SUPPLEMENTAL FIGURES, TABLES, AND TEXTS

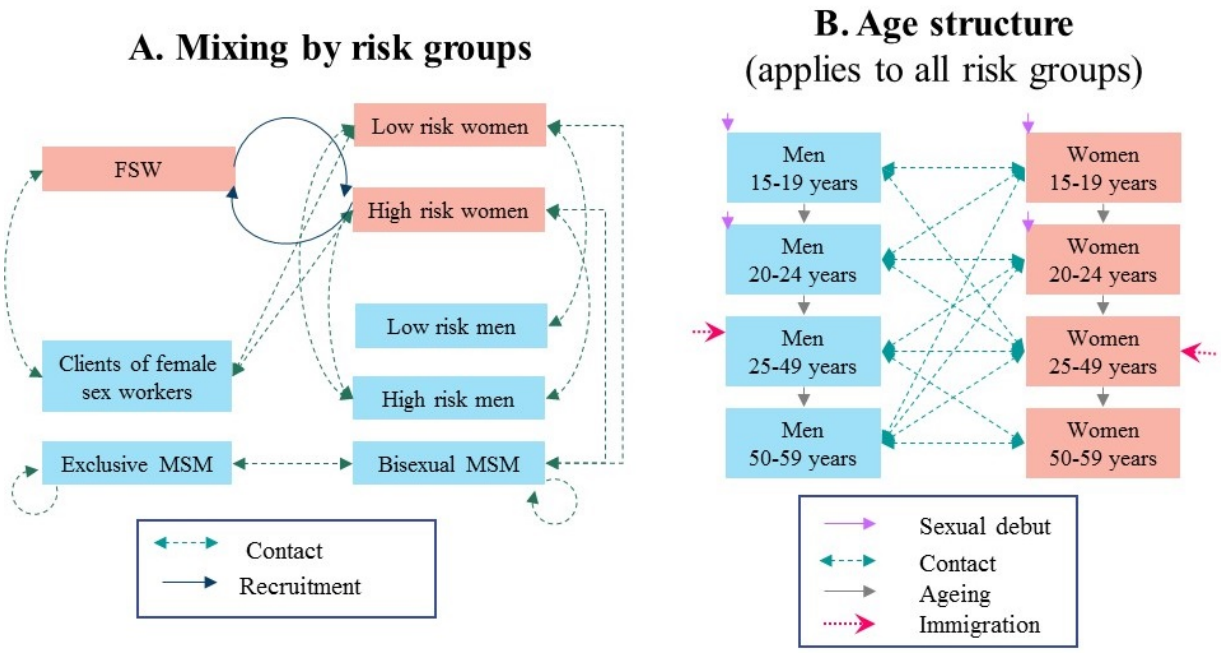

Figure S1. Representation of the different A) risk and B) age groups, as well as their contact patterns. A) Female sex workers (FSW) only have sexual contacts with their clients but can retire from sex work, in which case FSW integrate the group of high-risk women. CFSW have sexual contacts with FSW and both low- and high-risk women. Women in the low- and high-risk groups have sexual contacts with all members of the opposite sex, apart from exclusive men who have sex with men (MSM). Exclusive MSM have sexual contacts with both exclusive MSM and MSM who engage in bisexual practices. B) With regards to age, sexual debut is either at 15 or 20 years of age for both men and women. Immigration is allowed in the 25-49 year's age group. All age groups have sexual contacts with other age groups, except for women in the 50-59 age group who do not have sexual contacts with men younger than 25 years of age. This mixing by age was informed by data from Demographic and Health Survey (DHS). DHS data was also used to inform mixing between low- and high-risk groups of men and women.

In the remaining of this appendix, risk groups are indexed from 1 to 9 by subscript k. Low-risk women correspond to k=1; high-risk women k=2; FSW k=(3,4) (k=4 denotes those engaging in anal intercourse); low-risk men k=5; high-risk men k=6; CFSW k=7; MSM who engage in bisexual practices k=8; and exclusive MSM k=9. Age groups are indexed from 1 to 4 by subscript i. For 15-19 years old i=1; 20-24 years old i=2; 25-49 years old i=3; and 50-59 years old i=4.

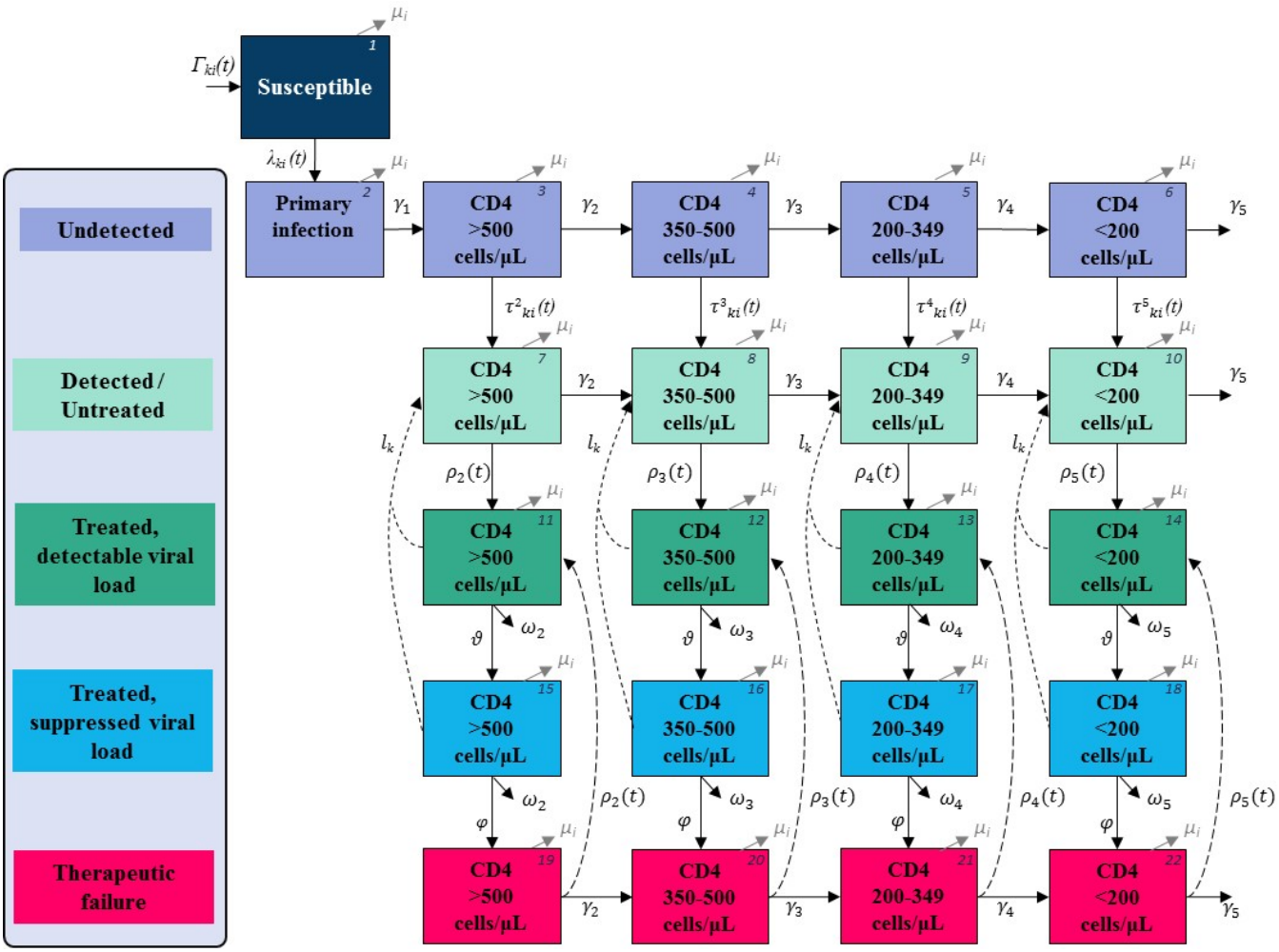

Figure S2. Model structure of HIV transmission, disease progression, and continuum of care. Where $\Gamma_{ki}(t)$ is the rate of entry in the sexually active population for members of risk group k and age class i (i.e., men start their sexually active life later than women and this proportion changes with time); μ_i is the HIV-unrelated background mortality rate for age class i; $\lambda_{ki}(t)$ is the force of infection at time t for individuals in risk group k and age class i; γ_s is the disease progression rate for the different stages of infections (defined by the CD4 levels and indexed by s); $\tau^s_{ki}(t)$ is the testing rate that varies with time, stage of infection, risk group, and age class; $\rho_s(t)$ is the ART recruitment rate which is a function of time and disease stage; ϑ is the rate at which individuals on ART become virally suppressed; l_k is the ART discontinuation rate; φ is the rate of therapeutic failures among virally suppressed individuals; and ω_s is the HIV-related mortality rate of individuals on ART that varies by disease stage.

In the remaining of this appendix, the different stages of infection are indexed by "*a*" and "*s*". The superscript "*a*" denotes the testing and antiretroviral therapy (ART) status: *"0"* for undetected individuals, *"1"* for those tested but untreated, *"2"* for those treated with a detectable viral load, *"3"* for those virally suppressed, and *"4"* for those experiencing therapeutic failures. The second superscript "*s*" described the disease progression according to CD4 cell counts: *"1"* for acute infection, *"2"* for CD4>500 cells/µL, *"3"* for CD4 between 350 and 500 cells/µL, *"4"* for CD4 between 200 and 349 cells/µL, and *"5"* for CD4 <200 cells/µL.

