SUPPLEMENTAL DIGITAL CONTENT

APPPENDIX: Technical model description

The model consists of a set of deterministic ordinary differential equations. It includes 7 behavioural subpopulations, with gender denoted by subscript *i* (female=1 and male=2), and sexual activity risk group denoted by the subscript *j*: low-volume or occasional female sex workers (OSW) (*j*=1), male clients and high-volume or full-time female sex workers (FTSW) (*j*=2), medium-risk engaging in casual sexual partnerships (j=3) or low-risk engaging only in long-term, main, sexual partnerships (j=4) (*Figure S1*). Individuals enter the sexually active population in a specified subgroup based on a fixed proportional size of each risk group (Z_{ij}). Sex worker subgroups are defined on the basis of mean yearly number of clients,[1] and women don't move between those subgroups. The client population size was determined by the ratio of clients to FSWs (F). A total population growth parameter (α) was calibrated at a rate of 0.06 per year based on population growth estimates in Bobo-Dioulasso between 1985 and 2006 (*Table S1*).

Individuals enter the sexually active population in a specified subgroup based on a fixed proportional size of each risk group, with population growth calibrated to census data (*Table S1*). All individuals leave the model due to non-HIV related mortality at a rate (τ_i) based on life expectancy at age 15. Deaths are replaced into each subgroup as susceptibles at a yearly rate Ω_i equal to the total leaving rate due to non-HIV related causes; deaths occurring due to AIDS were not replaced. Sex workers and clients leave high-risk behaviour as they cease sex work or buying sex (σ_{ij}), and enter the medium and low-risk populations, with the proportion going to each group based on the relative size of each group. They are replaced by an equal number from the sexually active non-commercial risk-groups across all infection compartments proportionally, to maintain a constant proportion of individuals in each risk group (Equation 1). The year of introduction of HIV was varied between 1975 and 1980 on the basis of the first HIV case reports in Burkina Faso occurring in 1986.[2,3]

Compartments and movements between them were based on gender, behavioural subgroup, and HIV and ART status, and were solved numerically in R (version 3.0.0) using a Runge-Kutta 4 algorithm (time-step=0.05 years).

The model structure is shown in *Supplementary fig.* 2 and is replicated for each sexual risk group *ij*. The model compartments are divided into the susceptible population (x_{ij}), those that are acutely infected and are in the initial high viraemia phase of infection (h_{ij}), those that have progressed to the latent phase of infection and have a CD4 count above 350 cells/μl (y_{ij}), below 350 and above 200 cells/μl (yb_{ij}), and below 200 cells/μl (yc_{ij}), and then below 200 cells/μl with high viraemia but without clinical manifestations of AIDS (yd_{ij}), and finally those that have clinical AIDS (a_{ij}). The total population in each sub-group is represented by N_{ij}.

Susceptibles that become infected are initially in the high viraemia phase of infection, for an average duration $1/\delta$. They then progress to the latent or chronic phases of infection with duration $1/\eta$ for the period when the CD4 count is greater than 350 cells/μl, duration $1/\gamma$ for the period when the CD4 count is below 350 cells/μl, duration $1/\iota$ for the period when the CD4 count is below 200 cells/μl, and duration $1/\pi$ with higher plasma viraemia but no clinical AIDS. Individuals then progress into clinical AIDS after which they die at a per capita rate Δ. All risk groups are assumed to progress through each period at the same rates.

Susceptible subpopulations are infected at a per capita rate (force of infection or λ_{ij}) which is determined by the number of main (c_r), commercial (c_{com}) and casual sexual partners (c_{ca}) per year, the number of yearly sex acts with main partners (*r*), the proportion that are in the acute (h_{ij}), chronic or latent ($y_{ij,}$ yb_{ij}, and yc_{ij}), or high viremic pre-AIDS (yd_{ij}) phase of infection, and the probability of HIV transmission per sexual act (β_{ij}).

Rates of sexual contacts were adjusted for low-risk partnerships to include periods of sexual inactivity. Individuals with clinical AIDS are assumed to cease sexually activity. Casual and commercial sexual partnerships are assumed to only involve one sex act per partnership. The factor difference (F) between the number of FSWs and clients was estimated as a range using the proportion of males paying for sex in the past 12 months over several surveys, to give a lower bound. The upper bound was estimated by dividing the mean frequency of clients per month reported by FTSW by the frequency that clients reported seeing FSWs. The number of commercial sexual partnerships for clients for each parameter set was then calculated by the number of commercial sexual partnerships reported by FTSW and OSW divided by the client factor multiplied by the number of FSWs in that parameter set. The number of female casual partnerships and main sex acts were calculated on the basis of male report and the size of the risk group so that the total number of contacts between males and females in the same risk group is balanced. The ratio of FTSW to OSW was based on the proportions observed after exhaustive recruitment efforts of FSW in Bobo-Dioulasso, and was also allowed to vary in the uncertainty analysis.

The force of infection is further determined by the proportion of sex acts in which a condom was used (Ψ), condom efficacy against heterosexual HIV transmission (κ), the proportion of males who are circumcised (ω), and the efficacy of male circumcision in reducing female-to-male sexual transmission (Ξ). Γ and Λ are the cofactor increases in the probability of HIV transmission during the acute phase and during the pre-AIDS phase of HIV, respectively. Γ was varied in the uncertainty analysis (range 4.5-26).[4]

ART was introduced into the model allowing recruitment ($cart_k$) at all stages aside from during acute infection. Yearly recruitment rates onto ART included those in the latent phase with a CD4 >350 cells/μl (k=1), those with a CD4 count≤350 cells/μL (k=2) or ≤200 cells/μL regardless of plasma viraemia (k=3) or clinical AIDS (k=4). There are five ART compartments depending on the HIV stage during which they were recruited: during the chronic but high CD4 count phase (Ay), during the period with a CD4 count ≤350 and >200 cells/μl (Ayb), during the latent period with a CD4 count ≤ 200 cells/μl (Ayc), during the asymptomatic period with a CD4 count ≤200 cells/μl and an increased HIV viral load (Ayd), and during the clinical AIDS period (Aa). ART recruitment rates are assumed to be independent of risk-group, based on data on CD4 counts at treatment initiation for FSW in Bobo-Dioulasso (median:147 cells/μl, IQR:79-183) which is comparable to data from the general population (range: 128-172 cells/μl).[5-7] HIV infected individuals at each of these stages leave the model due to non-HIV-related death (τ_i), but have an extended survival duration before dying from AIDS, with the progression rate between each HIV stage being reduced by cofactor Ҡ (*Supplementary fig.* 2). Φ is the relative HIV transmission probability while on ART compared to the latent phase probability.

