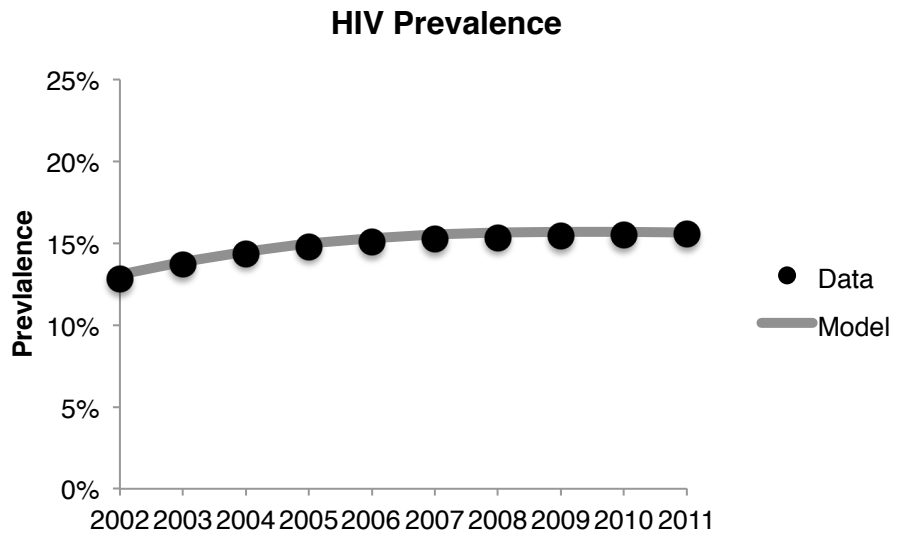
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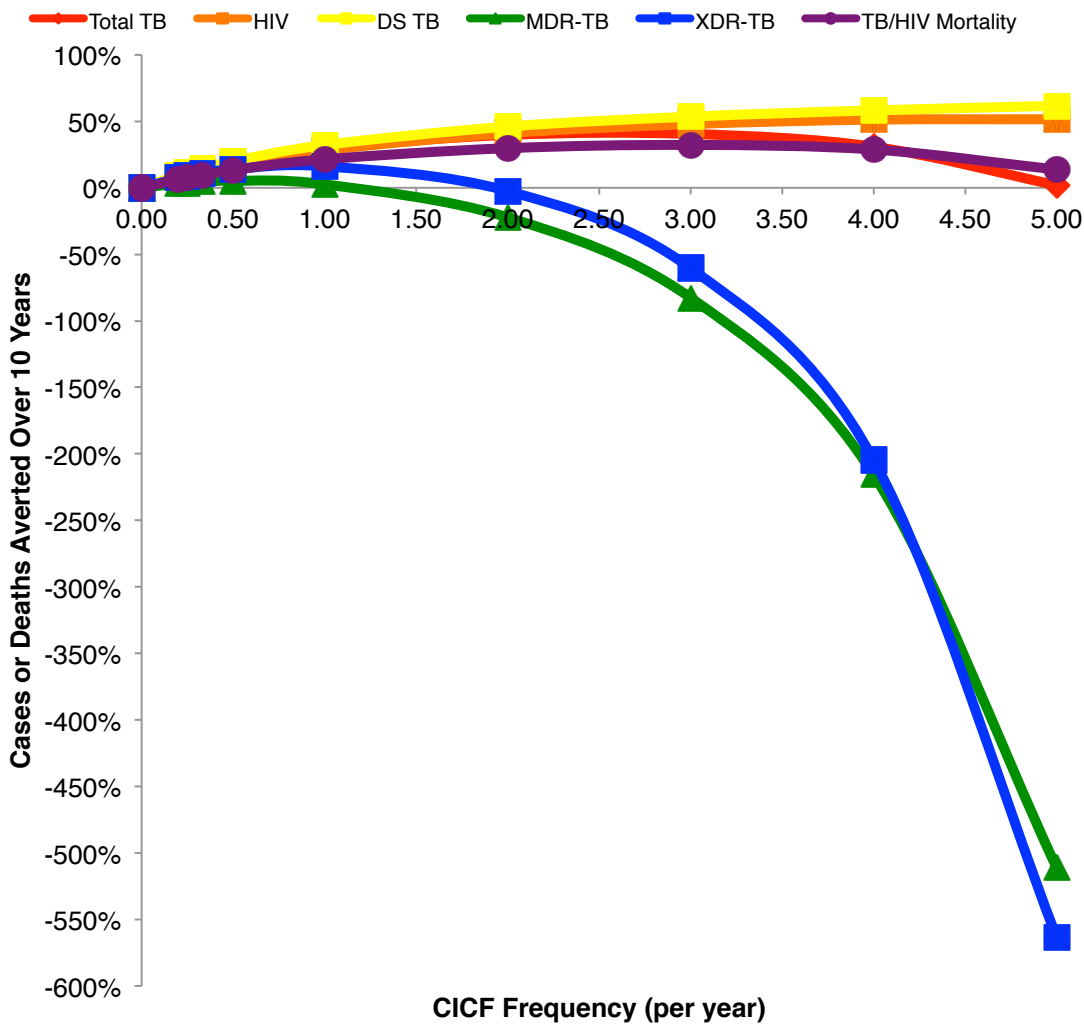
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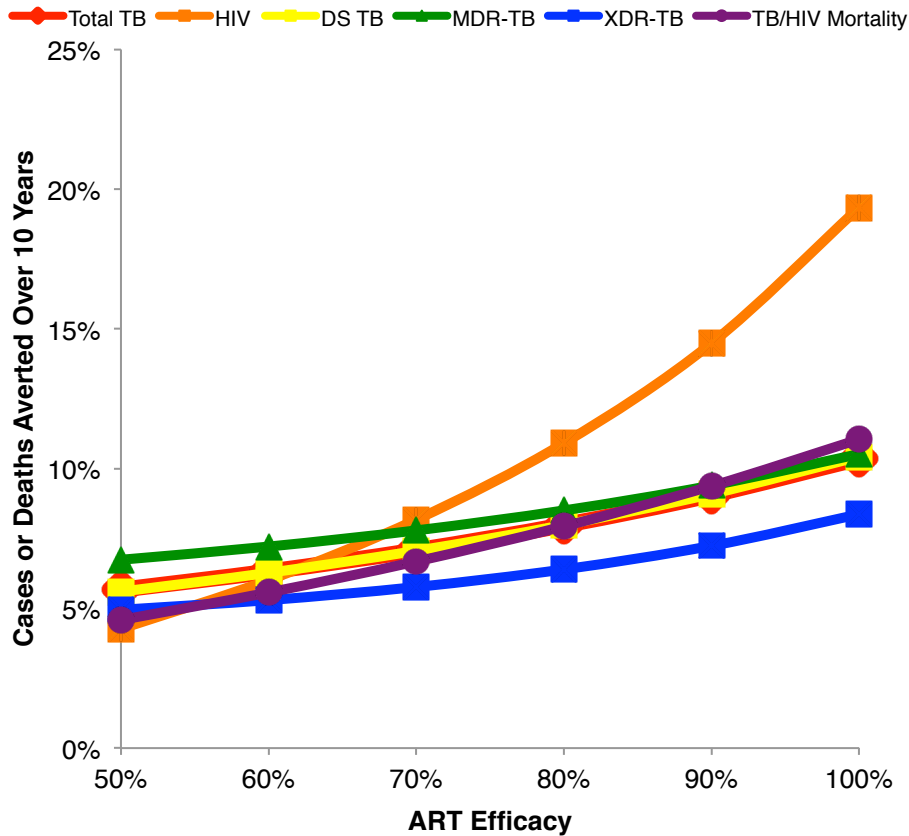
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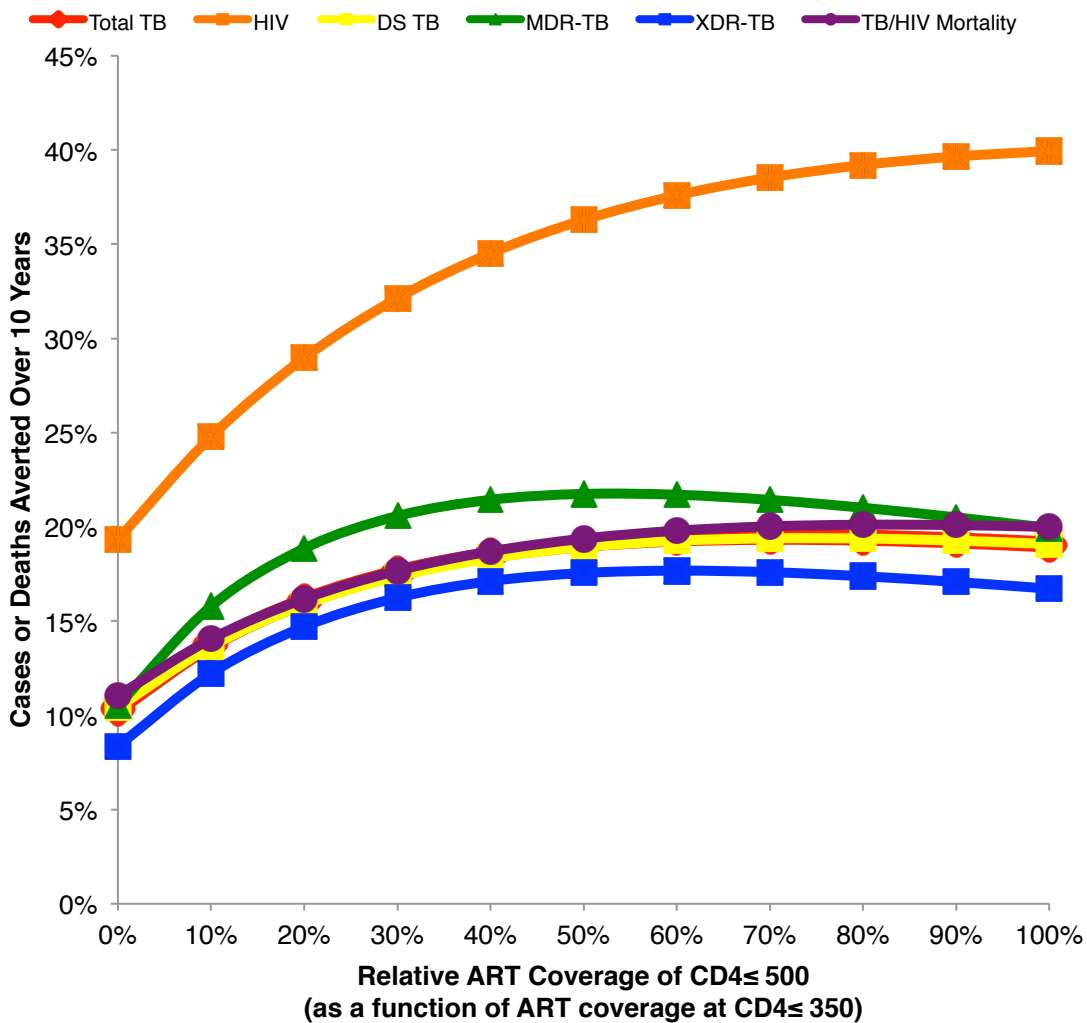
S2 Fig. CICF with ART eligibility at CD4+ cell count \leq 500 cells per milliliter. Impact of increasing eligibility to initiate ART from CD4+ cell count \leq 350 cells per milliliter to a CD4+ cell count \leq 500 cells per milliliter, and assuming ART coverage for individuals with a CD4+ cell count between 350 and 500 cells per milliliter is equal to the ART coverage for individuals with a CD4+ cell count below 350 cells per milliliter, on total TB cases averted, HIV infections averted, drug susceptible TB (DS TB) cases averted, MDR-TB cases averted, XDR-TB cases averted, and TB/HIV deaths averted by CICF at frequencies corresponding to screening individuals on average once every five years (annual frequency = 0.20), once every four years (annual frequency = 0.25), once every three years (annual frequency = 0.33), once every two years (annual frequency = 0.5), annually (annual frequency = 1), two times annually (annual frequency = 2), three times annually (annual frequency = 3), four times annually (annual frequency = 4), and five times annually (annual frequency = 5).



S3 Fig. Decreased ART Efficacy. Impact of decreasing ART efficacy on total TB cases averted, HIV infections averted, drug susceptible TB (DS TB) cases averted, MDR-TB cases averted, XDR-TB cases averted, and TB/HIV deaths averted by expanding ART coverage to 80% and increasing five-year retention to 70% by 2016. Note that Total TB and DS TB lines overlap because they are very close in value; the majority of total TB cases are drug susceptible.