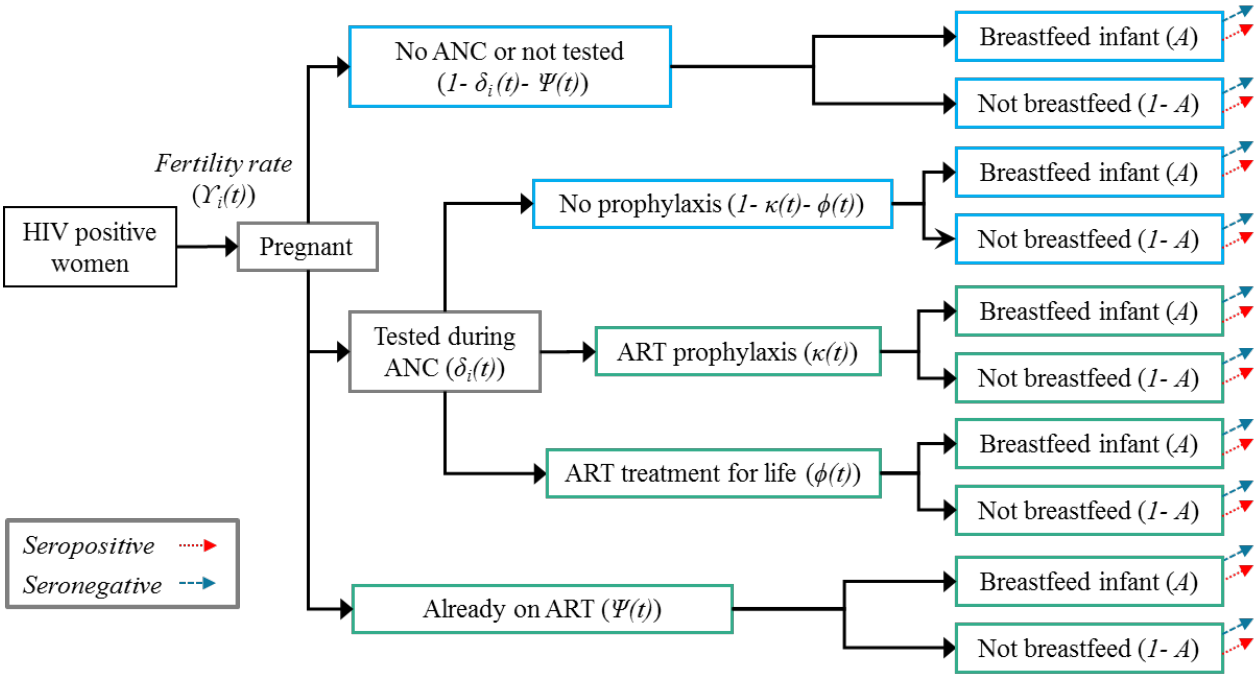

Figure S3. Decision tree used to estimate vertical transmission of HIV. Green boxes represent prevention of mother-to-child transmission (PMTCT) interventions. HIV positive women become pregnant at a rate $\Upsilon_i(t)$ that varies as a function of time t and age i. A proportion $\Psi(t)$ of these women - as determined by the dynamic transmission model - will already be on antiretroviral treatment (ART). Other women can benefit from PMTCT if they attend and are tested during antenatal care (ANC) visits, according to a proportion $\delta_i(t)$ that varies with time and age i (women not accessing ANC or not being tested for HIV do not benefit from PMTCT). This proportion was informed by self-reported ANC attendance and testing data from Demographic and Health Surveys (DHS). Among women tested for HIV during ANC, some will not receive any prophylaxis (1-$\kappa(t)$- $\phi(t)$), others will receive ART prophylaxis ($\kappa(t)$) for them and their babies or receive ART for life ($\phi(t)$). These proportions were derived from programmatic data reported by Côte d'Ivoire. The probability of mother-to-child transmission also depends on the proportion (A) of infants that will be breastfeed and the mother's CD4 cell count at delivery (not shown on figure). Breastfeeding parameters were informed by DHS data.

Table S1. Demographic parameters and the model's initial conditions.

Parameters	Symbol	Prior distributions	References
Initial conditions			
HIV prevalence in 1975 among FSW (%)	$Seed_{FSW}$	U(0.1%, 1%)	Assumption
HIV prevalence in 1975 among clients of FSW (%)	$Seed_{CFSW}$	U(0.1%, 0.5%)	Assumption
HIV prevalence in 1975 among MSM (%)	$Seed_{MSM}$	U(0.1%, 1%)	Assumption
Total population aged 15-59 years in 1970	N_0	2,711,050	[1]
Demography			
Population growth rate (year^{-1})	ε	0.032	[1]
Immigration rate of 25-49 years old (year^{-1})	χ	U(0.017, 0.029)	[1]
Mortality rate (1/life expectancy at 15, 25, and 50 years)			
15-24 years old (year^{-1})	$\mu_{1:2}$	U(0.020, 0.021)	[1]
25-49 years old (year^{-1})	μ_3	U(0.024, 0.025)	[1]
50-59 years old (year^{-1})	μ_4	U(0.044, 0.046)	[1]
Fertility rate of 15-24 years old (year^{-1})	$ASFR_{1:2}(t)$	Varies with time between 0.328 (1970) to 0.212 (2015)	[1]
Fertility rate of 25-49 years old (year^{-1})	$ASFR_3(t)$	Varies with time between 0.230 (1970) to 0.150 (2015)	[1]
Relative fertility reduction of HIV positive women	RR_{Fert}	T(0.76, 0.60, 0.89)	[2]
Size of sex, age, and risk groups			
Proportion of males in population		51.5%	[1]
Age class distributions			
15-19 years old (%)	PR_A_1	21.0%	[1]
20-24 years old (%)	PR_A_2	17.5%	[1]
25-49 years old (%)	PR_A_3	51.5%	[1]
50-59 years old (%)	PR_A_4	10.0%	[1]
Proportion of virgin females aged 15-19 years old (%) (k=1,2,3,4)	$Vir_k(t)$	1994 = 27.4% 1999 = 35.9% 2005 = 34.2% 2012 = 35.3%	[3] [4] [5] [6]
Proportion of virgin males aged 15-19 years old (%) (k=5,6,7,8,9)	$Vir_k(t)$	1999 = 44.3% 2005 = 48.9% 2012 = 57.3%	[4] [5] [6]
Proportion of high-risk (>2 partners year^{-1}) heterosexual males (%)	PR_{HRM}	U(5%, 10%)	[4-6]
Proportion of high-risk (>1 partner year^{-1}) heterosexual females (%)	PR_{HRF}	U(5%, 10%)	[4-6]
Proportion of MSM among males (%)	PR_{MSM}	U(0.8%, 1.6%)	[7-9]
Proportion of MSM who engage in bisexual practices (%)	PR_{Bi}	U(53.6%, 75.5%)	[10, 11]†
Ratio of FSW to MSM*	R_{FSW}	U(1, 1.7)	[4, 12, 13]
Proportion of FSW that engage in AI (%)	PR_{AI}	U(18.3%, 29.9%)	Based on [14]
Turnover rate from FSW to non-FSW females (year^{-1})	tur	U(1/15, 1/5)	Assumption

AI=anal intercourse; FSW=female sex worker; MSM=men who have sex with men; T(m,a,b)=Triangular distribution (m=mode, a=minimum, b=maximum); U(a,b)=Uniform distribution (a=minimum, b=maximum).

*The proportion of clients of FSW was indirectly estimated using the multiplier method, balancing the partner change rate reported by FSW and by clients of FSW. The proportion of clients of FSW was constrained to be less\ than 20%.

†Parameter informed by the analysis of primary data of respondent-driven sampling surveys conducted in five cities of Côte d'Ivoire (unpublished).

Table S2. Behavioral parameters.

Parameters	Symbols	Prior distributions or data	References
Partner change rate of sexually active			
Low-risk females (year^{-1})	c_1	U(0.8, 0.9)	[4-6]
High-risk females (year^{-1})	c_2	U(2.4, 9.4)	[4-6]
FSW (year^{-1})	$c_{3:4}$	U(216, 360)	[15-18]*
Low-risk males (year^{-1})	c_5	U(1.0, 1.2)	[4-6]
High-risk males (year^{-1})	c_6	U(4.7, 6.8)	[4-6]
Clients of FSW (with FSW) (year^{-1})	c_7	U(23, 37)	[19]
Clients of FSW (with women in the general population) (year^{-1})	c_{7b}	U(1, 6.8)	[4-6]
MSM engaging in bisexual practices (year^{-1})	c_8	U(1, 10)	Assumption
Exclusive MSM (year^{-1})	c_9	U(1, 10)	[11]
Number of sex acts			
Low-risk partners (partnership^{-1} year^{-1}) (k=1,5)	α_{kijl}	U(40, 48)	[6]
High-risk partners (partnership^{-1} year^{-1}) (k=2,6)	α_{kijl}	U(33, 66)	[6]
MSM partners (partnership^{-1} year^{-1}) (k=8,9)	α_{kijl}	U(33, 66)	Assumption
Clients-FSW partners (partnership^{-1} year^{-1}) (k=3,4,7)	α_{kijl}	U(1, 4)	[6]
Sexual mixing parameters			
Sexual balance parameter as per Garnett et al. 1994 [20]†	η	U(0, 1)	Assumption
Fraction of partnerships that are with females for MSM engaging in bisexual practices (%)	Bi_{Pref}	U(32%, 44%)	Primary data‡
Tuning parameter between assortative and proportional mixing by age among MSM	MSM_{AgeMix}	U(0, 1)	Assumption
Other parameters			
Proportion of sex acts that are anal for FSW that engage in AI (%)	Pr_{ActsAI}	U(14.8%, 27.6%)	Based on [14, 16]

AI=anal intercourse; CFSW=clients of female sex workers; DHS=Demographic and Health Survey; FSW=female sex worker; MSM=men who have sex with men; U(a,b)=Uniform distribution (a=min, b=max).

*Based on the assumption that FSW engage in sex work 4 days per week, 50 weeks per year.

†CFSW were assumed to drive demand and FSW were de facto assumed to adjust their partner change rate in consequence. For MSM, we assumed that the balance parameter is equal to 0.5.

‡ Parameter informed by the analysis of primary data of respondent-driven sampling surveys conducted in five cities of Côte d'Ivoire (unpublished).

Table S3. Biological and treatment parameters.

Parameters	Symbols	Prior distributions or data	References
HIV transmission probability			
Female-to-male transmission probability (per VI act^{-1})	β_{fm}	U(0.00013, 0.00141)	[21]
Male-to-female transmission probability (per VI act^{-1})	β_{mf}	U(0.00060, 0.00109)	[21]
Changes in HIV transmission probability			
RR of HIV acquisition for receptive AI as compared to receptive VI (act^{-1})	RR_{RAI}	T(10, 2, 20)	[22]
RR of HIV acquisition for insertive AI as compared to insertive VI (act^{-1})	RR_{IAI}	2	[22]
RR of HIV acquisition for women 15-24 years old as compared to those aged ≥25 years (act^{-1})	$RR_{YoungFem}$	U(1.25, 2.5)	[23, 24]
RR of HIV transmission during acute infection (act^{-1})	RR_{Acute}	T(9.17, 4.47, 18.81)	[21]
RR of HIV transmission for individuals on ART (detectable viral load) (act^{-1})	RR_{VLD}	T(0.5, 0.3, 0.8)	Assumption
RR of HIV transmission for individuals on ART (virally suppressed; <50 copies/μL) (act^{-1})	RR_{ART}	T(0.04, 0.01, 0.27)	[25]
RR of HIV transmission when sex act is protected by a condom (act^{-1})	ς	U(0.75, 0.942)	[26]
Natural history progression			
Time duration of acute infection (years)	$1/\gamma_1$	U(0.16, 0.50)	[27]
Time duration from seroconversion to 350 CD4 cells/μL (years)	$1/\gamma_1+1/\gamma_2+1/\gamma_3$	U(2.2, 4.6)	[28]
Time duration from 350 CD4 cells/μL to 200 CD4 cells/μL (years)	$1/\gamma_4$	U(3.9, 5.0)	[28]
Time duration from 200 CD4 cells/μL to death (years)	$1/\gamma_5$	U(1.9, 3.9)	[28]
Time duration from unsuppressed to suppressed viral load (<50 copies/μL) (years) (probability converted to duration using $1/-ln(1-0.871)/t$)	ϑ	0.49	[29]
ART			
Survival extension cofactor for individuals on ART (RR)*	RR_{ω}	U(2, 3)	[30, 31]
Rate of therapeutic failures (years^{-1})	φ	U(0.049, 0.09)	Based on [32, 33]
Rate of ART discontinuation (years^{-1}) (probability converted to rate using $-ln(1-P)/t$)	l	U(0.15, 0.27)	[34-39]
Relative risk of ART discontinuation for FSW	$RR_{LTFU\text{-}FSW}$	U(1.25, 1.75)	[40]
Relative risk of ART discontinuation for MSM	$RR_{LTFU\text{-}MSM}$	U(1.25, 1.75)	Assumed equal to that of FSW

AI=anal intercourse; ART=antiretroviral therapy; FSW=female sex worker; MSM=men who have sex with men; RR=relative risk; T(m,a,b)=Triangular distribution (m=mode, a=minimum, b=maximum); U(a,b)=Uniform distribution (a=minimum, b=maximum); VI=vaginal intercourse.