Equations:

The model is defined by the following differential equations:

$$\frac{dx_{i,j=1,2}}{dt} = Z_{ij}N_i\alpha + \Omega_{ij} - x_{ij}\left(\lambda_{sex} + \tau_i + \sigma_{ij}\right) + \sigma_{ij}n_{ij}\left[\frac{x_{i,3} + x_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dx_{i,j=3,4}}{dt} = Z_{ij}N_i\alpha + \Omega_{ij} - x_{ij}\left(\lambda_{sex} + \tau_i\right) + \frac{n_{ij}}{n_{i,3} + n_{i,4}}\left[\sigma_{i,1}x_{i,1} + \sigma_{i,2}x_{i,2}\right] - \left(\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4}\right)\left[\frac{x_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dh_{i,j=1,2}}{dt} = x_{ij}\left(\lambda_{sex}\right) - h_{ij}\left(\delta + \tau_i + \sigma_{ij}\right) + \sigma_{ij}n_{ij}\left[\frac{h_{i,3} + h_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dh_{i,j=3,4}}{dt} = x_{ij}\left(\lambda_{sex}\right) - h_{ij}\left(\delta + \tau_i\right) + \frac{n_{ij}}{n_{i,3} + n_{i,4}}\left[\sigma_{i,1}h_{i,1} + \sigma_{i,2}h_{i,2}\right] - \left(\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4}\right)\left[\frac{h_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dy_{i,j=1,2}}{dt} = \delta h_{ij} - y_{ij}\left(\eta + \tau_i + \sigma_{ij} + c_{art1}\right) + \sigma_{ij}n_{ij}\left[\frac{y_{i,3} + y_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dy_{i,j=3,4}}{dt} = \delta h_{ij} - y_{ij}\left(\eta + \tau_i + c_{art1}\right) + \zeta \mathrm{Ay}_{\mathrm{ij}} + \frac{n_{ij}}{n_{i,3} + n_{i,4}}\left[\sigma_{i,1}y_{i,1} + \sigma_{i,2}y_{i,2}\right] - \left(\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4}\right)\left[\frac{y_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dyb_{i,j=1,2}}{dt} = \eta y_{ij} - yb_{ij}\left(\gamma + \tau_i + \sigma_{ij} + c_{art2}\right) + \zeta \mathrm{Ayb}_{\mathrm{ij}} + \sigma_{ij}n_{ij}\left[\frac{yb_{i,3} + yb_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dyb_{i,j=3,4}}{dt} = \eta y_{ij} - yb_{ij}\left(\gamma + \tau_i + c_{art2}\right) + \zeta \mathrm{Ayb}_{\mathrm{ij}} + \frac{n_{ij}}{n_{i,3} + n_{i,4}}\left[\sigma_{i,1}yb_{i,1} + \sigma_{i,2}yb_{i,2}\right] - \left(\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4}\right)\left[\frac{yb_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dyc_{i,j=1,2}}{dt} = \gamma \mathrm{yb}_{\mathrm{ij}} - yc_{ij}\left(\iota + \tau_i + \sigma_{ij} + c_{art3}\right) + \zeta \mathrm{Ayc}_{\mathrm{ij}} + \sigma_{ij}n_{ij}\left[\frac{yc_{i,3} + yc_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dyc_{i,j=3,4}}{dt} = \gamma \mathrm{yb}_{\mathrm{ij}} - yc_{ij}\left(\iota + \tau_i + c_{art3}\right) + \zeta \mathrm{Ayc}_{\mathrm{ij}} + \frac{n_{ij}}{n_{i,3} + n_{i,4}}\left[\sigma_{i,1}yc_{i,1} + \sigma_{i,2}yc_{i,2}\right] - \left(\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4}\right)\left[\frac{yc_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dyd_{i,j=1,2}}{dt} = \iota \mathrm{yc}_{\mathrm{ij}} - yd_{ij}\left(\pi + \tau_i + \sigma_{ij} + c_{art3}\right) + \zeta \mathrm{Ayd}_{\mathrm{ij}} + \sigma_{ij}n_{ij}\left[\frac{yd_{i,3} + yd_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dyd_{i,j=3,4}}{dt} = \iota \mathrm{yc}_{\mathrm{ij}} - yd_{ij}\left(\pi + \tau_i + c_{art3}\right) + \zeta \mathrm{Ayd}_{\mathrm{ij}} + \frac{n_{ij}}{n_{i,3} + n_{i,4}}\left[\sigma_{i,1}yd_{i,1} + \sigma_{i,2}yd_{i,2}\right] - \left(\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4}\right)\left[\frac{yd_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{da_{i,j=1,2}}{dt} = \pi \mathrm{yd}_{\mathrm{ij}} - a_{ij}\left(\Delta + \tau_i + \sigma_{ij} + c_{art4}\right) + \zeta \mathrm{Aa}_{\mathrm{ij}} + \sigma_{ij}n_{ij}\left[\frac{a_{i,3} + a_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{da_{i,j=3,4}}{dt} = \pi \mathrm{yd}_{\mathrm{ij}} - a_{ij}\left(\Delta + \tau_i + c_{art4}\right) + \zeta \mathrm{Aa}_{\mathrm{ij}} + \frac{n_{ij}}{n_{i,3} + n_{i,4}}\left[\sigma_{i,1}a_{i,1} + \sigma_{i,2}a_{i,2}\right] - \left(\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4}\right)\left[\frac{a_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAy_{i,j=1,2}}{dt} = c_{art1}y_{ij} - Ay_{ij}(\zeta + \tau_i + \sigma_{ij} + \text{Ꝃ}\eta) + \sigma_{ij}n_{ij}\left[\frac{Ay_{i,3} + Ay_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAy_{i,j=3,4}}{dt} = c_{art1}y_{ij} - Ay_{ij}(\zeta + \tau_i + \text{Ꝃ}\eta) + \frac{n_{ij}}{n_{i,3} + n_{i,4}}[\sigma_{i,1}Ay_{i,1} + \sigma_{i,2}Ay_{i,2}] - (\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4})\left[\frac{Ay_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAyb_{i,j=1,2}}{dt} = c_{art2}yb_{ij} + \text{Ꝃ}\eta Ay_{ij} - Ayb_{ij}(\zeta + \tau_i + \sigma_{ij} + \text{Ꝃ}\gamma) + \sigma_{ij}n_{ij}\left[\frac{Ayb_{i,3} + Ayb_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAyb_{i,j=3,4}}{dt} = c_{art2}yb_{ij} + \text{Ꝃ}\eta Ay_{ij} - Ayb_{ij}(\zeta + \tau_i + \text{Ꝃ}\gamma) + \frac{n_{ij}}{n_{i,3} + n_{i,4}}[\sigma_{i,1}Ayb_{i,1} + \sigma_{i,2}Ayb_{i,2}] - (\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4})\left[\frac{Ayb_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAyc_{i,j=1,2}}{dt} = c_{art3}yc_{ij} + \text{Ꝃ}\gamma Ayb_{ij} - Ayc_{ij}(\zeta + \tau_i + \sigma_{ij} + \text{Ꝃ}\iota) + \sigma_{ij}n_{ij}\left[\frac{Ayc_{i,3} + Ayc_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAyc_{i,j=3,4}}{dt} = c_{art3}yc_{ij} + \text{Ꝃ}\gamma Ayb_{ij} - Ayc_{ij}(\zeta + \tau_i + \text{Ꝃ}\iota) + \frac{n_{ij}}{n_{i,3} + n_{i,4}}[\sigma_{i,1}Ayc_{i,1} + \sigma_{i,2}Ayc_{i,2}] - (\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4})\left[\frac{Ayc_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAyd_{i,j=1,2}}{dt} = c_{art3}yd_{ij} + \text{Ꝃ}\iota Ayc_{ij} - Ayd_{ij}(\zeta + \tau_i + \sigma_{ij} + \text{Ꝃ}\pi) + \sigma_{ij}n_{ij}\left[\frac{Ayd_{i,3} + Ayd_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAyd_{i,j=3,4}}{dt} = c_{art3}yd_{ij} + \text{Ꝃ}\iota Ayc_{ij} - Ayd_{ij}(\zeta + \tau_i + \text{Ꝃ}\pi) + \frac{n_{ij}}{n_{i,3} + n_{i,4}}[\sigma_{i,1}Ayd_{i,1} + \sigma_{i,2}Ayd_{i,2}] - (\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4})\left[\frac{Ayd_{ij}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAa_{i,j=1,2}}{dt} = c_{art4}a_{ij} + \text{Ꝃ}\pi Ayd_{ij} - Aa_{ij}(\zeta + \tau_i + \sigma_{ij} + \text{Ꝃ}\Delta) + \sigma_{ij}n_{ij}\left[\frac{Aa_{i,3} + Aa_{i,4}}{n_{i,3} + n_{i,4}}\right]$$