S4 Fig. Expansion of ART coverage with ART eligibility at CD4+ cell count ≤ 500 cells per milliliter. Impact of increasing eligibility to initiate ART from CD4+ cell count ≤ 350 cells per milliliter to a CD4+ cell count ≤ 500 cells per milliliter, with ART coverage for individuals with a CD4+ cell count between 350 and 500 cells per milliliter varied between 0% and 100% of the ART coverage for individuals with a CD4+ cell count ≤ 350 cells per milliliter, on total TB cases averted, HIV infections averted, drug susceptible TB (DS TB) cases averted, MDR-TB cases averted, XDR-TB cases averted, and TB/HIV deaths averted by expanding ART coverage to 80% and increasing five-year retention to 70% by 2016. Note that Total TB and DS TB lines overlap because they are very close in value; the majority of total TB cases are drug susceptible.



S1 Table. Model parameters, ranges, and references. Rates are in units of year⁻¹ unless otherwise noted. *HIV+ individuals on ART have the effect of HIV on the natural history of TB reduced by the effectiveness of ART (parameter *treat*).

Parameter	Symbol	TB Disease Status	HIV–	HIV+ (No ART)	HIV+ (ART)	Reference
Annual population growth rate	g		0.0572 (0.02–0.06)	NA	NA	Fitted to [1,2]
Annual mortality rate	μ	<i>Baseline (no TB)</i>	0.003 (0.0009–0.004)	0.0155 (0.004–0.13, CD4+ >350), 0.339 (0.21–0.64, CD4+ ≤350)	0.0155 (0.004–0.13, CD4+ >350), 0.122 (0.004–0.13, CD4+ ≤350)	Fitted to [1,2], ranges adapted from [3-8]
	μ_{TB}	<i>Active TB</i>	0.30 (0.2–0.4)	0.992 (0.75–1)	0.508 (0.2–0.76)	Fitted to [1,2], ranges adapted from [3]
TB transmissibility coefficient	β_{TB}		9.52×10^{-5}	9.52×10^{-5}	9.52×10^{-5}	Fitted to [1,2]
Relative fitness penalty drug resistance TB (proportion)	fit_2	<i>MDR</i>	0.12 (0–0.7)	0.12 (0–0.7)	0.12 (0–0.7)	[3,9]
	fit_3	<i>XDR</i>	0.16 (0–0.7)	0.16 (–0.7)	0.16 (0–0.7)	[3,9]
Proportion who develop primary progressive TB	p		0.14 (0.08–0.25)	0.67 (0.36–0.8)	*	[3,10]
Endogenous annual TB reactivation rate	ν	<i>Long latency</i>	0.00011 (0.0001–0.0003)	0.17 (0.04–0.2)	*	[3,10]
	τ	<i>Short latency</i>	0.88 (0.76–0.99)	12 (10.4–13.5)	*	[3,10]
Degree susceptibility despite prior TB infection (proportion)	x_{TB}		0.35 (0.1–0.6)	0.75 (0.5–1)	*	[3]
Proportion of TB infections that are infectious	f		0.65 (0.5–0.65)	0.3 (0.19–0.4)	*	[3]
Rate of conversion from non-infectious to infectious TB	w		0.015 (0.007–0.02)	0.015 (0.007–0.02)	0.015 (0.007–0.02)	[3,11]
Rate of natural self cure	ζ		0.2 (0.15–0.25)	0.2 (0.15–0.25)	0.2 (0.15–0.25)	[3]
Baseline TB detection and treatment	δ		1.0299 (0.8415–1.1137)	1.0299 (0.8415–1.1137)	1.0299 (0.8415–1.1137)	Fitted to [1,2]
Proportion cured by 1 st line TB drugs	q_{11}	<i>DS</i>	0.73 (0.65–0.88)	0.58 (0.52–0.74)	*	[3,9]
	q_{12}	<i>MDR</i>	0.47 (0.18–0.58)	0.30 (0.16–0.36)	*	[3,9,12,13]
	q_{13}	<i>XDR</i>	0	0	0	[3,9,12,13]
Proportion cured by 2 nd line TB drugs	q_{22}	<i>MDR</i>	0.67 (0.43–0.80)	0.45 (0.43–0.51)	*	[3,9,12-14]
	q_{33}	<i>XDR</i>	0.54 (0.328–0.545)	0.36 (0.328–0.400)	*	[3,12,15]
Duration TB treatment (months)	$\frac{1}{\rho_1}$	<i>DS</i>	6 (6–8)	6 (6–8)	6 (6–8)	[16]
	$\frac{1}{\rho_2}$	<i>MDR</i>	24 (18–24)	24 (18–24)	24 (18–24)	[17]