*HIV-related mortality (ω_s) for those on treatment is calculated as followed: $\omega_s=(\Sigma\gamma_s)/RR_{\omega}$.

Table S4. Mother-to-child HIV transmission probabilities as a function of the availability (or lack thereof) of different interventions, CD4 cell counts, and breastfeeding status.

Parameters	Symbols	Prior distributions or data	References
No prophylaxis (prior to 2000)			
Peripartum transmission probability (CD4<200 cells/μL)	$\beta_{<200}^{0}$	U(0.22, 0.54)	[41]
Peripartum transmission probability (CD4 200-349 cells/μL)	$\beta_{<350}^{0}$	U(0.131, 0.326)	[41]
Peripartum transmission probability (CD4≥350 cells/μL)	$\beta_{\geq 350}^{0}$	U(0.097, 0.202)	[41]
Monthly postnatal transmission probability for any breastfeeding (CD4<350 cells/μL)	$\beta_{BF<350}^{0}$	0.0157	[41]
Monthly postnatal transmission probability for any breastfeeding (CD4≥350 cells/μL)	$\beta_{BF\geq 350}^{0}$	0.0051	[41]
Single-dose nevirapine (from 2000 to 2005)			
Peripartum transmission probability	β_{Px}^{1}	U(0.094, 0.121)	[41]
Monthly postnatal transmission probability for any breastfeeding (CD4<350 cells/μL)	$\beta_{BF<350}^{1}$	0.0157	[41]
Monthly postnatal transmission probability for any breastfeeding (CD4≥350 cells/μL)	$\beta_{BF\geq 350}^{1}$	0.0051	[41]
Dual prophylaxis (from 2005 to 2010)			
Peripartum transmission probability	β_{Px}^{2}	U(0.023, 0.053)	[41]
Monthly postnatal transmission probability for any breastfeeding (CD4<350 cells/μL)	$\beta_{BF<350}^{2}$	0.0157	[41]
Monthly postnatal transmission probability for any breastfeeding (CD4≥350 cells/μL)	$\beta_{BF\geq 350}^{2}$	0.0051	[41]
WHO's option A or B (from July 2010 onward)			
Peripartum transmission probability	β_{Tx}^{3}	U(0.009, 0.029)	[41]
Monthly postnatal transmission probability for any breastfeeding		0.002	[41]
Women already on ART			
Peripartum transmission probability	β_{ARV}	0.005	[41]
Monthly postnatal transmission probability for any breastfeeding		0.0016	[41]
Breastfeeding			
Proportion of infants not being breastfeed (%)	*(1-A)*	U(1.4%, 3.6%)	[4-6]
Average duration of any breastfeeding (months)	*D*	U(18.8, 20.5)	[4-6]

ART=antiretroviral therapy; U(a,b)=Uniform distribution (a=minimum, b=maximum); WHO=World Health Organization.

Table S5. Parameters used to estimate historical trends in the proportion of sex acts protected by a condom.

Parameters	Symbols	Prior distributions/ ranges or data	References
General population (excluding CFSW, FSW, MSM)			
Among 15-24 years old (%)	$Condom_{1:2}(t)$	1981 = (0%, 5%)	[42, 43]
(Proportion of protected sex acts)		1994 = (9.9%, 47.2%)	[3]*
		1999 = (11.5%, 55.7%)	[4]*
		2005 = (20.9%, 53.5%)	[5]*
		2012 = (20.7%, 59.5%)	[6]*
Among 25-49 years old (%)	$Condom_3(t)$	1981 = (0%, 2.5%)	[42, 43]
		1994 = (2.5%, 21.7%)	[3]*
		1999 = (3.1%, 21.8%)	[4]*
		2005 = (4.7%, 23.8%)	[5]*
		2012 = (7.3%, 24.2%)	[6]*
Among 50-59 years old (%)	$Condom_4(t)$	1981 = (0%, 2.0%)	[42, 43]
		1994 = (0.2%, 9.7%)	[3]*†
		1999 = (0.6%, 9.7%)	[4]*†
		2005 = (0.6%, 10.0%)	[5]*†
		2012 = (1.8%, 11.5%)	[6]*†
Female sex workers with their clients (VI)			
All age groups (%)	*CondomSW(t)*	1981 = (0%, 5.0%)	Based on [42, 43]
(Proportion of protected sex acts)		1991 = (57%, 68%)	[15]
		1993 = (74%, 81%)	[15]
		1995 = (73%, 88%)	[15]
		1997 = (88%, 93%)	[15]
		1998 = (88%, 98%)	[18]
		2002 = (91%, 99%)	[18]
		2007 = (90%, 99%)	[18]
		2011 = (90%, 95%)	[18]
		2014 = (85%, 93%)	[14, 16]
Relative reduction in condom use for FSW AI versus VI			
All age groups (RR)	RR_{CondAI}	T(0.75, 0.61, 0.92)	[14, 16]
Men who have sex with men			
All age groups (%)	*CondomMSM(t)*	1981 = 0%	Assumption
(Proportion of protected sex acts)		2004 = (35%, 50%)	Based on [44]
		2012 = (57%, 69%)	[10]
		2015 = (63%, 81%)	§
Year of condom increase in the 1980s			
General population (k=1,2,5,6)	$DateCond_k$	U(1981,1990)	Assumption
Sex work (k=3,4,7)	$DateCond_k$	U(1981,1990)	Assumption
MSM (k=8,9)	$DateCond_k$	U(1981,1990)	Assumption
Scaling factor for the proportion of sex acts protected by condoms‡			
15-24 years old (general population)	$CondPtl_{1:2}$	U(0, 1)	Assumption
25-49 years old (general population)	$CondPtl_3$	U(0, 1)	Assumption
50-59 years old (general population)	$CondPtl_4$	U(0, 1)	Assumption
FSW (all age groups)	*CondSWPtl*	U(0, 1)	Assumption
MSM (all age groups)	*CondMSMPtl*	U(0, 1)	Assumption

AI=anal intercourse; CFSW=client of female sex worker; FSW=female sex worker; MSM=men who have sex with men; RR=relative risk; T(m,a,b)=Triangular distribution (m=mode, a=minimum, b=maximum); U(a,b)=Uniform distribution (a=minimum, b=maximum); VI=vaginal intercourse.

*The minimum of the range corresponds to the lower confidence bound of the estimate reported by females and the maximum to the upper confidence bound of the estimate reported by males.
†Only the 2005 AIDS Indicator Survey collected information on men aged 50-59 years old. When unavailable, estimates for this age class were approximated by extrapolating those of the 45-49 years old age group.
‡The estimates of the proportion of sex acts protected by a condom are sampled for each year using the same percentile of the distribution to obtain temporally consistent estimates.
§Parameter informed by the analysis of primary data of respondent-driven sampling surveys conducted in five cities of Côte d'Ivoire (unpublished).

Table S6. Parameters used to estimate historical trends in HIV testing.

Parameters	Symbols	Prior distributions/ranges or data	References
HIV testing probability (last 12 months) for asymptomatic females (excluding those tested during ANC)*			
Among 15-24 years old (year^{-1}) (k=1,2)	$\tau_{k1:2}^{0}(t)$	2000 = 0 2005 = (0.011, 0.024) 2012 = (0.063, 0.086)	Based on [45] [5] [6]
Among 25-49 years old (year^{-1}) (k=1,2)	$\tau_{k3}^{0}(t)$	2000 = 0 2005 = (0.018, 0.045) 2012 = (0.060, 0.080)	Based on [45] [5] [6]
Among 50-59 years old (year^{-1}) (k=1,2)	$\tau_{k4}^{0}(t)$	2000 = 0 2005 = (0.001, 0.027) 2012 = (0.041, 0.080)	Assumption [5]† [6]†
HIV testing probability (last 12 months) for asymptomatic males*			
Among 15-24 years old (year^{-1}) (k=5,6,7)	$\tau_{k1:2}^{0}(t)$	2000 = 0 2005 = (0.013, 0.036) 2012 = (0.058, 0.097)	Based on [45] [5] [6]
Among 25-49 years old (year^{-1}) (k=5,6,7)	$\tau_{k3}^{0}(t)$	2000 = 0 2005 = (0.029, 0.054) 2012 = (0.089, 0.131)	Based on [45] [5] [6]
Among 50-59 years old (year^{-1}) (k=5,6,7)	$\tau_{k4}^{0}(t)$	2000 = 0 2005 = (0.008, 0.029) 2012 = (0.031, 0.081)	Assumption [5]† [6]†
Proportion of pregnant women accessing ANC and being tested for HIV‡			
Among 15-24 years old (year^{-1})	$ANC\tau_{1:2}(t)$	1999 = 0 2005 = (4.6%, 10.9%) 2012 = (32.1%, 41.1%)	Based on [45] [5] [6]
Among 25-49 years old (year^{-1})	$ANC\tau_{3}(t)$	1999 = 0 2005 = (10.9%, 18.9%) 2012 = (36.6%, 44.9%)	Based on [45] [5] [6]
Relative increase in testing rate for different groups			
Symptomatic stage (<200 CD4 cells/μL) (RR)	$Symp\_RR_{Test}$	$U(2, 8)$	Assumption
Female sex worker (RR)	FSW_RR_{Test}	$U(1, 4)$	Based on [6, 18]
Men who have sex with men (RR)	MSM_RR_{Test}	$U(1, 4)$	Based on [6, 10]
Scaling factor for HIV testing§			
All age and risk groups (excluding ANC)	$TestPtl$	$U(0, 1)$	Assumption
Pregnant women tested during ANC	$ANCPtl$	$U(0, 1)$	Assumption

ANC=antenatal care; FSW=female sex worker; MSM=men who have sex with men; RR=relative risk; T(m,a,b)=Triangular distribution (m=mode, a=minimum, b=maximum); U(a,b)=Uniform distribution (a=minimum, b=maximum); VI=vaginal intercourse.

*Probabilities of being tested during last 12 months was converted to rate (year^{-1}) using Rate = -ln(1-Probability)

†Only the 2005 AIDS Indicator Survey collected information on men aged 50-59 years old. When unavailable, estimates for this age class were approximated by extrapolating those of the 45-49 years old age group.

‡Women aged 50-59 years old are assumed to have a fertility rate of zero.

§The estimates for HIV testing rate and proportion of pregnant women tested as part of their ANC are sampled for each year using the same percentile of the distribution to obtain temporally consistent estimates.

Table S7. Parameters used to estimate historical trends in the availability of interventions for the prevention of mother-to-child transmission.

Parameters	Symbols	Prior distributions/ranges or data	References
Pregnant women tested positive for HIV during ANC receiving ART prophylaxis (%)*			
	$K(t)$	1999 = 0	Assumption
		2002 = (40.5%, 53.4%)	[46]
		2007 = (51.7%, 65.4%)	[34]
		2008 = (37.3%, 62.4%)	[34]
		2009 = (44.2%, 61.5%)	[35]
		2010 = (47.5%, 59.5%)	[36]
		2011 = (53.0%, 60.5%)	[37]
		2012 = (43.4%, 55.8%)	[38]
		2013 = (41.1%, 55.8%)	[39]
		2014 = (49.6%, 66.5%)	[47]
Pregnant women tested positive for HIV during ANC receiving ART treatment (%)†			
	$\Phi(t)$	1999 = 0	Assumption
		2008 = (9.6%, 11.9%)	[34]
		2009 = (10.4%, 10.7%)	[35]
		2010 = (10.7, 13.2%)	[36]
		2011 = (11.9, 14.7%)	[37]
		2012 = (11.9, 14.7%)	[38]
		2013 = (18.8%, 23.2%)	[39]
		2014 = (22.5%, 27.8%)	[47]
Scaling factor for PMTCT coverage‡			
ART prophylaxis	*ARTPxPtl*	$U(0, 1)$	Assumption
ART treatment	*ARTTxPtl*	$U(0, 1)$	Assumption

ANC=antenatal care; ART=antiretroviral therapy; PMTCT=prevention of mother-to-child transmission.
*The lower bound of the confidence interval corresponds to the proportion of infants receiving prophylaxis and the upper bound to the proportion of mothers receiving prophylaxis.
†The bound of the prior distribution were constructed by varying point estimates by ± 10%.
‡The estimates for proportion of pregnant women testing positive for HIV receiving prevention of mother-to-child transmission interventions are sampled for each year using the same percentile of the distribution to obtain temporally consistent estimates.