$$\frac{dAa_{i,j=3,4}}{dt} = c_{art4}a_{ij} + \text{Ꝃ}\pi Ayd_{ij} - Aa_{ij}(\zeta + \tau_i + \text{Ꝃ}\Delta) + \frac{n_{ij}}{n_{i,3} + n_{i,4}}[\sigma_{i,1}Aa_{i,1} + \sigma_{i,2}Aa_{i,2}] - (\sigma_{i,3}n_{i,3} + \sigma_{i,4}n_{i,4})\left[\frac{Aa_{ij}}{n_{i,3} + n_{i,4}}\right]$$

(Equation 1)

Z_{ij}= Proportion of people entering sexually active population who enter each risk group

N_i= Total population by gender at baseline

α=Population growth factor

Ω_{ij}=Sum of deaths due to non-HIV mortality

τ_i=Non-HIV mortality rate by gender

σ_{ij}=Rate of leaving high risk groups (σ=0 for LR and MR groups)

n_{ij}=Total number of individuals in gender and risk sub-group i,j at each time step

The force of infection for HIV is dependent on gender and risk sub-group. It is 1 minus the probability of not getting infected per unit time. This is calculated as the product of the probability of not being infected by any partnership with any individual in each subgroup:

$$\lambda_{ij} = 1- \Pi_{\text{over all } l\leq 4} (1-\varphi 0_{ijkl})^{d0ij\ b0ijkl} (1-\varphi 1_{ijkl})^{d1ij\ b1ijkl} (1-\varphi 2_{ijkl})^{d2ij\ b2ijkl}$$

(Equation 2)

The functions $\varphi 0_{ij}$, $\varphi 1_{ij}$, and $\varphi 2_{ij}$ are the probabilities that a susceptible individual becomes infected with HIV per unit time from a main, casual or commercial partnership with an individual in group kl where l=1 if j=0 and l=0 if j=1. The symbols $d0_{ij}$, $d1_{ij}$ and $d2_{ij}$ represent the total number of main, casual and commercial partners per year by an individual in gender and risk sub-group ij, with $d0_{ij}$ being non-zero for $j\leq 4$, $d1_{ij}$ being non-zero for $j\leq 3$ and $d2_{ij}$ being non-zero for $j\leq 2$. The symbols $b0_{ijkl}$, $b1_{ijkl}$, and $b2_{ijkl}$ represent the probabilities that individuals within each subgroup ij form main, casual or commercial sexual partnerships with individuals from each other subgroup kl and has the following form (repeated for each type of partnership, and each subgroup involved):

$$b0_{ijkl} = d0_{kl}N_{kl}/ \textstyle\sum_{all\ o} d0_{ko}\, N_{ko} \quad \text{for all } j\leq 4$$

$$b1_{ijkl} = d1_{kl}N_{kl}/ \textstyle\sum_{all\ o\leq 3} d1_{ko}\, N_{ko} \quad \text{if } j\leq 3\text{, and zero if } j=4$$

$$b2_{ijkl} = d2_{kl}N_{kl}/ \textstyle\sum_{all\ o\leq 2} d2_{ko}\, N_{ko} \quad \text{if } j\leq 2\text{, and zero if } j=3 \text{ or } 4$$

(Equation 3)

The probability of an individual becoming infected per partnership per unit time (defined as φ_{ij} above) was then calculated using the weighted prevalence of HIV (I_{ij}, see below) in each subgroup at each time step, with the number in ART multiplied by the efficacy of ART for reducing HIV transmission (Φ), and the number in the HIV acute or pre-AIDS high viraemia phases multiplied by the cofactors for how much they increase HIV transmission ($\Gamma$and Λ, respectively):

$$I_{ij}= [((\Gamma h_{ij} + y_{ij}+ yb_{ij} +yc_{ij} +yd_{ij} + \Lambda yd_{ij}) + \Phi\ (Ay_{ij} + Ayb_{ij} + Ayc_{ij} + Ayd_{ij} + Aa_{ij}))]/ N_{ij}$$

(Equation 4)

This weighted prevalence is multiplied by the probability of transmission of HIV to the susceptible from the infected partner, where β_{ij} is the per sex act HIV transmission probability for different genders and sexual partnership types, and ƫ representing the number of sex acts per partnership:

$$\varphi_{ij} =I_{ij}\ (1-[1-\beta_{ij}(1- \Psi \text{ʒ})\ (1- \omega\Xi)]^{\text{ƫ}})$$

(Equation 5)

where Ψ is the consistency of condom use, $ʒ$ is the efficacy of condoms for reducing the risk of heterosexual HIV transmission, ω is the proportion of males who are circumcised, and Ξ is the efficacy of male circumcision in reducing female-to-male sexual transmission.

MODEL PARAMETER DERIVATION

Estimates of yearly condom use increases

Estimates for the consistency of condom use during the last commercial sex act were derived from self-reported survey data from FSW and their clients.[1,6,8,9] Projections of condom use for years in which data was not available were calculated by fitting linear slopes to available estimates. The slopes were derived in two stages, before and after 1993, as condom use was assumed to be almost negligible during the 1980s and early 1990s, until the national condom social marketing program began in 1991;[10] the average number of condoms per person per year available in Burkina Faso was 0.6 in 1992, and less than 5% of women reported condom use with their last partner in the 1993 DHS survey.[3] Reported usage rates rapidly increased in conjunction with availability.[1,8,11] A range for rates of increase in condom use were derived by applying a linear slope to estimates over time (*Supplementary fig*. 3). The calculated range was then used in the uncertainty analysis, with a maximum rate per sex act of 95% after 2010. Data of self-reported use from FSW were allowed to be an overestimate and a bias factor was included allowing for 60-100% accuracy in reporting, based on differences in rates reported by clients from that reported by FSWs; this bias factor was varied in the uncertainty analysis.[12] Condom use for OSW was assumed to be 75% that of FTSW on the basis of a local survey.[1]

Estimates of condom use for casual sex were derived in the same manner from population survey data (Table 1 and *Table S1*), and included a separate bias factor. Condom use for main partnerships was constant and low over time based on population surveys showing little increase over time (table 1), but was allowed to vary in the uncertainty analysis. The model predicted condom use at last sex act as 87.1% (95% CI: 82.5-95.0) in commercial partnerships, 35.4% (95% CI: 29.0-43.5) in casual partnerships, and 4.5% (95% CI: 3.5-5.5) in main partnerships by 2010.