	$\frac{1}{\rho_3}$	<i>XDR</i>	26 (24.6–27.8)	26 (24.6–27.8)	26 (24.6–27.8)	[10]
Proportion defaulting from TB treatment	d_{TB1}	<i>DS</i>	0.07 (0.048–0.088)	0.07 (0.048–0.088)	0.07 (0.048–0.088)	[18]

	d_{TB2}	<i>MDR</i>	0.2 (0.19–0.37)	0.2 (0.19–0.37)	0.2 (0.19–0.37)	[19–21]
	d_{TB3}	<i>XDR</i>	0.28 (0.19–0.37)	0.28 (0.19–0.37)	0.28 (0.19–0.37)	[17,19,22]
Proportion of treated TB patients who acquire or amplify resistance	ω_1	<i>DS to MDR</i>	0.038 (0.025–0.1)	0.038 (0.025–0.1)	0.038 (0.025–0.1)	[3]
	ω_2	<i>MDR to XDR</i>	0.030 (0.025–0.1)	0.030 (0.025–0.1)	0.030 (0.025–0.1)	[3]
Time to identification of TB treatment failure (months)	$\frac{1}{\kappa}$		2 (1–4)	2 (1–4)	2 (1–4)	[10]
Time from culture collection to MDR treatment initiation (days)	$\frac{1}{\sigma_{DR}}$	<i>Baseline</i>	93 (71–120)	93 (71–120)	93 (71–120)	[23]
	$\frac{1}{\sigma_{DS}}$	<i>Decentralized</i>	72 (56–99)	72 (56–99)	72 (56–99)	[23]
Proportion of cases defaulting before TB treatment initiation	ϕ_{TB}	<i>DS outpatient (DOTS)</i>	0.15 (0–0.24)	0.15 (0–0.24)	0.15 (0–0.24)	[24]
		<i>MDR inpatient (baseline)</i>	0.5 (0.29–0.73)	0.5 (0.29–0.73)	0.5 (0.29–0.73)	[17]
		<i>XDR inpatient</i>	0.5 (0.29–0.73)	0.5 (0.29–0.73)	0.5 (0.29–0.73)	[17]
HIV transmissibility coefficient	β_{HIV}		NA	1.63×10^{-6}	1.63×10^{-6}	Fitted to [1,2]
α (HIV transmission shape parameter)	α		NA	4.55 (1–6)	4.55 (1–6)	Fitted to [1,2]
Relative infectivity of HIV on ART (proportion)	x_{HIV}		NA	NA	0.12 (0–0.12)	[25]
Relative infectivity of ART eligible	νl		NA	6.87 (1.00–3.33)	NA	Fitted to [1,2], Range from [26]
ART coverage (CD4+ < 350)	η		NA	50% (46–57%)	NA	[27]
Proportion of cases detected defaulting before HIV treatment initiation	ϕ_{HIV}		NA	0.38 (0.16–0.61)	NA	[28,29]
Proportion retained in HIV treatment over 3 years	d_{HIV}		NA	NA	0.75 (0.64–0.87)	[30]
Rate of relapse from chemotherapeutic cure	ν		0.001 (0–0.01)	0.001 (0–0.01)	0.001 (0–0.01)	[3]
Duration of HIV infection, CD4+ cell count >350 (years)	$\frac{1}{\gamma}$		NA	6 (5–7); 3 (2–4, active TB infx)	NA	[5–8]
Sensitivity of TB symptom screening	sx		69% (51.9–83.7%)	79% (58.3–90.9%)	79% (58.3–90.9%)	[31,32]
Sensitivity of TB sputum smear	sm_i	<i>Infectious</i>	83.3% (80–83.3%)	83.3% (80–83.3%)	83.3% (80–83.3%)	[3,33,34]
	sm_n	<i>Noninfectious</i>	0%	0%	0%	[3,33,34]
Sensitivity of TB sputum culture/DST	c_i	<i>Infectious</i>	100%	100%	100%	[4]
	c_n	<i>Noninfectious</i>	68%	68%	68%	[4]
Sensitivity of Xpert MTB/RIF for TB diagnosis	sm_{XPTi}	<i>Infectious</i>	98.3% (97–99%)	98.3% (97–99%)	98.3% (97–99%)	[35]
	sm_{XPTn}	<i>Noninfectious</i>	76.9% (72.4–80.8%)	76.9% (72.4–80.8%)	76.9% (72.4–80.8%)	[35]
Sensitivity of Xpert MTB/RIF for RIF resistance detection given MTB detected	xpt		94.4% (90.8–98.6%)	94.4% (90.8–98.6%)	94.4% (90.8–98.6%)	[35]
Sensitivity of rapid HIV antibody test	r		NA	100% (98.2–100%)	NA	[36]
Bacteriologic coverage rate	rtx		80% (73–94%)	80% (73–94%)	80% (73–94%)	[37]
Percentage of HIV+ individuals who are	tst		NA	70% (64.3–74.5%)	70% (64.3–74.5%)	[38]

TST+					
Effectiveness of ART in reversing effect of HIV on TB natural history	<i>treat</i>	NA	NA	0.7 (0.47– 0.87)	[39-41]

S2 Table. Additional Model Calibration and Validation.