Table S8. Parameters used to estimate historical trends in antiretroviral therapy coverage.

Parameters	Symbols	Prior distributions	References
Recruitment rate into ART when symptomatic (<200 CD4 cells/μL) (years^{-1})	ρ_5	$U(0.5, 4)$	Assumption
Slope cofactor to define linear relation between CD4 stages and recruitment into ART	ι	$U(0, 1)$	Assumption

ART=antiretroviral treatment; U(a,b)=Uniform distribution (a=minimum, b=maximum).

Table S9. List of outcomes that the mathematical model was fitted to.

Outcomes	Year	Value	95% CI*	Prior Constraints		References
				Lower limit	Upper limit	
Outcomes included in the likelihood[£] (binomial likelihoods and pre-specified constraints)						
Female HIV prevalence						
15-24 years old	1989†	2.5%	(0.9%-4.4%)	0.0%	13.2%	[48]
	2005	2.4%	(1.6%-3.0%)	0.4%	5.3%	[5]
	2012	2.2%	(1.5%-3.0%)	0.4%	5.3%	[6]
25-49 years old	1989†‡	2.5%	(1.0%-4.3%)	0.0%	13.0%	[48]
	2005	9.9%	(8.4%-12.0%)	2.1%	21.0%	[5]
	2012	6.3%	(5.2%-8.0%)	1.3%	14.0%	[6]
50-59 years old	1989†‡	1.9%	(0.4%-4.4%)	0.0%	13.3%	[48]
	2005‡	10.2%	(6.2%-16.0%)	1.6%	28.0%	[5]
	2012‡	9.5%	(5.7%-15.0%)	1.4%	26.3%	[6]
Male HIV prevalence						
15-24 years old	1989†	2.4%	(0.8%-4.3%)	0.0%	13.0%	[48]
	2005	0.3%	(0.1%-1.0%)	0.0%	1.8%	[5]
	2012	0.3%	(0.1%-1.0%)	0.0%	1.8%	[6]
25-49 years old	1989†‡	7.7%	(5.5%-10.0%)	0.0%	30.1%	[48]
	2005	4.8%	(3.6%-6.0%)	0.9%	10.5%	[5]
	2012	4.3%	(3.3%-5.0%)	0.8%	8.8%	[6]
50-59 years old	1989†‡	1.7%	(0.4%-3.9%)	0.0%	11.7%	[48]
	2005‡	4.9%	(2.4%-10.0%)	0.6%	17.5%	[5]
	2012	8.7%	(5.4%-14.0%)	1.4%	24.5%	[6]
Female sex workers						
	1986†	36.9%	(27.6%-46.7%)	15.0%	75.0%	[49]
	1987†	38.9%	(30.1%-48.2%)	15.0%	85.0%	[49]
	1989†	47.6%	(38.4%-56.7%)	20.0%	90.0%	[49]
	1990†	68.4%	(57.0%-78.6%)	25.0%	95.0%	[49]
	1994	67.0%	(63.2%-70.8%)	25.0%	85.0%	[15]††
	1995	54.0%	(50.5%-57.4%)	20.0%	80.0%	[15]††
	1996	52.0%	(48.7%-55.2%)	20.0%	75.0%	[15] ††
	1997	52.0%	(48.7%-55.4%)	20.0%	70.0%	[15] ††
	1998	32.0%	(28.9%-35.3%)	15.0%	65.0%	[50] ††
	1999	32.0%	(28.7%-35.5%)	15.0%	65.0%	[50] ††
	2000	28.0%	(24.8%-31.4%)	12.5%	55.0%	[50] ††
	2001	31.0%	(27.7%-34.4%)	12.5%	55.0%	[50] ††
	2002	27.0%	(23.8%-30.3%)	12.5%	55.0%	[50] ††
	2003	33.0%	(28.0%-38.0%)	12.5%	55.0%	[51] ††
	2004	27.0%	(22.4%-31.9%)	10.0%	55.0%	[51] ††
	2005	18.0%	(14.1%-22.4%)	7.5%	50.0%	[51] ††
	2006	19.0%	(15.1%-23.6%)	7.5%	50.0%	[51] ††
	2007	21.0%	(16.9%-25.7%)	7.5%	45.0%	[51] ††
	2007	22.9%	(13.7%-35.6%)	7.5%	45.0%	[52]
	2008	19.0%	(15.1%-23.6%)	5.0%	40.0%	[51] ††
	2009	20.0%	(15.9%-22.5%)	5.0%	35.0%	[51] ††
	2009	11.2%	(6.4%-18.9%)	5.0%	35.0%	[52]
	2010	21.0%	(16.9%-25.7%)	5.0%	35.0%	[51] ††
	2014	11.0%	(8.3%-14.3%)	5.0%	25.0%	[14]
Men who have sex with men						

15-24 years	2012	12.5%	(6.8%-18.2%)	5.0%	25.0%	[10]
	2015	11.4%	(6.6%-19.0%)	5.0%	25.0%	¶
25-49 years	2012	25.8%	(16.7%-34.9%)	15.0%	40.0%	[10]
	2015	16.3%	(7.5%-32.0%)	5.0%	35.0%	¶
Clients of female sex workers						
	1999	13.4%	(10.4%-17.1%)	2.6%	29.9%	[19]‡‡
Outcomes included in the likelihood using pre-specified constraints only§						
ART coverage						
Adults (15+)	2003	0.5%	(0.5-0.6%)	0%	6%	[53]
	2007	8.7%	(8-10%)	2%	15%	[34]
	2008	12%	(11-13%)	5%	19%	[34]
	2009	16%	(15-18%)	8%	23%	[35]
	2010	19%	(17-20%)	11%	26%	[36]
	2011	21%	(19-23%)	14%	29%	[37]
	2012	25%	(23-28%)	17%	33%	[38]
	2013	28%	(25-31%)	20%	36%	[39]
	2014	32%	(29-35%)	24%	41%	[47]

*95% CI: 95% confidence intervals.
£The overall likelihood of the model is calculated by summing the binomial log-likelihoods of the relevant model's outcomes and assigning a likelihood of zero if any of the model-predicted outcomes fall outside of the pre-specified constraints.
†Surveys were adjusted for imperfect sensitivity and specificity of the diagnostic assays (see Text S6).
‡Some age categories in the surveys do not exactly match the ones in the model. For the 1989 survey the 25-49 age category corresponds to prevalence of the 25-54 years old and the 50-59 age category corresponds to prevalence in the 55-64 years old. For the 2005 AIDS Indicator Survey, the 50-59 age category corresponds to prevalence from the 45-49 years old. For the 2011-12 Demographic and Health Survey, the 50-59 age category for females corresponds to prevalence in females aged 45-49 years old.
¶ Parameter informed by the analysis of primary data of respondent-driven sampling surveys conducted in five cities of Côte d'Ivoire. The city-specific prevalence estimates were pooled by weighting each city by its total population.
††These prevalence estimates are from first time attendees of the Clinique de Confiance in Abidjan. A design effect of 5 was applied to obtain an effective sample size in the likelihood calculations to take into account the clustered nature of these observations.
‡‡Confidence intervals were adjusted for the clustered design of the survey by using the number of clusters (n=84) as the effective sample size.
§ART coverage was not included in the binomial likelihood because this was derived from programmatic data on the number of individuals on ART (numerator) and the number of HIV positive individuals in Côte d'Ivoire estimated by UNAIDS. As such, there was no sample size to use in the binomial likelihood.

Text S1. Details on sexual mixing patterns.

Sexual mixing

Sexual mixing is a function of age, sex, and the risk category of individuals. The probability p_{kijl} of a sexual contact between someone of risk category k and age i with an individual of risk category j and age l is estimated using the following equation:

$$p_{kijl} = WMW_{kj}(M_{kj})\Lambda_{kil}$$

$$WMW_{kj} = \begin{pmatrix} & F_{LR} & F_{HR} & F_{FSW} & F_{FSW_{AI}} & M_{LR} & M_{HR} & M_{CFSW} & M_{BI} & M_{MSM} \\ F_{LR} & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \\ F_{HR} & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \\ F_{FSW} & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ F_{FSW_{AI}} & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ M_{LR} & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ M_{HR} & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ M_{CFSW} & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ M_{BI} & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ M_{MSM} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \end{pmatrix}$$

$$M_{kj} = \begin{pmatrix} & F_{LR} & F_{HR} & F_{FSW} & F_{FSW_{AI}} & M_{LR} & M_{HR} & M_{CFSW} & M_{BI} & M_{MSM} \\ F_{LR} & 0 & 0 & 0 & 0 & 0.91 & \frac{0.09*M_{HR}}{M_{HR+CFSW+Bi}} & \frac{0.09*M_{CFSW}}{M_{HR+CFSW+Bi}} & \frac{0.09*M_{Bi}}{M_{HR+CFSW+Bi}} & 0 \\ F_{HR} & 0 & 0 & 0 & 0 & 0.88 & \frac{0.12*M_{HR}}{M_{HR+CFSW+Bi}} & \frac{0.12*M_{CFSW}}{M_{HR+CFSW+Bi}} & \frac{0.12*M_{Bi}}{M_{HR+CFSW+Bi}} & 0 \\ F_{FSW} & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ F_{FSW_{AI}} & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ M_{LR} & 0.91 & 0.09 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ M_{HR} & 0.88 & 0.12 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ M_{CFSW} & 0.88(1-CFSW_{Mix}) & 0.12(1-CFSW_{Mix}) & CFSW_{Mix}(1-\Pr_{AI}) & CFSW_{Mix}\Pr_{AI} & 0 & 0 & 0 & 0 & 0 \\ M_{BI} & 0.88(Bi_{Pref}) & 0.12(Bi_{Pref}) & 0 & 0 & 0 & 0 & 0 & \Pr_{Bi}(1-Bi_{Pref}) & (1-\Pr_{Bi})(1-Bi_{Pref}) \\ M_{MSM} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \Pr_{Bi} & 1-\Pr_{Bi} \end{pmatrix}$$

The binary *WMW* matrix described the types of contacts allowed in the model for the following risk groups: low-risk female (F_{LR}), high-risk female (F_{HR}), female sex worker (F_{FSW}), female sex worker that practice anal intercourse (F_{FSWAI}), low-risk males (M_{LR}), high-risk males (M_{HR}), clients of female sex workers (M_{CFSW}), men who have sex with men who engage in bisexual practices (M_{BI}), and exclusive men who have sex with men (M_{MSM}).