HIV transmission probabilities

The transmission probability was allowed to vary according to risk-group and direction of transmission (*Tables S1 and S3*), based on a meta-analysis that calculated that the transmission probability is likely to be higher during commercial sexual contact.[13] The higher range allowed during high-risk exposures also allows for the potential for a cofactor increase in infectivity attributable to sexually transmitted infections.

Estimates of the impact of ART on transmission based on genital shedding data

The risk of transmission of HIV-1 has been shown to be independently correlated with the endo-cervical concentration of HIV-1 RNA in an observational study embedded in a trial of acyclovir to reduce HIV transmission (Partners in Prevention), where there was a 2.20 (95% CI: 1.60-3.04) fold increase in HIV-1 transmission risk for each $\log_{10}$ increase in cervico-vaginal HIV-1 RNA concentration.[14] We used data from a longitudinal analysis of HIV-1 RNA levels in enriched cervico-vaginal lavages (eCVLs) obtained from 188 HIV-1-seropositive FSWs on ART over 8 years in the Yerelon cohort, which demonstrated high rates of shedding while having fully suppressed HIV-1 RNA in the plasma.[15] We estimated the potential impact of ART on HIV-1 transmission by comparing individual-level HIV-1 RNA quantities pre and post initiation of ART in eCVL (*Supplementary fig*.4).

This was done using 2 methods: 1) by calculating the per woman decrease in the mean $\log_{10}$ quantity of eCVL HIV-1 RNA after initiating ART restricted to samples that had detectable eCVL, and the reduction in the proportion of visits positive for detectable eCVL HIV-1 RNA, and then applying these to the data from PiP; or 2) by estimating the rate of transmission per woman before initiating ART by extrapolating a rate from the relationship between endo-cervical RNA concentration and transmission seen in PiP and the mean quantity pre-ART, and then estimating the rate of transmission on ART on the basis of the mean quantity post-ART. For those visits with an undetectable eCVL HIV-1 RNA ($<2.48\log_{10}$ copies/ml), we assumed a low potential rate of transmission (0.6/100 person-years) if the plasma viral load was detectable, and a rate of transmission of zero if not. A simple ratio of pre to post-ART was then calculated for each woman, to give a reduction in rate. These methods produced 1) an 88.8% estimated reduction, and 2) 57.5% estimated reduction. This informed the use of 90% in our original model, and of 58% in the sensitivity analysis.

POSTERIOR RANGES OF MODEL PARAMETERS

Although the vast majority of parameter sets were rejected during the fitting stage, most posterior ranges were similar to their prior distribution (*Table* S3). The number of yearly clients for FTSW was skewed towards the lower bound (prior 312-2500; posterior median 636 and range 315-1421) and towards the upper bound for OSW (prior 24-104; posterior median 82 and range 39-103). The per sex act HIV transmission probability during chronic HIV was substantially higher for male-to-female (β_1, prior 0.001-0.02, posterior median 0.011 and range 0.005-0.02) vs. female-to-male transmission (β2, prior 0.001-0.02, posterior median 0.003 and range 0.002-0.01) during commercial sex work, which were both higher than transmission ($\beta_{3,4}$ priors 0.0001-0.01, posterior median 0.001, ranges 0.0001-0.009, and 0.0001-0.004, respectively) in the general population.

Correlation between parameters in model fits

Of the model parameter fits, few had parameter correlation coefficients above 0.50. The number of clients per year for FTSW was negatively correlated with the FTM transmission probability for high-risk partnerships (β_2; r=-0.64), whereas the number of sex acts with FSW per year for clients was negatively correlated with MTF transmission probability for high-risk partnerships (β_1; r=-0.56). The number of sex acts per main partnership was negatively correlated with MTF transmission in low-risk partnerships (β_3; r=-0.51). The proportion of FSW with main partnerships was correlated with the male to female transmission probability for low-risk partnerships (β_3; r=0.58), and negatively with the number of sex acts per main partnership (r=-0.54). These relationships reflect that if there are more sex acts with high-risk or with main partners, infectivity cannot be too high or prevalence would be higher than the upper 95% confidence intervals. The rate of increase in condom use from 1993 to 2010 for commercial partnerships (r= -0.52) and casual partnerships (r= -0.53) were negatively correlated with the rate of leaving being a client, likely because a longer duration of high-risk behaviour is balanced by higher condom use.

In *Supplementary fig.* 8, the correlation of the %HIA over 20 years for scenarios targeting all FSW with various parameters is described. In settings of 90% commercial condom use, the FA is most highly negatively correlated with infectivity during low risk partnerships (β_{3-} r=-0.54, β_4 r=-0.55). In the setting of lower commercial condom use (70%), the FA is highly negatively correlated with infectivity during acute infection (r=-0.72), as ART is only introduced into the model during chronic infection. It is positively correlated with the size of the sex worker population (r=0.54).

Table S1. Model input parameters, including prior input ranges sampled at the fitting stage

Model parameter	Value or range used		Data source
Demographic model parameters	Female	Male	
Initial size of sexually active population	63,968	54,230	[16]
Population growth parameter (**α**) per year	0.06		Calibrated to observed growth rate[3,17,18]
Life expectancy at age 15 in Burkina Faso (**1/τ**) (yrs)	52.7	45.4	[19,20]
Behavioural model parameters			
Percentage of population FSW or clients	2.0% (1.0-3.0%) =NSW	5-39% =NSW*F	From [17,21] and from a mapping exercise of FSW in 2010. Derived estimate for clients
Ratio of clients to FSWs (F)	5-13		Range derived from surveys [17,22,23]
Percentage of FSW who have lower numbers of yearly clients	75% (65-80)		[1,11]
Percentage of FSWs/clients who had a main sexual partner (married or cohabitating)	16% (14-22)	29% (26-32)	[1,11]
Percentage of FSWs/clients who had casual partners in past year	15- 25%	30% (25-31)	[11]
Percentage of general population currently having casual sex	1.0-8.3%	5.5-18.1%	[3,17,22]
Percentage of general population who are in a polygamous main partnership (marriage)	36%	25%	[3] Used to calculate frequency of main partners per year
Average frequency of main partners per year amongst low-risk individuals (c_r)	1.0	1.05	Supplementary material
Average number of yearly sex acts with main partner (*r*)	20-61	48 (24-72)	[3], Number of female sex acts calculated from male reports
Frequency of casual partners per year amongst medium and high-risk groups (c_{ca})	2-93	2-7	[11] Little data on the number of casual partners of FSW or females, therefore calculated from male reports
Average duration of sex work or buying sex in years (**1/σ**)			Derived as a range using [6,8,9,11]
OSW	5-10		
FTSW	3-6		
Clients		4-8	