Statistic	Model	Data	Year and Source
TB case detection rate	59.7%	67% (56% - 81%)	[2]
MDR-TB prevalence	4.25%	1.1% - 4.8%	[19]
Ratio XDR/MDR prevalence	12.0%	1.2% - 53.1%	[19]
ART coverage of eligible cases (CD4+<200 cells/ml per SA ART guidelines 2011 and earlier)	75.6%	79.0%	[27]

S3 Table. Global Sensitivity Analysis. Partial rank correlation coefficients (PRCCs) and p-values calculated from model outcomes generated from minimum and maximum of parameter distributions found in S1 Table in a global sensitivity analysis of annual CICF screening.

Parameters		Total TB Cases Averted over 10 Years		DS-TB Cases Averted over 10 Years		MDR-TB Cases Averted over 10 Years		XDR-TB Cases Averted over 10 Years		HIV Infections Averted over 10 Years		TB/HIV Deaths Averted over 10 Years	
		PRCC	p-value	PRCC	p-value	PRCC	p-value	PRCC	p-value	PRCC	p-value	PRCC	p-value
<i>sm</i>		0.025	0.450	0.024	0.468	-0.005	0.882	-0.007	0.830	0.011	0.743	0.028	0.398
σ		0.154	<0.01	0.027	0.405	0.312	<0.01	0.304	<0.01	0.025	0.435	0.028	0.397
<i>sx</i>	<i>HIV-</i>	0.456	<0.01	0.486	<0.01	0.354	<0.01	0.565	<0.01	-0.112	<0.01	0.176	<0.01
	<i>HIV+/ART</i>	0.350	<0.01	0.426	<0.01	0.163	<0.01	0.157	<0.01	0.027	0.411	0.257	<0.01
<i>r</i>		0.048	0.140	0.026	0.429	-0.004	0.903	-0.027	0.400	0.038	0.248	0.010	0.752
ϕ_{HIV}		-0.007	0.837	0.026	0.417	0.053	0.106	-0.102	<0.01	0.135	<0.01	0.057	0.079
<i>tst</i>		0.016	0.633	0.002	0.952	-0.011	0.741	0.034	0.301	-0.006	0.862	-0.017	0.599
<i>xpt</i>		0.045	0.166	0.038	0.238	0.014	0.670	-0.008	0.814	-0.050	0.128	0.048	0.145
<i>sm_{xpti}</i>		0.027	0.415	0.009	0.791	-0.023	0.477	0.003	0.928	-0.065	0.048	0.027	0.407
<i>sm_{xptn}</i>		0.019	0.567	0.040	0.224	-0.029	0.371	0.046	0.156	0.036	0.265	-0.008	0.810
<i>rtx</i>		-0.002	0.947	-0.020	0.538	0.028	0.393	-0.001	0.964	0.043	0.189	-0.031	0.343
<i>fit₂</i>		0.228	<0.01	0.086	<0.01	-0.106	<0.01	0.091	0.005	-0.034	0.296	0.013	0.687
<i>fit₃</i>		0.254	<0.01	0.042	0.200	0.010	0.764	0.133	<0.01	-0.028	0.394	0.072	0.026
<i>p</i>	<i>HIV-</i>	0.719	<0.01	0.936	<0.01	-0.459	<0.01	-0.747	<0.01	-0.217	<0.01	0.498	<0.01
	<i>HIV+/ART</i>	0.257	<0.01	0.483	<0.01	0.070	0.032	-0.106	<0.01	-0.141	<0.01	0.164	<0.01
<i>x_{TB}</i>		0.427	<0.01	0.677	<0.01	0.010	0.758	-0.027	0.406	-0.147	<0.01	0.215	<0.01