The sizes of the low- and high-risk groups were defined using data from the 2011-12 Demographic and Health Survey (DHS) based on the number of sexual partners during the last 12 months (F_{HR} defined as >1 partner year^{-1}; M_{HR} defined as >2 partners year^{-1}; excluding those that reported selling or buying sex) [6]. Mixing by risk groups was calculated using these individual-level records for low- and high-risk males and females. Due to data limitation, mixing by risk groups was only available for couples living in the same household who both agreed to be interviewed and reported complete data on their sexual partners. Because some unions in Côte d'Ivoire are polygamous, mixing by risk group was analyzed from the female perspective. This DHS-reported matrix *M* was expanded to include the other risk groups and their associated

parameters: Bi_{Pref} being the fraction of partnerships that are with females for MSM engaging in bisexual practices, Pr_{Bi} the fraction of MSM who are bisexual (implicitly assuming proportional mixing between exclusive MSM and MSM who engage in bisexual practices), and $CFSW_{Mix}$ the fraction of partnerships that are with FSW for CFSW ($CFSW_{Mix}=c_7/(c_7+c_{7b})$).

Mixing patterns by age (Λ) were informed using data from the 2011-12 DHS [6] for the general population. The survey data refers to the reported age of the most recent sexual partner among the population that was sexually active in the 12 months preceding the interview. The age mixing matrices differ for males and females. For sex workers and clients, it was assumed that age mixing would correspond to that reported by males in the general population. For MSM, it was assumed that age mixing would be somewhere between completely assortative and proportional mixing using the tuning parameter MSM_{AgeMix}, which was given a non-informative distribution.

$$\Lambda_{kil} = \begin{cases} \begin{pmatrix} 0.130 & 0.130 & 0.719 & 0.021 \\ 0.130 & 0.130 & 0.719 & 0.021 \\ 0.003 & 0.003 & 0.753 & 0.241 \\ 0 & 0 & 0.187 & 0.813 \end{pmatrix}; & \text{for } k=1,2 \text{ } (i \text{ indexes row and } l \text{ columns}) \\ \begin{pmatrix} 0.483 & 0.483 & 0.035 & 0 \\ 0.483 & 0.483 & 0.035 & 0 \\ 0.194 & 0.194 & 0.609 & 0.004 \\ 0.125 & 0.125 & 0.808 & 0.167 \end{pmatrix}; & \text{for } k=3,4,5,6,7 \\ (1-MSM_{AgeMix}) \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} + MSM_{AgeMix} \begin{pmatrix} 0.152 & 0.188 & 0.553 & 0.107 \\ 0.152 & 0.188 & 0.553 & 0.107 \\ 0.152 & 0.188 & 0.553 & 0.107 \\ 0.152 & 0.188 & 0.553 & 0.107 \end{pmatrix}; & \text{for } k=8,9 \end{cases}$$

The probability of a sexual contact is calculated separately for each type of partnerships (*kijl)*. Imbalances between demand for sexual partnerships by one group and offer by another group are thus possible. Balance between supply of and demand for sexual partnership was achieved by altering the partner change rate (c_{kijl}^*) using the methods described by Garnett and Anderson [20] and is described below.

$$\Delta_{kijl} = \frac{c_{jl} p_{jlki} N_{jl}}{c_{ki} p_{kijl} N_{ki}}$$

$$c_{kijl}^* = c_{ki} \Delta_{kijl}^{\eta_k}$$

$$c_{jlki}^* = c_{jl} \Delta_{kijl}^{-(1-\eta_k)}$$

where Δ_{kijl} measures the degree of initial imbalance between supply and demand for sexual partnerships of type *kijl* and η_k is the balance parameter that determines the degree to which partners are submissive (i.e., the degree to which they alter their demand/offer of sexual partnerships). For clients and FSW, we assumed that clients would drive demand. For MSM, the balance parameter was assumed to be equal to 0.5.

Text S2. HIV transmission model's ordinary differential equations.

The dynamic system formed by the different model's compartments can be represented through 22 differential equations. All susceptible individuals at time *t* in risk category *k* and age *i* are represented by $S_{ki}(t)$. The different stages of infection are indexed by I_{ki}^{as}. The superscript "*a*" denotes the testing and antiretroviral therapy (ART) status: *"0"* for undetected individuals, *"1"* for those tested but untreated, *"2"* for those treated with a detectable viral load, *"3"* for those virally suppressed, and *"4"* for those experiencing therapeutic failures. The second supersript "*s*" described the disease progression according to CD4 cell counts: *"1"* for acute infection, *"2"* for CD4>500 cells/µL, *"3"* for CD4 between 350 and 500 cells/µL, *"4"* for CD4 between 200 and 349 cells/µL, and *"5"* for CD4 <200 cells/µL.

1. Susceptible

$$\frac{dS_{ki}(t)}{dt} = E_{ki}(t) + W_i^1 - S_{ki}(t)\sum\nolimits_{jl}\left(\lambda_{kijl}(t)\right) - S_{ki}(t)(\mu_i + Aging_i)$$

$$\frac{dE_{ki}(t)}{dt} = \begin{cases} \left(\begin{array}{l} \sum \mu_1 V_k(t) + \sum\left(\mu_i\left(I_{ki}^{as}(t) + S_{ki}(t)\right)\right) + \gamma_5\left(I_{ki}^{0,5}(t) + I_{ki}^{1,5}(t) + I_{ki}^{4,5}(t)\right) + \\ \sum_{s=2}^{5} I_{ki}^{2,s}(t)\omega_{s-1} + \sum_{s=2}^{5} I_{ki}^{3,s}(t)\omega_{s-1} + \varepsilon\sum\left(I_{ki}^{as}(t) + S_{ki}(t) + V_k(t)\right) + \\ \sum\left(Aging_4\left(I_{k,4}^{as}(t) + S_{k,4}(t)\right)\right) \end{array}\right)(1 - Vir_k(t)); \text{ if } i = 15-19 \text{ years old} \\ V_k(t)Aging_2; \text{ if } i = 20\text{-}24 \text{ years old} \\ \chi\sum\left(I_{ki}^{as}(t)\right); \text{ if } i = 25\text{-}49 \text{ years old} \\ 0; \text{ if } i = 50\text{-}59 \text{ years old} \end{cases}$$

$$\frac{dV_k(t)}{dt} = \left(\begin{array}{l} \sum \mu_1 V_k(t) + \sum\left(\mu_i\left(I_{ki}^{as}(t) + S_{ki}(t)\right)\right) + \gamma_5\left(I_{ki}^{0,5}(t) + I_{ki}^{1,5}(t) + I_{ki}^{4,5}(t)\right) + \\ \sum_{s=2}^{5} I_{ki}^{2,s}(t)\omega_{s-1} + \sum_{s=2}^{5} I_{ki}^{3,s}(t)\omega_{s-1} + \varepsilon\sum\left(I_{ki}^{as}(t) + S_{ki}(t) + V_k(t)\right) + \\ \sum\left(Aging_4\left(I_{k,4}^{as}(t) + S_{k,4}(t)\right)\right) \end{array}\right) Vir_k(t) - V_k(t)(\mu_1 + Aging_1)$$

$E_{ki}(t)$ represents individuals of category *k* and age class *i* entering the susceptible compartment at time *t*. These individuals are those lost by the system at time t_{-1} as a result of background mortality, HIV-related mortality, and exit from sexually active life. Immigration occurs at a rate χ and immigrants are assumed to be aged between 25 and 49 years old. The population of Côte d'Ivoire grows at a rate ε. It should be noted that individuals enter the sexual active life either at 15 or 20 years old, according to the proportion $Vir_k(t)$, and $V_k(t)$ is the number of individuals 15-19 years of age who are not yet sexually active at time *t*. They do not get infected and cannot die of AIDS but are subjected to the same background mortality rate. Aging rates are stored in the homonymous vector and the aging process is defined the following way:

$$\frac{dAged_{ki}^{a,s}(t)}{dt} = \begin{cases} 0; & \text{if } i\text{=15-19 years old} \\ I_{k(i-1)}^{as}(t)Aging_{(i-1)}; & \text{if } i \neq \text{15-49 years old} \end{cases}$$

$$\text{where } Aging = \left\{\frac{1}{5}, \frac{1}{5}, \frac{1}{25}, \frac{1}{10}\right\}$$

Female sex workers (FSW) will be involved in sex work for a certain period of time before exiting this practice and returning to the group composed of high-risk females. This turnover (symbol in tables: *tur*) is denoted by W_{ki}^{c} (where *c* indexes the compartment's number that varies from 1 to 22, as in the equations presented here). It occurs independently of HIV status and disease progression. An

equal number of high-risk females will then enter the FSW risk group to maintain stable the size of the FSW population. The decision tree used to model mother-to-child transmission also calculates the number of HIV positive pregnant women that will be tested at time *t* or be given antiretroviral treatment. These women are then attributed to the relevant compartment using the symbol $P_{ki}^{c}(t)$. Finally, immigration into the 25-49 years old age group of infected individuals (assumed undetected and untreated) is denoted by U_{ki}^{as}. These immigrants are assumed to have the same HIV prevalence as observed in Côte d'Ivoire at time *t*.

2. Primary Infection

$$\frac{dI_{ki}^{0,1}(t)}{dt} = Aged_{ki}^{0,1}(t) + S_{ki}(t)\sum\nolimits_{jl}\left(\lambda_{kijl}(t)\right) + W_{ki}^{2}(t) + U_{ki}^{0,1}(t) - I_{ki}^{0,1}(t)(\gamma_1 + \mu_i + Aging_i)$$

$$U_{ki}^{0,1}(t) = \begin{cases} \chi(\sum\nolimits_a I_{ki}^{a,1}(t)); & \text{if } i\text{=25-49 years old} \\ 0; & \text{if } i \neq \text{25-49 years old} \end{cases}$$

3. Undetected HIV positive with CD4>500 cell/μL

$$\frac{dI_{ki}^{0,2}(t)}{dt} = Aged_{ki}^{0,2}(t) + I_{ki}^{0,1}(t)\gamma_1 + W_{ki}^{3}(t) + U_{ki}^{0,2}(t) - I_{ki}^{0,2}(t)\left(\tau_{ki}^{1}(t) + \gamma_2 + \mu_i + Aging_i\right) - P_{ki}^{3}(t)$$

$$U_{ki}^{0,2}(t) = \begin{cases} \chi(\sum\nolimits_a I_{ki}^{a,2}(t)); & \text{if } i\text{=25-49 years old} \\ 0; & \text{if } i \neq \text{25-49 years old} \end{cases}$$

4. Undetected HIV positive with CD4 between 350 and 500 cells/μL

$$\frac{dI_{ki}^{0,3}(t)}{dt} = Aged_{ki}^{0,3}(t) + I_{ki}^{0,2}(t)\gamma_2 + W_{ki}^{4}(t) + U_{ki}^{0,3}(t) - I_{ki}^{0,3}(t)\left(\tau_{ki}^{1}(t) + \gamma_3 + \mu_i + Aging_i\right) - P_{ki}^{4}(t)$$

$$U_{ki}^{0,3}(t) = \begin{cases} \chi(\sum\nolimits_a I_{ki}^{a,3}(t)); & \text{if } i\text{=25-49 years old} \\ 0; & \text{if } i \neq \text{25-49 years old} \end{cases}$$

5. Undetected HIV positive with CD4 between 200 and 349 cells/μL

$$\frac{dI_{ki}^{0,4}(t)}{dt} = Aged_{ki}^{0,4}(t) + I_{ki}^{0,3}(t)\gamma_3 + W_{ki}^{5}(t) + U_{ki}^{0,4}(t) - I_{ki}^{0,4}(t)\left(\tau_{ki}^{1}(t) + \gamma_4 + \mu_i + Aging_i\right) - P_{ki}^{5}(t)$$

$$U_{ki}^{0,4}(t) = \begin{cases} \chi(\sum\nolimits_a I_{ki}^{a,4}(t)); & \text{if } i\text{=25-49 years old} \\ 0; & \text{if } i \neq \text{25-49 years old} \end{cases}$$