Average number of clients per year		Derived as a range from [6]
OSW (c_{11})	24-104	
FTSW (c_{12})	312-2500	
Condom use parameters (Ψ)		
Proportion of FSW reporting using condoms during last sex act with clients in Bobo-Dioulasso		
1980	0	Estimated due to <5% of women reporting condom use in 1992[3]
1993	65-80%	Derived from [8,12,24]
Yearly rate of increase in condom use with last commercial partner 1980-1993	0-1%	Calculated using data points from [3,6,11,17,23] Supplementary material
Yearly rate of increase in condom use with last commercial partner 1993-2010	0-1.6%	
Reported condom use bias factor for clients and FSWs, and for casual sexual partnerships	0.60-1	Supplementary material
Ratio of condom use OSW:FTSW	75%	[1] OSW report less condom use with clients
Proportion of population reporting condom use during last sex act with a casual partner		Sex worker survey 2011
1980	0	Estimated due to <5% of women reporting condom use in 1992[3]
1993	5-18%	Range from surveys of general population[3]
Yearly rate of increase in condom use with last casual partner 1993-2010	1.5-2.5%	Fit using data points in [3,11,17]
Percentage of population reporting condom use with main partner (generally married/cohabitating)	0.7-9.7%	Range from surveys of general population[3,17]
Proportion of males circumcised (**ω**)	0.90	[23]
Biological model parameters		
Start of HIV epidemic in Burkina Faso	1975-1980	Estimated from the first case being reported in 1986[3]
HIV transmission probability per sex act (**β**)		
Male to Female CSW ($\boldsymbol{\beta_1}$)	0.001-0.02	[13]
Female to Male CSW ($\boldsymbol{\beta_2}$)	0.001-0.02	
Male to Female ($\boldsymbol{\beta_3}$)	0.001-0.01	
Female to Male ($\boldsymbol{\beta_4}$)	0.001-0.01	
Cofactor increase in HIV transmission probability during:		

Initial period of high viremia (**Γ**)	4.5-26	[4,25]
Pre-AIDS period of high viremia (**Λ**)	7	[4,26]
Duration of acute phase of high viremia (**1/δ**)	3-6 months	[4]
Duration of latent period to a CD4 count of 350 cells/μL (**1/η**)	4.56 years	[27]
Duration of latent period from 350 to 200 cells/μL (**1/γ**)	4.61 years	[27]
Duration of latent period with a CD4 count ≤200 cells μl with low plasma viraemia (**1/ι**)	3.45 years	Calculated from [27]
Duration of pre-AIDS period of high viremia (**1/π**)	0.75 years	[4]
Duration of Clinical AIDS period (**1/Δ**)	1 year	[27]
Reduction in female to male transmission by male circumcision (**Ξ**)	0.60	[28-30]
Reduction in transmission by male condom use (**κ**)	0.90	Chosen as an average of [31,32]

Table S2. Epidemiological data used for model fitting and data sources in Bobo-Dioulasso, Burkina Faso

Epidemiological data	HIV prevalence model inputs (range)	Source of input values
FSW		
All FSW 1990	35-60%	[33]
FTSW 1994	55-75%	[8]
OSW 1994	48-60%	[8]
All FSW 1999	30-50%	[1]
All FSW 2003	20-40%	[6]
Clients		
Truck drivers 1994	10-30%	[9]
Overall population		
Female population 2000	4-8%	[22]
Male population 2000	3-6%	[22]
Additional data not used in model fitting		
FSW		
All FSW 1987	35%	[3]
FTSW 1999	44%	[33]
OSW 1999	27%	[33]
FTSW 2003	37%	[6]
OSW 2003	24%	[6]
All FSW 2010	20%	[11]
Clients		
Clients 2000	7%	[22]
Clients 2010	4%	[11]
Overall population		
Female population-HB 2003	2%	[23]
Female population-HB 2010	2%	[34]
Male population-HB 2003	1%	[23]
Female population- HB 2010	1%	[34]

Note- HB=Hauts-Bassins region of Burkina Faso, containing Bobo-Dioulasso.

Table S3. Distribution of prior parameter ranges and posterior fits

Parameter	Prior median or range	Posterior median (range) (N=24)
HIV transmission probability per sex act (**β**)		
Male to Female CSW (**β_1**)	0.001-0.02	0.011 (0.005-0.02)
Female to Male CSW (**β_2**)	0.001-0.02	0.003 (0.002-0.01)
Male to Female (**β_3**)	0.0001-0.01	0.001 (0.0001-0.009)
Female to Male (**β_4**)	0.0001-0.01	0.001 (0.0001-0.004)
Factor increase during acute HIV infection	4.5-26	11.1 (4.6-26.0)
Duration of acute HIV (months)	3-6	3.5 (3-6)
Proportion of females who are sex workers	1-3%	1.3% (1.0-2.6%)
Proportion of sex workers who are OSW	65-80%	76% (66-80%)
Proportion of the male population who buy sex	6-30%	12.8% (6.8-26.1%)
Duration of sex work or buying sex in years (1/**σ**) (years)		
OSW	5-10	7.9 (5.6-9.8)
FTSW	3-6	3.8 (3.1-5.7)
Clients	4-8	5.4 (4.1-7.7)
Median number of clients per year		
OSW (c_{11})	24-104	85 (39-103)
FTSW (c_{12})	312-2500	589 (315-1421)
Client ratio (F)	5-13	7 (5-13)
Clients (calculated)(c_{13})	6-104	29 (17-56)
Median number of casual partners per year for		
Males	2-7	3.2 (2.1-6.7)
Females	calculated	10.5 (2.8-45.7)
Yearly sexual acts per main partnership for:		
Males	24-72	31 (24-67)
Females	20-61	24 (19-51)
Year of HIV introduction into population	1975-1980	1978 (1975-1980)
Condom parameters		
Main partnerships	0.7-9.7%	4.0% (1.0-8.9)
Casual partnerships		
Proportion of use (1993)	5-18%	9.8% (5.4-17.6%)
Rate of yearly increase (1993-2010)	0.015-0.025	1.9% (1.5-2.5%)
Bias factor	0.60-1.0	82% (62-99%)
Commercial partnerships		
Proportion of use (1993)	0.65-0.80	72.6% (66.1-78.5%)
Rate of yearly increase (1993-2010)	0.01-0.016	1.3% (1.0-1.6%)
Bias factor	0.60-1.0	95% (79-100%)

Table S4. Projected impact and efficiency of ART scenarios compared to SQ, 2014-2034 in Bobo-Dioulasso, Burkina Faso

	ART coverage in 2034 (%)		Median impact and efficiency of scenario vs. SQ (range)					
Scenario	**All HIV+**	**FSW**	**Additional PYAs (range)**	**Fraction of HIA (%)**	**HIA (range)**	**HIA per 100 PYAs**	**Life-years gained (range)**	**LYG per 100 PYAs**
SQ- CD4<350-25% recruitment	61	37						
Any CD4-FSW	67	79	1696 (-813 to 3207)	14.8 (4.3-38.2)	1089 (195 to 3604)	**64.21**	1656 (444 to 3762)	**97.64**
Any CD4-FTSW	65	54	328 (-1288 to 1035)	8.5 (2.8-32.6)	702 (118 to 2634)	**214.02**	822 (183 to 2234)	**250.61**
Any CD4-OSW	63	65	1623 (136 to 2688)	5.3 (1.6-16.0)	339 (84 to 1592)	**20.89**	852 (266 to 1685)	**52.49**
CD4<350-80% recruitment of all HIV-infected	82	59	33284 (20544 to 49701)	36.4 (22.3-38.9)	2467 (686 to 5994)	**7.41**	21461 (12900 to 34447)	**64.48**
Any CD4- 80% recruitment of all HIV-infected	92	85	45312 (28017 to 69784)	64.7 (53.6-71.1)	4615 (1082 to 10317)	**10.18**	25064 (14525 to 41006)	**55.31**
Any CD4- 25% recruitment of all HIV-infected	77	61	18908 (9071 to 33402)	30.1 (19.7-36.4)	2152 (398 to 4977)	**11.38**	5376 (2307 to 10265)	**28.43**

Note- ART=antiretroviral; SQ= status quo scenario; PYAs=additional person-years of ART compared to SQ. FSW=female sex worker, all typologies; HIA=HIV infections averted; LYG=life-years gained; SQ=status quo scenario; FTSW=full-time female sex worker; OSW= occasional female sex worker. Negative values imply less PYs of ART than SQ, meaning that it is highly efficient.