<i>v</i>	<i>HIV-</i>	-0.009	0.775	0.018	0.574	-0.021	0.520	0.009	0.775	0.024	0.465	0.041	0.211
	<i>HIV+/ART</i>	-0.111	<0.01	-0.257	<0.01	-0.140	<0.01	-0.258	<0.01	0.066	0.043	0.269	<0.01
τ	<i>HIV-</i>	0.032	0.330	0.157	<0.01	-0.015	0.645	-0.073	0.026	0.016	0.629	-0.014	0.673
	<i>HIV+/ART</i>	-0.025	0.443	-0.079	0.015	0.009	0.787	0.024	0.462	0.018	0.589	0.004	0.907
$\frac{1}{\kappa}$		-0.010	0.763	0.051	0.118	0.550	<0.01	0.787	<0.01	0.114	<0.01	0.187	<0.01
ω_1		-0.137	<0.01	-0.028	0.389	-0.108	<0.01	0.015	0.653	-0.003	0.921	-0.035	0.283
ω_2		-0.033	0.314	0.022	0.493	0.046	0.160	-0.178	<0.01	0.016	0.623	-0.006	0.846
$\frac{1}{\rho_1}$	<i>DS-TB</i>	-0.025	0.436	-0.010	0.748	0.017	0.608	-0.017	0.600	0.028	0.392	0.032	0.329
$\frac{1}{\rho_2}$	<i>MDR-TB</i>	0.002	0.948	0.015	0.641	0.016	0.621	-0.001	0.972	0.048	0.139	0.014	0.663
$\frac{1}{\rho_3}$	<i>XDR-TB</i>	-0.035	0.282	-0.042	0.193	-0.007	0.828	-0.019	0.556	0.016	0.622	-0.033	0.313
<i>q₁₁</i>	<i>DS-TB</i>	0.101	<0.01	0.154	<0.01	0.025	0.448	-0.027	0.414	-0.017	0.600	-0.035	0.278
<i>q₁₂, q₂₂</i>	<i>MDR-TB</i>	0.141	<0.01	0.011	0.727	-0.058	0.073	0.022	0.496	-0.062	0.055	0.006	0.851
<i>q₃₃</i>	<i>XDR-TB</i>	0.069	0.033	0.026	0.431	0.012	0.722	0.337	<0.01	-0.013	0.694	0.030	0.365
<i>x_{HIV}</i>		-0.104	<0.01	-0.118	<0.01	-0.067	0.040	-0.071	0.028	-0.789	<0.01	-0.105	<0.01
ϕ_{TB1}	<i>DS-TB</i>	0.183	<0.01	0.194	<0.01	-0.386	<0.01	-0.467	<0.01	-0.105	<0.01	0.055	0.093
$\phi_{TB2/3}$	<i>MDR- & XDR-TB</i>	-0.563	<0.01	0.084	0.010	-0.827	<0.01	-0.871	<0.01	0.014	0.659	-0.243	<0.01
<i>d_{TB1}</i>	<i>DS-TB</i>	0.041	0.211	-0.009	0.783	0.005	0.880	0.022	0.491	-0.016	0.633	0.032	0.321
<i>d_{TB2/3}</i>	<i>MDR- & XDR-TB</i>	0.002	0.959	-0.001	0.967	-0.025	0.434	0.018	0.588	0.001	0.985	0.002	0.959

d_{HIV}		-0.015	0.656	-0.040	0.217	0.013	0.690	0.021	0.515	0.032	0.320	0.052	0.111
$\frac{1}{\gamma}$	<i>TB-</i>	0.121	<0.01	0.121	<0.01	0.014	0.661	0.116	<0.01	0.694	<0.01	0.155	<0.01
	<i>TB+</i>	-0.040	0.219	0.028	0.397	-0.056	0.083	0.024	0.463	0.003	0.937	0.019	0.551
f	<i>HIV-</i>	0.097	<0.01	0.275	<0.01	-0.108	<0.01	-0.210	<0.01	-0.057	0.081	0.093	0.004
	<i>HIV+/ART</i>	0.341	<0.01	0.576	<0.01	-0.014	0.671	-0.285	<0.01	-0.118	<0.01	0.257	<0.01
ξ		-0.115	<0.01	-0.207	<0.01	-0.060	0.065	-0.065	0.045	0.009	0.787	-0.062	0.057