6. Undetected HIV positive with CD4<200 cells/μL

$$\frac{dI_{ki}^{0,5}(t)}{dt} = Aged_{ki}^{0,5}(t) + I_{ki}^{0,4}(t)\gamma_4 + W_{ki}^{6}(t) + U_{ki}^{0,5}(t) - I_{ki}^{0,5}(t)\left(\tau_{ki}^{2}(t) + \gamma_5 + \mu_i + Aging_i\right) - P_{ki}^{6}(t)$$

$$U_{ki}^{0,5}(t) = \begin{cases} \chi(\sum\nolimits_a I_{ki}^{a,5}(t)); & \text{if } i\text{=25-49 years old} \\ 0; & \text{if } i \neq \text{25-49 years old} \end{cases}$$

7. Detected/untreated HIV positive with CD4>500 cells/μL

$$\frac{dI_{ki}^{1,2}(t)}{dt} = Aged_{ki}^{1,2}(t) + I_{ki}^{0,2}(t)\tau_{ki}^{1}(t) + l_k(I_{ki}^{2,2}(t) + I_{ki}^{3,2}(t)) + W_{ki}^{7}(t) + P_{ki}^{7}(t) - I_{ki}^{1,2}(t)\left(\rho_2(t) + \gamma_2 + \mu_i + Aging_i\right)$$

8. Detected/untreated HIV positive with CD4 between 350 and 500 cells/μL

$$\frac{dI_{ki}^{1,3}(t)}{dt} = Aged_{ki}^{1,3}(t) + I_{ki}^{1,2}(t)\gamma_2 + I_{ki}^{0,3}(t)\tau_{ki}^{1}(t) + l_k(I_{ki}^{2,3}(t) + I_{ki}^{3,3}(t)) + W_{ki}^{8}(t) + P_{ki}^{8}(t) - I_{ki}^{1,3}(t)\left(\rho_3(t) + \gamma_3 + \mu_i + Aging_i\right)$$

9. Detected/untreated HIV positive with CD4 between 200 and 349 cells/μL

$$\frac{dI_{ki}^{1,4}(t)}{dt} = Aged_{ki}^{1,4}(t) + I_{ki}^{1,3}(t)\gamma_3 + I_{ki}^{0,4}(t)\tau_{ki}^{1}(t) + l_k(I_{ki}^{2,4}(t) + I_{ki}^{3,4}(t)) + W_{ki}^{9}(t) + P_{ki}^{9}(t) - I_{ki}^{1,4}(t)\left(\rho_4(t) + \gamma_4 + \mu_i + Aging_i\right)$$

10. Detected/untreated HIV positive with CD4 <200 cells/μL

$$\frac{dI_{ki}^{1,5}(t)}{dt} = Aged_{ki}^{1,5}(t) + I_{ki}^{1,4}(t)\gamma_4 + I_{ki}^{0,5}(t)\tau_{ki}^{2}(t) + l_k(I_{ki}^{2,5}(t) + I_{ki}^{3,5}(t)) + W_{ki}^{10}(t) + P_{ki}^{10}(t) - I_{ki}^{1,5}(t)\left(\rho_4(t) + \gamma_5 + \mu_i + Aging_i\right)$$

11. Treated HIV positive, with detectable viral load and CD4>500 cells/μL

$$\frac{dI_{ki}^{2,2}(t)}{dt} = Aged_{ki}^{2,2}(t) + \rho_2(t)(I_{ki}^{1,2}(t) + I_{ki}^{4,2}(t)) + W_{ki}^{11} + P_{ki}^{11}(t) - I_{ki}^{2,2}(t)\left(l_k + \vartheta + \omega_1 + \mu_i + Aging_i\right)$$

12. Treated HIV positive, with detectable viral load and CD4 between 350 and 500 cells/μL

$$\frac{dI_{ki}^{2,3}(t)}{dt} = Aged_{ki}^{2,3}(t) + \rho_3(t)(I_{ki}^{1,3}(t) + I_{ki}^{4,3}(t)) + W_{ki}^{12}(t) + P_{ki}^{12}(t) - I_{ki}^{2,3}(t)\left(l_k + \vartheta + \omega_2 + \mu_i + Aging_i\right)$$

13. Treated HIV positive, with detectable viral load and CD4 between 200 and 349 cells/μL

$$\frac{dI_{ki}^{2,4}(t)}{dt} = Aged_{ki}^{2,4}(t) + \rho_4(t)(I_{ki}^{1,4}(t) + I_{ki}^{4,4}(t)) + W_{ki}^{13}(t) + P_{ki}^{13}(t) - I_{ki}^{2,4}(t)\left(l_k + \vartheta + \omega_3 + \mu_i + Aging_i\right)$$

14. Treated HIV positive, with detectable viral load and CD4<200 cells/μL

$$\frac{dI_{ki}^{2,5}(t)}{dt} = Aged_{ki}^{2,5}(t) + \rho_5(t)(I_{ki}^{1,5}(t) + I_{ki}^{4,5}(t)) + W_{ki}^{14}(t) + P_{ki}^{14}(t) - I_{ki}^{2,5}(t)\left(l_k + \vartheta + \omega_4 + \mu_i + Aging_i\right)$$

15. Treated HIV positive, with undetectable viral load and CD4>500 cells/μL

$$\frac{dI_{ki}^{3,2}(t)}{dt} = Aged_{ki}^{3,2s}(t) + I_{ki}^{2,2}(t)\vartheta + W_{ki}^{15} - I_{ki}^{3,2}(t)\left(l_k + \varphi + \omega_1 + \mu_i + Aging_i\right)$$

16. Treated HIV positive, with undetectable viral load and CD4 between 350 and 500 cells/μL

$$\frac{dI_{ki}^{3,3}(t)}{dt} = Aged_{ki}^{3,3}(t) + I_{ki}^{2,3}(t)\vartheta + W_{ki}^{16}(t) - I_{ki}^{3,3}(t)\left(l_k + \varphi + \omega_2 + \mu_i + Aging_i\right)$$

17. Treated HIV positive, with undetectable viral load and CD4 between 200 and 349 cells/μL

$$\frac{dI_{ki}^{3,4}(t)}{dt} = Aged_{ki}^{3,4}(t) + I_{ki}^{2,4}(t)\vartheta + W_{ki}^{17}(t) - I_{ki}^{3,4}(t)\left(l_k + \varphi + \omega_3 + \mu_i + Aging_i\right)$$

18. Treated HIV positive, with undetectable viral load and CD4<200 cells/μL

$$\frac{dI_{ki}^{3,5}(t)}{dt} = Aged_{ki}^{3,5}(t) + I_{ki}^{2,5}(t)\vartheta + W_{ki}^{18}(t) - I_{ki}^{3,5}(t)\left(l_k + \varphi + \omega_4 + \mu_i + Aging_i\right)$$

19. HIV positive experiencing treatment failure and with CD4>500 cells/μL

$$\frac{dI_{ki}^{4,2}(t)}{dt} = Aged_{ki}^{4,2}(t) + I_{ki}^{3,2}(t)\varphi + W_{ki}^{19}(t) - I_{ki}^{4,2}(t)\left(\gamma_2 + \rho_2(t) + \mu_i + Aging_i\right)$$

20. HIV positive experiencing treatment failure and with CD4 between 350 and 500 cells/μL

$$\frac{dI_{ki}^{4,3}(t)}{dt} = Aged_{ki}^{4,3}(t) + I_{ki}^{3,3}(t)\varphi + I_{ki}^{4,2}(t)\gamma_2 + W_{ki}^{20}(t) - I_{ki}^{4,3}(t)\left(\gamma_3 + \rho_3(t) + \mu_i + Aging_i\right)$$

21. HIV positive experiencing treatment failure and with CD4 between 200 and 349 cells/μL

$$\frac{dI_{ki}^{4,4}(t)}{dt} = Aged_{ki}^{4,4}(t) + I_{ki}^{3,4}(t)\varphi + I_{ki}^{4,3}(t)\gamma_3 + W_{ki}^{21}(t) - I_{ki}^{4,4}(t)\left(\gamma_4 + \rho_4(t) + \mu_i + Aging_i\right)$$

22. HIV positive experiencing treatment failure and with CD4<200 cells/μL

$$\frac{dI_{ki}^{4,5}(t)}{dt} = Aged_{ki}^{4,5}(t) + I_{ki}^{3,5}(t)\varphi + I_{ki}^{4,4}(t)\gamma_4 + W_{ki}^{22}(t) - I_{ki}^{4,5}(t)\left(\gamma_5 + \rho_5(t) + \mu_i + Aging_i\right)$$

Text S3. Equations for the force of infection.

The force of infection (FOI) is defined as the annual probability of HIV transmission from an individual of risk group *j* and age class *l* to an individual of risk group *k* and age class *i* [54]. Five equations are used to describe the force of infection, depending on partnership and type of sexual contacts in the partnership: 1) vaginal female-to-male or 2) vaginal male-to-female, 3) receptive and insertive anal male-to-male, 4) vaginal and anal female-to-male, 4) vaginal and anal male-to-female. The $\lambda_{kijl}(t)$ matrix contains the FOI for each partnership combination of category *k/j* and age *i/l*, where the susceptible partner is the one indexed by *ki*.

1) Force of infection for HIV transmission between a female (j) and a male (k).

$$\lambda_{kijl}(t) = c^*_{kijl} p_{kijl} \left[\sum_a^s \left(\left(\frac{I_{jl}^{as}(t)}{\sum_a^s I_{jl}^{as}(t) + S_{jl}(t)} \right) \left(1 - \left(\left(1 - \beta_{fm} R_{ji}^{as} \right)^{\alpha_{kijl}(1-v_{ki}(t))} \left(1 - \beta_{fm} R_{ji}^{as} (1-\varsigma) \right)^{\alpha_{kijl}(v_{ki}(t))} \right) \right) \right) \right]$$

(2) Force of infection for HIV transmission between a male (j) and a female (k).

$$\lambda_{kijl}(t) = c^*_{kijl} p_{kijl} \left[\sum_a^s \left(\left(\frac{I_{jl}^{as}(t)}{\sum_a^s I_{jl}^{as}(t) + S_{jl}(t)} \right) \left(1 - \left(\left(1 - \beta_{mf} R_{ji}^{as} \right)^{\alpha_{kijl}(1-v_{ki}(t))} \left(1 - \beta_{mf} R_{ji}^{as} (1-\varsigma) \right)^{\alpha_{kijl}(v_{ki}(t))} \right) \right) \right) \right]$$

(3) Force of infection for HIV transmission between a male (j) and a male (k).

$$\lambda_{kijl}(t) = c^*_{kijl} p_{kijl} \left[\sum_a^s \left(\left(\frac{I_{jl}^{as}(t)}{\sum_a^s I_{jl}^{as}(t) + S_{jl}(t)} \right) \left(1 - \left(\begin{array}{l} \left(1 - \beta_{fm} Z_{ji}{}^{as} \right)^{\alpha_{kijl}(1-v_{ki}(t))*0.5} \left(1 - \beta_{fm} Z_{ji}{}^{as} (1-\varsigma) \right)^{\alpha_{kijl}(v_{ki}(t))*0.5} \\ \left(1 - \beta_{mf} L_{ji}{}^{as} \right)^{\alpha_{kijl}(1-v_{ki}(t))*0.5} \left(1 - \beta_{mf} L_{ji}{}^{as} (1-\varsigma) \right)^{\alpha_{kijl}(v_{ki}(t))*0.5} \end{array} \right) \right) \right) \right]$$