Table S5. Projected impact and efficiency of ART compared to SQ with varying assumptions 2014-2034 in Bobo-Dioulasso, Burkina Faso

	ART coverage in 2034 (%) if target FSW		ART coverage in 2034 (%) if SQ		Median impact and efficiency of scenario vs. SQ (range)					
Scenario	**All HIV+**	**FSW**	**All HIV+**	**FSW**	**Additional person years of ART (range)**	**Fraction of HIA (%) (range)**	**HIA (range)**	**HIA per 100 PYs of ART**	**Life-years gained (LYG) (range)**	**LYG per 100 PYs of ART**
80% recruitment FSW	67	79	61	37	1696 (-813 to 3207)	14.8 (4.3 to38.2)	1089 (195 to 3604)	**64.21**	1656 (444 to 3762)	**97.64**
26% reduction in transmission	57	74	52	31	6039 (1275 to 9689)	3.5 (1.0 to 9.8)	511 (111 to 1541)	**8.46**	1698 (475 to 3239)	**28.12**
58% reduction in transmission	60	76	56	33	3745 (775 to 5870)	8.4 (2.4 to 22.4)	855 (179 to 2829)	**22.83**	1727 (468 to 3581)	**46.11**
1/3rd progression on ART	65	78	59	36	1654 (-783 to 3121)	15.0 (4.4 to 38.7)	1079 (191 to 3603)	**65.24**	1646 (431 to 3877)	**99.52**
1/5th progression on ART	67	79	62	38	1720 (-834 to 3256)	14.5 (4.3 to 37.8)	1097 (199 to 3604)	**63.78**	1656 (453 to 3679)	**96.28**
13% yearly LTFU	52	72	47	29	1950 (-336 to 3565)	13.4 (3.8 to 34.9)	1132 (229 to 3778)	**58.05**	1887 (525 to 4164)	**114.36**
58% reduction in transmission FSW, 90% in others	65	78	61	36	2831 (610 to 4361)	10.0 (3.1 to 24.9)	775 (139 to 2585)	**27.38**	1529 (411 to 3281)	**54.01**
Commercial condom use plateau at 70%	60	74	53	28	2013 (-2877 to 6818)	24.0 (10.4 to 39.8)	4115 (2015 to 7118)	**204.42**	3878 (2100 to 6241)	**192.65**

Note- Values are estimates of the impact of targeting FSW with 80% yearly recruitment onto ART compared to continuing the SQ with 25% yearly recruitment of all HIV infected individuals onto ART, using the described biological or behavioural parameter in both scenarios. ART=antiretroviral; FSW=female sex worker, all typologies; FA=fraction of new HIV cases averted; HIA=HIV infections averted; LYG=life-years gained; LTFU=loss to follow-up; 90% commercial condom use unless otherwise stated.

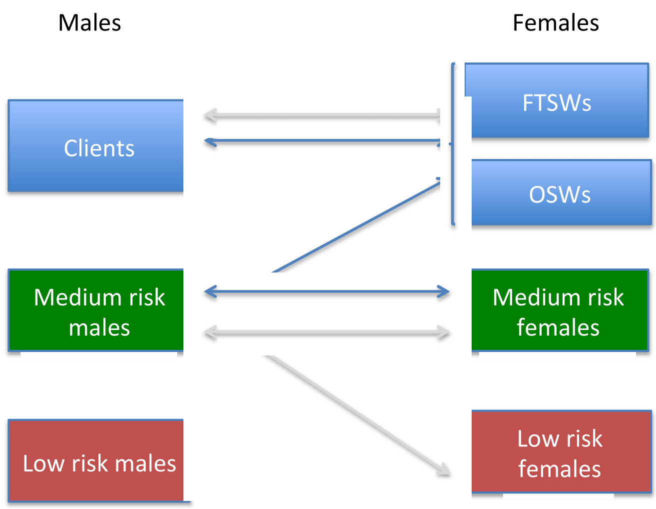

Figure S1. Model schematic showing behavioural subgroups of the model and sexual mixing. Arrows indicate sexual partnerships forming between individuals in each subgroup, with red arrows indicating commercial partnerships, blue indicating casual partnerships, and grey indicating main partnerships.

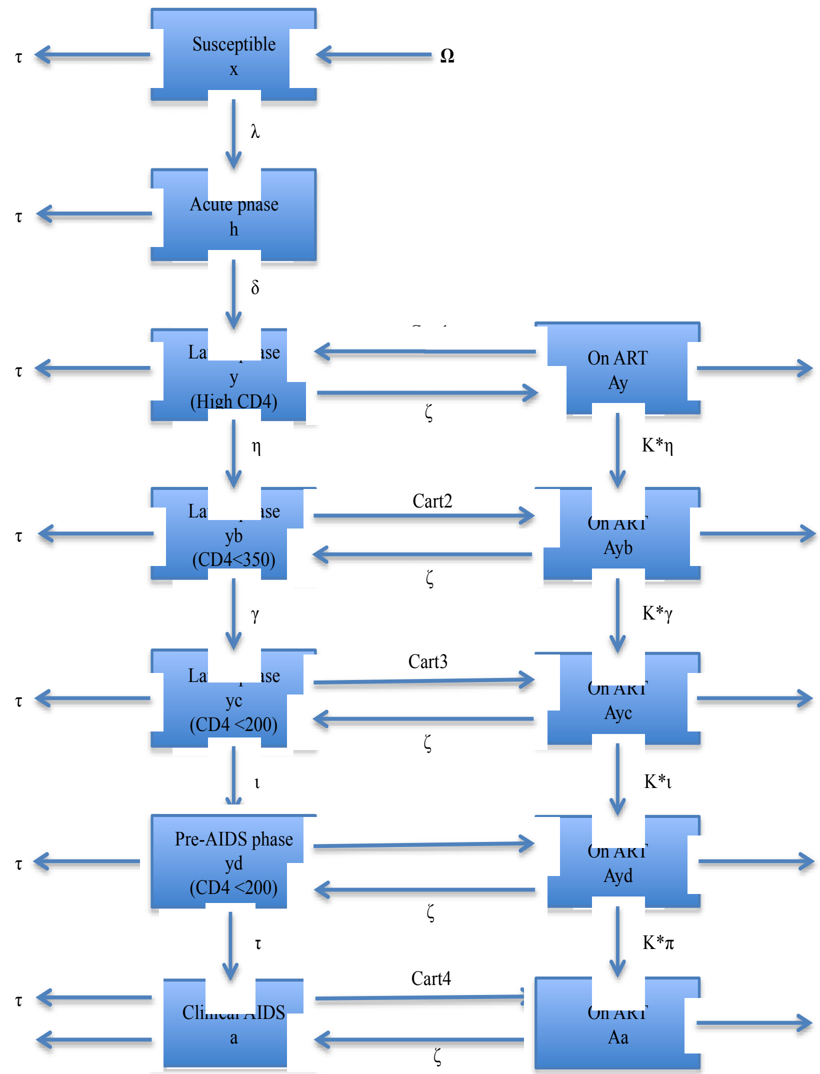

Figure S2. Flow diagram of compartments for HIV infection and recruitment onto ART. This is replicated for each risk group. λ_{ij}= force of infection, Cart1-4=yearly rates of recruitment onto ART at each stage of HIV progression, ζ=yearly rates of loss to follow-up. See supplementary table 1 for reference for other symbols.