w		-0.018	0.591	0.071	0.029	-0.041	0.210	-0.038	0.239	0.000	0.991	-0.005	0.874
v		-0.119	<0.01	-0.200	<0.01	-0.102	<0.01	-0.078	0.017	-0.012	0.710	0.001	0.979
β_{TB}		0.240	<0.01	0.525	<0.01	-0.138	<0.01	-0.280	<0.01	-0.073	0.024	0.117	<0.01
β_{HIV}		0.206	<0.01	0.286	<0.01	0.131	<0.01	0.013	0.700	-0.332	<0.01	0.445	<0.01
μ	<i>HIV-</i>	0.023	0.482	-0.039	0.227	-0.012	0.711	0.050	0.123	0.033	0.305	-0.023	0.481
	<i>HIV+ or ART CD4 >350</i>	-0.078	0.017	-0.163	<0.01	-0.012	0.717	0.190	<0.01	0.428	<0.01	-0.799	<0.01
	<i>ART CD4 ≤350</i>	0.054	0.095	0.032	0.332	0.054	0.098	0.089	<0.01	0.128	<0.01	-0.795	<0.01
	<i>HIV+ CD4 ≤350</i>	-0.602	<0.01	-0.693	<0.01	-0.441	<0.01	-0.395	<0.01	-0.906	<0.01	0.020	0.532
μ_{TB}	<i>HIV-</i>	-0.092	<0.01	-0.323	<0.01	-0.050	0.126	-0.026	0.430	0.010	0.765	0.023	0.487
	<i>HIV+</i>	-0.146	<0.01	-0.132	<0.01	-0.116	<0.01	-0.094	<0.01	-0.008	0.801	-0.046	0.158
	<i>ART</i>	0.139	<0.01	-0.146	<0.01	0.286	<0.01	0.529	<0.01	-0.006	0.862	0.007	0.822
δ		-0.432	<0.01	-0.548	<0.01	0.205	<0.01	0.299	<0.01	0.203	<0.01	-0.189	<0.01
η		-0.019	0.567	-0.023	0.474	-0.063	0.054	-0.049	0.136	-0.239	<0.01	-0.105	<0.01
vl		0.285	<0.01	0.363	<0.01	0.173	<0.01	0.123	<0.01	0.828	<0.01	0.443	<0.01
α		-0.241	<0.01	-0.263	<0.01	-0.085	<0.01	-0.016	0.620	0.344	<0.01	-0.433	<0.01
g		0.220	<0.01	0.453	<0.01	-0.001	0.969	-0.154	<0.01	0.036	0.269	0.253	<0.01
<i>treat</i>		0.490	<0.01	0.467	<0.01	0.492	<0.01	0.420	<0.01	0.004	0.905	0.056	0.088

S4 Table. Modeled Disease States.

<i>Disease State</i>	<i>Description</i>
<i>TB</i>	
<i>S</i>	Susceptible
<i>P_S</i>	Susceptible receiving IPT
<i>L</i>	Latent infection, slow
<i>E</i>	Latent infection, fast
<i>P_L</i>	Latent infection receiving IPT
<i>A</i>	Active infection
<i>T</i>	Active infection on effective TB treatment
<i>F</i>	Active infection in ineffective TB treatment
<i>D</i>	Active infection detected and awaiting culture/DST results
<i>R</i>	Recovered
<i>P_R</i>	Recovered receiving IPT
<i>HIV</i>	
<i>S</i>	Susceptible
<i>I</i>	Infected, CD4+ cell count > 350 cells/ml
<i>E</i>	Infected, CD4+ cell count ≤ 350 cells/ml
<i>I_{ART}</i>	Infected and on ART at CD4+ cell count > 350 cells/ml
<i>E_{ART}</i>	Infected and on ART at CD4+ cell count ≤ 350 cells/ml