(4) Force of infection for HIV transmission between a female (j) and a male (k) who engage in both anal and vaginal intercourse.

$$\lambda_{kijl}(t) = c^*_{kijl} p_{kijl} \left[\sum_a^s \left(\left(\frac{I_{jl}^{as}(t)}{\sum_a^s I_{jl}^{as}(t) + S_{jl}(t)} \right) \left(1 - \left(\begin{array}{l} \left(1 - \beta_{mf} R_{ji}{}^{as} \right)^{VI_{kijl}(1-v_{ki}(t))} \left(1 - \beta_{mf} R_{ji}{}^{as} (1-\varsigma) \right)^{VI_{kijl}(v_{ki}(t))} \\ \left(1 - \beta_{fm} L_{ji}{}^{as} \right)^{AI_{kijl}(1-CondAI(t))} \left(1 - \beta_{fm} L_{ji}{}^{as} (1-\varsigma) \right)^{AI_{kijl}(CondAI(t))} \end{array} \right) \right) \right) \right]$$

(5) Force of infection for HIV transmission between a male (j) and a female (k) who engage in both anal and vaginal intercourse.

$$\lambda_{kijl}(t) = c^*_{kijl} p_{kijl} \left[\sum_a^s \left(\left(\frac{I_{jl}^{as}(t)}{\sum_a^s I_{jl}^{as}(t) + S_{jl}(t)} \right) \left(1 - \left(\begin{array}{l} \left(1 - \beta_{mf} R_{ji}{}^{as} \right)^{VI_{kijl}(1-v_{ki}(t))} \left(1 - \beta_{mf} R_{ji}{}^{as} (1-\varsigma) \right)^{VI_{kijl}(v_{ki}(t))} \\ \left(1 - \beta_{mf} Z_{ji}{}^{as} \right)^{AI_{kijl}(1-CondAI(t))} \left(1 - \beta_{mf} Z_{ji}{}^{as} (1-\varsigma) \right)^{AI_{kijl}(CondAI(t))} \end{array} \right) \right) \right) \right]$$

Where c^*_{kijl} is the balanced partner change rate and p_{kijl} is the probability of a sexual contact between an individual of risk category *k* and age class *i* with an individual of risk category *j* and age class *l*. The terms β_{mf} and β_{fm} represent the per act probability of HIV transmission from an infected partner with whom receptive vaginal intercourse (β_{mf}) and insertive vaginal intercourse (β_{fm}) is performed, respectively. The matrix $R_{ji}{}^{as}$ contains the coefficients for the relative risk of HIV

transmission associated with different stages of infection (indexed by superscript *a*), treatment (indexed by superscript *s*), or susceptibility of young women (*i*).

For the FOI between two males (Equation 3), two matrices of coefficients are introduced and they contain the relative risk estimates specific to anal intercourse. Z_{ji}^{as} is similar to R_{ji}^{as}, except that it includes relative risks that take into account the increased probability of HIV transmission for receptive anal intercourse. Similarly, the matrix L_{ji}^{as} contains the relative risks that take into account the increased probability of HIV transmission resulting from insertive anal intercourse. It was assumed that, within each MSM partnership, half of sex acts would be performed as the receptive partner and the other half as the insertive partner. When both anal and vaginal intercourse are involved in a partnership (Equations 4 and 5), it was assumed that each sexual contact would either involve anal intercourse or vaginal intercourse - but not both.

Condom efficacy was modeled using the term ς, which reduces the probability of HIV transmission. The proportion of sex acts protected by a condom is equal to $v_{ki}(t)$ and the number of sex acts between individuals *ki* and *jl* is α_{kijl}. When both vaginal and anal sex acts are involved in a partnership, we divided these sex acts between those that are vaginal ($VI_{kijl}= \alpha_{kijl}*(1-Pr_{ActsAI})$) and anal ($AI_{kijl}= \alpha_{kijl}*Pr_{ActsAI}$). It should be noted that the additive scale was used to calculate the effect of multiple risk factors in matrices R_{ji}^{as}, L^{as}, and Z_{ji}^{as}. This was necessary because the multiplicative risk scale resulted, for some combination of parameters, in per act transmission probability greater than one. This suggested interaction of some risk factors on the multiplicative scale and provided evidence that the additive scale was more appropriate. When the effect was protective (reducing transmission), however, we used the multiplicative scale as not to underestimate the impact of potential interventions. This matrix was calculated as follows:

$$R_{ji}^{as} = \begin{cases} RR_{Acute}; & \text{for } j=(1{:}9);\ i=(1{:}4);\ a=0;\ \text{and } s=1 \\ 1+(RR_{Acute}-1)+(RR_{YoungFem}-1); & \text{for } j=(5{:}8);\ i=(1,2);\ a=0;\ \text{and } s=1 \\ 1; & \text{for } j=(1{:}9);\ i=(1{:}4);\ a=(0,1,4);\ \text{and } s=(2{:}5) \\ RR_{YoungFem}; & \text{for } j=(5{:}8);\ i=(1,2);\ a=(0,1,4);\ \text{and } s=(2{:}5) \\ RR_{VLD}; & \text{for } j=(1{:}9);\ i=(1{:}4);\ a=2;\ \text{and } s=(2{:}5) \\ RR_{VLD}RR_{YoungFem}; & \text{for } j=(5{:}8);\ i=(1,2);\ a=2;\ \text{and } s=(2{:}5) \\ RR_{ART}; & \text{for } j=(1{:}9);\ i=(1{:}4);\ a=3;\ \text{and } s=(2{:}5) \\ RR_{ART}RR_{YoungFem}; & \text{for } j=(5{:}8);\ i=(1,2);\ a=3;\ \text{and } s=(2{:}5) \end{cases}$$

$$Z_{ji}^{as} = \begin{cases} 1+(RR_{Acute}-1)+(RR_{RAI}-1); & \text{for } j=(7{:}9);\ i=(1{:}4);\ a=0;\ \text{and } s=1 \\ 1+(RR_{Acute}-1)+(RR_{YoungFem}-1)+(RR_{RAI}-1); & \text{for } j=7;\ i=(1,2);\ a=0;\ \text{and } s=1 \\ RR_{RAI}; & \text{for } j=(7{:}9);\ i=(1{:}4);\ a=(0,1,4);\ \text{and } s=(2{:}5) \\ 1+(RR_{YoungFem}-1)+(RR_{RAI}-1); & \text{for } j=7;\ i=(1,2);\ a=(0,1,4);\ \text{and } s=(2{:}5) \\ RR_{VLD}RR_{RAI}; & \text{for } j=(7{:}9);\ i=(1{:}4);\ a=2;\ \text{and } s=(2{:}5) \\ RR_{VLD}(1+(RR_{AI}-1)+(RR_{YoungFem}-1)); & \text{for } j=7;\ i=(1,2);\ a=2;\ \text{and } s=(2{:}5) \\ RR_{ART}RR_{RAI}; & \text{for } j=(7{:}9);\ i=(1{:}4);\ a=3;\ \text{and } s=(2{:}5) \\ RR_{ART}(1+(RR_{AI}-1)+(RR_{YoungFem}-1)); & \text{for } j=7;\ i=(1,2);\ a=3;\ \text{and } s=(2{:}5) \end{cases}$$

$$L_{ji}^{as} = \begin{cases} 1+(RR_{Acute}-1)+(RR_{IAI}-1); & \text{for } j=(4,8,9);\ i=(1{:}4);\ a=0;\ \text{and } s=1 \\ RR_{IAI}; & \text{for } j=(4,8,9);\ i=(1{:}4);\ a=(0,1,4);\ \text{and } s=2{:}5 \\ RR_{VLD}RR_{IAI}; & \text{for } j=(4,8,9);\ i=(1{:}4);\ a=2;\ \text{and } s=2{:}5 \\ RR_{ART}RR_{IAI}; & \text{for } j=(4,8,9);\ i=(1{:}4);\ a=3;\ \text{and } s=2{:}5 \end{cases}$$

Text S4. Equations for the vertical transmission of HIV.

The decision tree describing mother-to-child transmission of HIV can be translated into the following set of equations. The number of babies, born to HIV positive mothers at time *t*, who became infected is equal to $BB_{HIV}(t)$. Note that the equations below only apply for females ($k=1,2,3,4$).

$$BB_{HIV}(t) = \sum_{i=1}^{3}\left(\Upsilon_i(t)\sum I_{ki}^{as}(t)\right)\begin{pmatrix}\left(\left(1-\delta_i(t)-\Psi(t)\right)+\delta_i(t)\left(1-\kappa(t)-\phi(t)\right)\right)MTCT(t)+\\ \left(\delta_i(t)\kappa(t)\right)PMTCT_{Px}(t)+\\ \left(\delta_i(t)\phi(t)\right)PMTCT_{Tx}(t)+\\ \Psi(t)\,ART\end{pmatrix}$$

where $\Upsilon_i(t) = ASFR_i(t) * RR_{Fert}$

The age-specific fertility rates of HIV positive women at time *t* ($\Upsilon_i(t)$) are used to estimate the number of expected pregnancies. All pregnancies are assumed to be singleton. The number of pregnancies from HIV positive women is then multiplied by peripartum and postpartum transmission probabilities for the different interventions and distribution of women among the different model's compartments: women not tested or that did not access antenatal care [$(1-\delta_i(t) - \psi(t)) + \delta_i(t)(1- \kappa(t) - \phi(t)))MTCT$], those that are tested and received ART prophylaxis [$(\delta_i(t)\kappa(t))PMTCT_{Px}(t))$], those that are tested and received ART treatment [$(\delta_i(t)\phi(t))PMTCT_{Tx}(t))$], and those already receiving ART treatment before becoming pregnant [$\psi(t)ART$]. The transmission probabilities are described below.

$$MTCT(t) = A\begin{pmatrix}\left(\beta_{<200}^{0} + (1-(1-\beta_{BF<350}^{0})^{D})\right)\frac{\sum_{i=1}^{3} I_{ki}^{a5}(t)}{\sum_{i=1}^{3} I_{ki}^{as}(t)} +\\ \left(\beta_{<350}^{0} + (1-(1-\beta_{BF<350}^{0})^{D})\right)\frac{\sum_{i=1}^{3} I_{ki}^{a4}(t)}{\sum_{i=1}^{3} I_{ki}^{as}(t)} +\\ \left(\beta_{\geq 350}^{0} + (1-(1-\beta_{BF\geq 350}^{0})^{D})\right)\frac{\sum_{i=1}^{3}\sum_{s=1}^{3} I_{ki}^{as}(t)}{\sum_{i=1}^{3} I_{ki}^{as}(t)}\end{pmatrix}$$
$$+ (1-A)\left(\beta_{<200}^{0}\frac{\sum_{i=1}^{3} I_{ki}^{a5}(t)}{\sum_{i=1}^{3} I_{ki}^{as}(t)} + \beta_{<350}^{0}\frac{\sum_{i=1}^{3} I_{ki}^{a4}(t)}{\sum_{i=1}^{3} I_{ki}^{as}(t)} + \beta_{\geq 350}^{0}\frac{\sum_{i=1}^{3}\sum_{s=1}^{3} I_{ki}^{a4}(t)}{\sum_{i=1}^{3} I_{ki}^{as}(t)}\right)$$