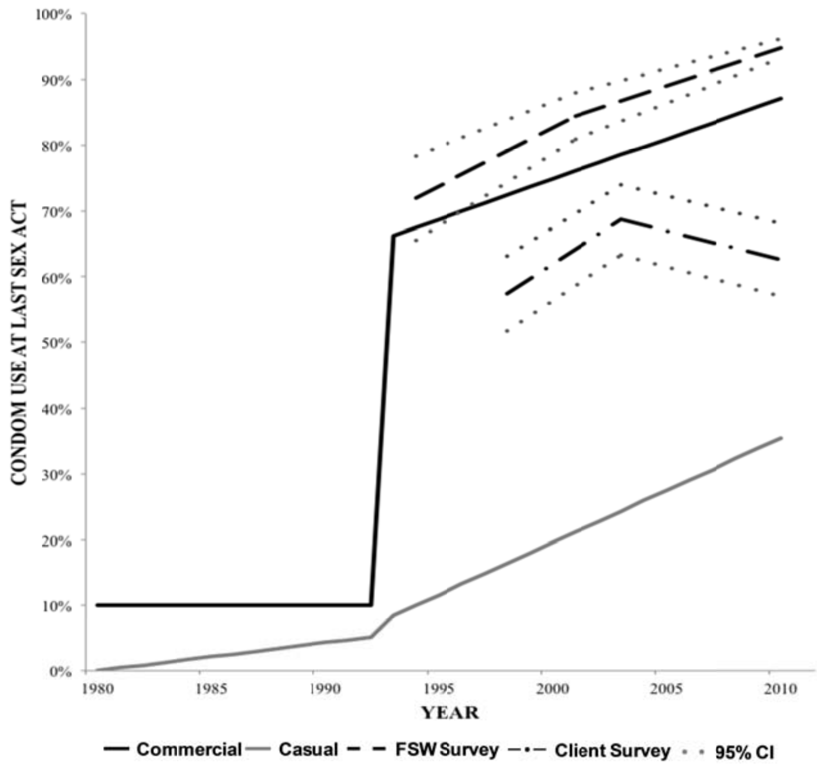

Figure S3. Model fit projections of proportion using condoms at last sex act, for casual and commercial partnerships. The long dashed lines represent the data from surveys of FSW and clients of self-reported condom use, with 95% CI indicated in short dashes. The solid lines represent the median model projections of 24 fits for commercial (black) and casual (gray) partnerships.

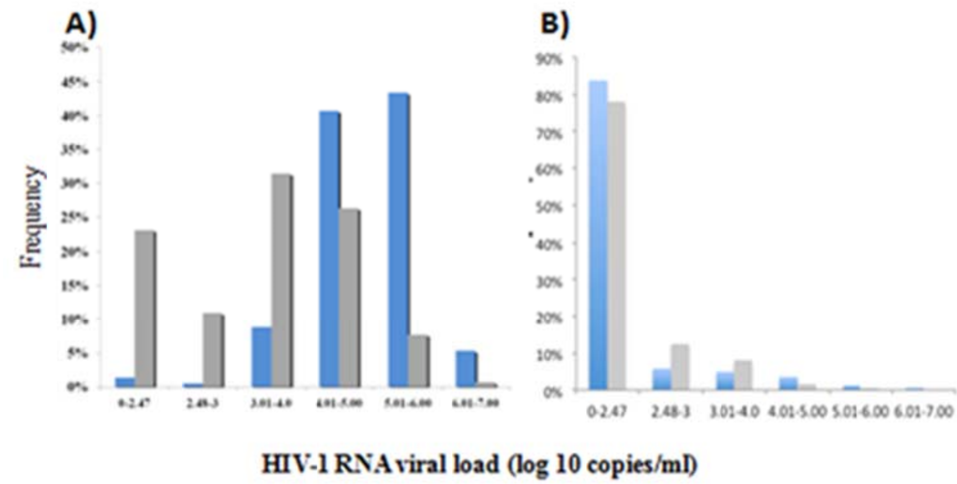

Figure S4. Distribution of plasma and genital viral load a) before and b) after ART initiation, from the Yerelon cohort in Bobo-Dioulasso. There was no evidence of an impact of duration of ART on quantity or risk of shedding. The threshold for detection of HIV-1 RNA in plasma and enriched cervico-vaginal lavage (eCVL) samples was 300 or 2.47 log_{10} copies/ml.[15] Blue lines represent plasma and grey lines represent eCVL HIV-1 RNA. Note the different values on the y-axis.

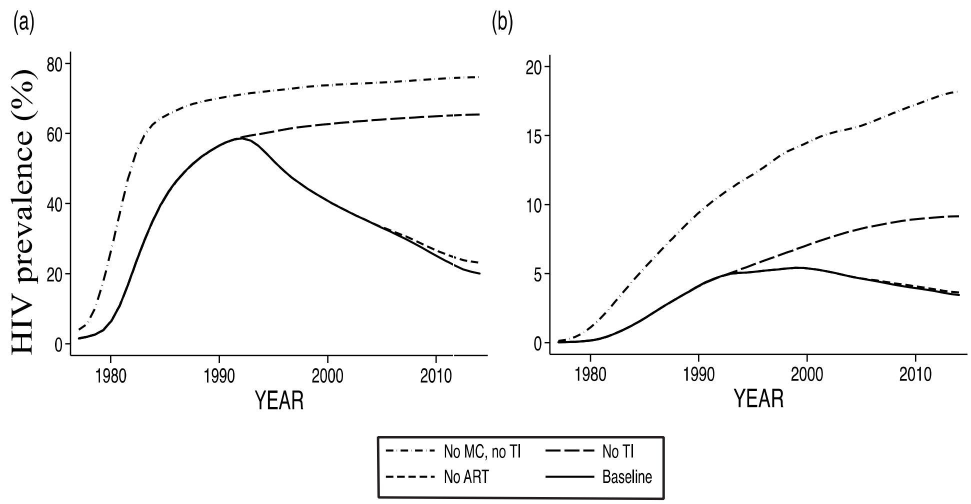

Figure S5. Projections of HIV prevalence in FSWs (a) and overall (b) from 1980-2014 in the absence of different interventions and male circumcision (MC). Baseline represents the status quo scenario of 25% recruitment per year onto ART of CD4<350 cells per µl. TI- therapeutic interventions, meaning condom promotion and ART. Note different scales on y-axis.

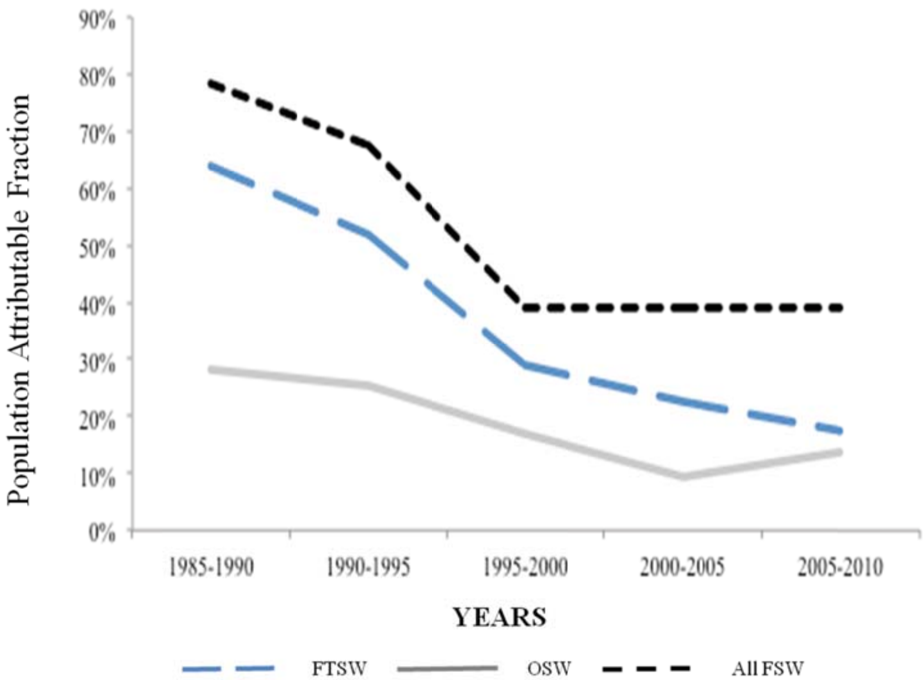

Figure S6. Population attributable fractions (PAFs) for commercial partnerships by FSW typology, over 5 year periods. The relative contribution of the 2 different FSW populations, and FSW overall, to new infections (PAF) was calculated by setting transmission rates in high-risk partnerships to 0 bi-directionally for either OSW or FTSW or both, and their clients for 5-year periods, done in separate simulations. The median number of incident cases in the total population over each set of simulations compared to the median number of new cases in the original model is shown.

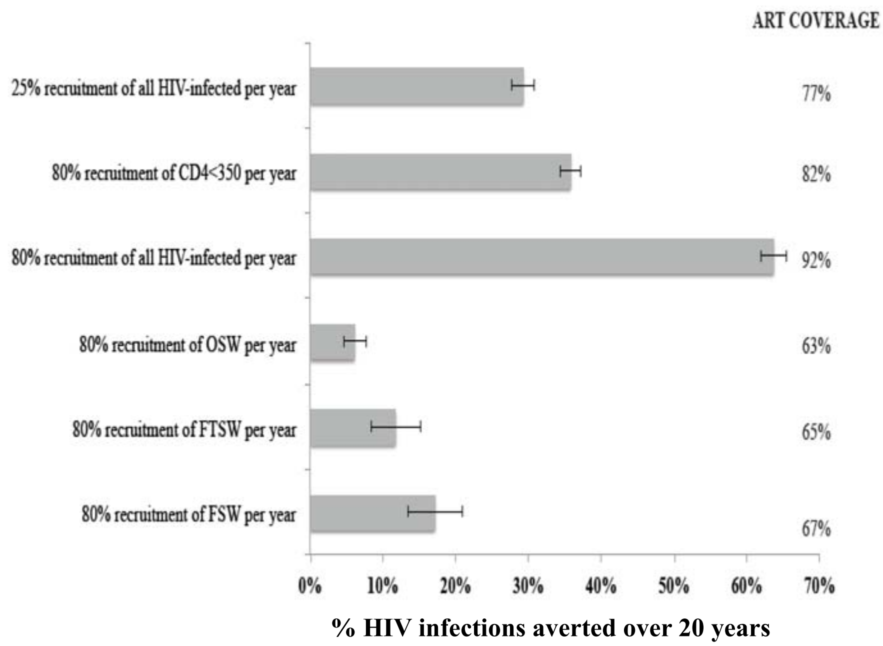

Figure S7. Impact of ART scenarios in terms of percent of new HIV infections averted from 2014 to 2034, compared to the SQ. Loss to follow-up is 6.5% per year for each scenario, and commercial condom use is 90%. Bars represent 95% CrI.

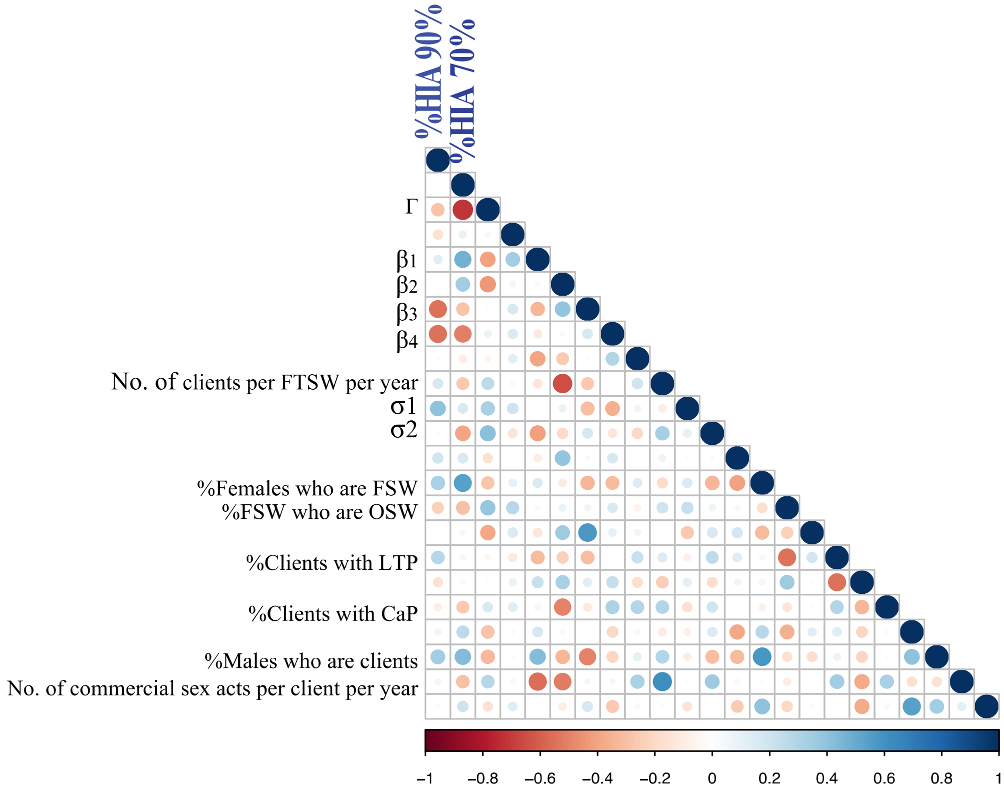

Figure S8. Correlation matrix comparing percent of HIV infections averted (%HIA) over 20 years for scenarios targeting female sex workers (FSW) and selected uncertainty parameters. The matrix lists only those parameters with moderate correlation (r>0.20 or <-0.20)) to the %HIA. %HIA 90%=percent value indicates the percent of commercial sex acts with condoms; Γ= cofactor increase in transmission during acute infection; β=transmission probability per sex act (1-male to female during commercial sex acts, 2-female to male during commercial sex acts, 3- male to female lower risk, 4- female to male lower risk); FTSW=full-time sex worker; $\sigma_{1,2,}$= 1/duration of occasional, or full-time sex work respectively; OSW=occasional sex worker; LTP= long-term or main partnerships; CaP= casual partnerships.

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