The proportion of infant being breastfed is equal to *A* and the average duration of any breastfeeding is equal to *D* months. Women receiving PMTCT were assumed not to reduce their breastfeeding period, in line with qualitative data on the topic [55]. The vector β_x^0 contains the peripartum transmission probabilities in the absence of prevention interventions. Similarly, the vector β_{BFx}^0 has the monthly postpartum probability of HIV transmission from any breastfeeding in the absence of prevention interventions. Because the probability of transmission is a function of CD4 count concentrations, the *x* subscript is associated with the following categories of CD4 cell counts: less than 200 CD4 cells/µL ($\beta_{<200}^0$), between 200 and 349 CD4 cells/µL ($\beta_{<350}^0$), and >350 CD4 cells/µL ($\beta_{>350}^0$). These probabilities are then added and weighted according to the distribution of women in the different stages of infection at time *t*.

$$PMTCT_{Px}(t) = A\left(\begin{array}{l}\left(\beta_{Px}^{t} + (1-(1-\beta_{BF<350}^{t})^{D})\right)\dfrac{\sum_{i=1}^{3}\sum_{s=4}^{5} I_{ki}^{as}(t)}{\sum_{i=1}^{3} I_{ki}^{as}(t)} + \\ \left(\beta_{Px}^{t} + (1-(1-\beta_{BF\geq 350}^{t})^{D})\right)\dfrac{\sum_{i=1}^{3}\sum_{s=1}^{3} I_{ki}^{as}(t)}{\sum_{i=1}^{3} I_{ki}^{as}(t)}\end{array}\right) + (1-A)(\beta_{Px}^{t})$$

PMTCT interventions evolved in time and the vector $\beta_{Px}{}^{t}$ contains the peripartum probability of transmission for the type of interventions available at time *t* (see Table S4 for details). These probabilities do not depend on CD4 count concentrations. The vector $\beta_{BFx}{}^{t}$ has the monthly probabilities of HIV transmission due to breastfeeding. These probabilities differ according to CD4 cell counts, except when the available intervention is the Option A/B in which case the same probabilities are used regardless of CD4 cell counts.

$$PMTCT_{Tx}(t) = \mathrm{A}\left(\beta_{Tx} + \left((1-(1-\beta_{BFTx})^{D})\right)\right) + (1-\mathrm{A})\left(\beta_{Tx}\right)$$

When a woman is put on lifelong ART during her pregnancy, the probability of peripartum HIV transmission is β_{Tx}. During breastfeeding, infants are still protected by their mothers' intake of ART, and the monthly probability of postpartum transmission is equal to β_{BFTx}.

$$ART = \mathrm{A}\left(\beta_{ARV} + \left((1-(1-\beta_{BFART})^{D})\right)\right) + (1-\mathrm{A})\left(\beta_{ART}\right)$$

Similarly, when a woman is already on ART before getting pregnant, the probability of peripartum HIV transmission is β_{ARV}. Finally, the monthly probability of postpartum transmission due to breastfeeding is equal to β_{BFARV}.

Text S5. Details on the estimation of historical trends in the proportion of sex acts protected by a condom, HIV testing, prevention of mother-to-child transmission, and antiretroviral therapy coverage.

Proportion of sex acts protected by a condom

Few estimates on the proportion of sex acts protected by condoms ($v_{ki}(t)$) were available during the 1980s. We used data from the 1980-81 World Fertility Survey (WFS) as an approximation of the baseline proportion of condom-protected sex acts [42, 43]. The next estimates available are from the early-to-mid 1990s, depending on the risk groups. The latter are considerably higher than reports found in the 1980-81 WFS. Because of the uncertainties associated with the timing of increases in condom use, the model was parameterized using a uniform prior distribution for the date condom use begun to increase between 1981 and 1990 ($DateCond_k$). Independent distributions were used for the following groups: general population, FSW, and MSM. Because each estimate of condom use had its associated uncertainty, and to maintain temporal consistency, the following quantities were computed by uniformly sampling a percentile of the uniform distribution for all time points were data was available. (Figure A).

$$v_{ki}(t) = \begin{cases} Condom_i(t) * CondPtl; & \text{for } k=(1,2,5,6,7) \\ CondomSW(t) * CondSWPtl; & \text{for } k=(3,4) \\ CondomMSM(t) * CondMSMPtl; & \text{for } k=(8,9) \end{cases}$$

Date of condom increase during the 1980s

$$v_{ki}(DateCond_k) = v_{ki}(1981)$$

For Anal Intercourse during Sex Work

$$CondAI(t) = v_4(t) * RR_{CondAI}$$

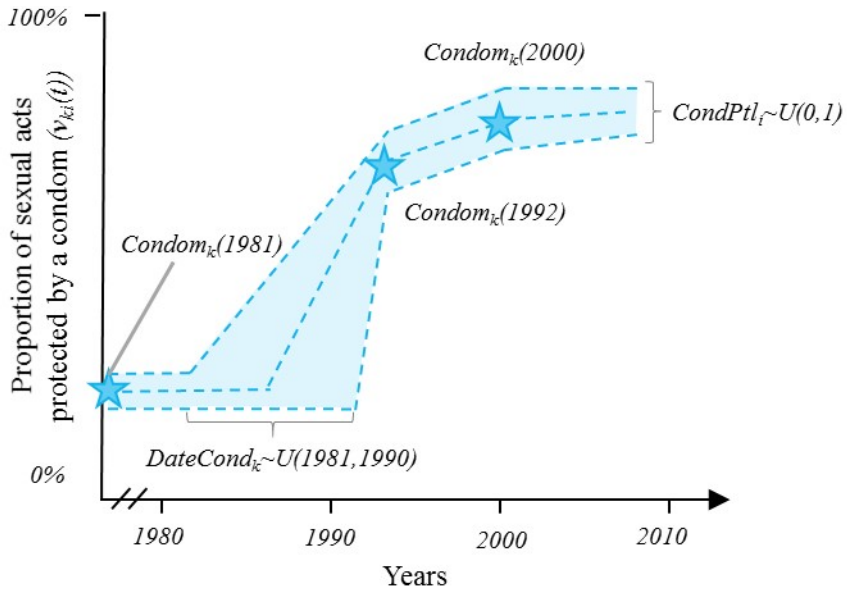

Figure A: Schematic representation of historical trends estimation of the proportion of sex acts protected by condoms. The stars represent data points from which survey estimates are available. These are sampled by using the same percentile ($CondPtl_i$) of their range. No data points are available from 1981 to 1990s and condom use during that period rose rapidly. The specific date of increase remains unknown, however. This

uncertainty was taken into account by maintaining fixed the proportion of sex acts protected by a condom until a specific date has been reached ($DateCond_k$), date after which condom use increased.

Finally, a shape-preserving cubic piecewise interpolation was used to estimate the proportion of sex acts protected by condoms for the years were this information was not available (the figure above represents linear interpolation for ease of visualization). Extrapolation beyond the last available estimate (i.e., the 2011-12 Demographic and Health Survey) was achieved by assuming that this estimate would remain constant.

HIV testing

The first population-based survey that collected information on HIV testing was conducted in 2000 [45]. It only recorded if women reported having ever been tested for HIV and it was not possible to know if it was as part of antenatal care visits (ANC). The survey's results show that 3.9% and 6.0% of women had ever been tested for HIV among the 15-24 and 25-49 years old, respectively. We therefore conservatively assumed testing rates of zero for men and women before 1996. The 2005 AIDS Indicator Survey and 2011-12 Demographic and Health Survey were used to inform testing rates and proportions of pregnant women accessing ANC and being tested [5, 6]. The probabilities of being tested for HIV during the last year were converted to yearly rate using the following formula: *Rate = -ln(1-Prob)/t*. Testing rates for each risk and age categories were computed as followed for each date were data was available:

$$\tau_{ki}^{\ s}(t) = \begin{cases} \tau_{ki}^{\ 0}(TestPtl); & \text{for } k=(1,2,5,6,7) \text{ and } s=(2,3,4) \\ \tau_{ki}^{\ 0}(Symp\_RR_{Test})Test; & \text{for } k=(1,2,5,6,7) \text{ and } s=5 \\ \tau_{ki}^{\ 0}(FSW\_RR_{Test})TestPtl; & \text{for } k=(3,4) \text{ and } s=(2,3,4) \\ \tau_{ki}^{\ 0}(1+(FSW\_RR_{Test}-1)+(Symp\_RR_{Test}-1))TestPtl; & \text{for } k=(3,4) \text{ and } s=5 \\ \tau_{ki}^{\ 0}(MSM\_RR_{Test})TestPtl; & \text{for } k=(8,9) \text{ and } s=(2,3,4) \\ \tau_{ki}^{\ 0}((1+(MSM\_RR_{Test}-1)+(Symp\_RR_{Test}-1))TestPtl; & \text{for } k=(8,9) \text{ and } s=5 \end{cases}$$

HIV testing for pregnant women as part of ANC visits were calculated as followed (this is the marginal probability of ANC attendance and of being tested for HIV):

$$\delta_i(t) = ANC\tau_i * ANCPtl$$

HIV testing rates and probability of being tested for pregnant women were both interpolated using a shape-preserving cubic piecewise algorithm. Because programmatic data [34-39, 47] suggested a sustained increased in HIV testing rates beyond 2012, we extrapolated the trends observed during the 2005-2012 period over the 2012-2015 period.

Prevention of mother-to-child transmission

In 2002, only 16 sites were offering prevention of mother-to-child transmission (PMTCT) interventions [56]. It is further believed that, prior to 2005, PMTCT interventions were only available in urban areas of Côte d'Ivoire [46]. Information on the historical trends in coverage of PMTCT activities were abstracted from government reports available from 2002 onwards [34-39, 47]. For each year were such data was available, we computed the following quantities:

$$\kappa(t) = K(t)(ARTPxPtl)$$
$$\phi(t) = \Phi(t)(ARTTxPtl)$$

Again, a shape-preserving cubic piecewise interpolation was used to estimate the trends in coverage of PMTCT activities. Extrapolation beyond the last available estimate was achieved by assuming that this estimate would remain constant.

Antiretroviral therapy

The UNAIDS initiative's pilot phase for treatment access was officially launched in Côte d'Ivoire in November of 1997 and was supposed to provide ART to 4,000 individuals [57]. In August of 1998, the Minister of Health announced at a press conference that ART would become effectively accessible at the end of that month. At that time, the only individuals benefiting from free/subsidized ART in Côte d'Ivoire were those enrolled in clinical trials. From August 1998 to March 2000, 422 patients enrolled in the Retro-CI project were able to access ART [57]. In May of 2002, it is reported that 703 patients had obtained ART in Côte d'Ivoire [57]. Ministry of Health data indicated that a total of 3,190 individuals received ART from 1998 to 2002 [56]. For the purpose of the modeling exercise, it was assumed that individuals could receive ART after 2000. Comprehensive data on the number of people receiving ART was abstracted from government reports for the years 2002 and from 2007 to 2014 [34-39, 47].

Precise quantification of ART coverage scale-up and differential recruitment into ART according to CD4 cell counts is difficult. ART eligibility criteria were expanded in 2012 to include all patients with a CD4≤350 cells/μL or with WHO stage 4 clinical disease [58] but the country has yet to adopt the new WHO guidelines [59]. Further, CD4 cell counts are not believed to have been widely available in Côte d'Ivoire [39]. A flexible approach was therefore adopted. Specifically, we assumed that ART coverage would increase at a rate corresponding to the ratio of number of individuals on ART at time t to the number of individuals on ART in 2015. The parameter $\sigma(t)$ is used to identify availability of ART at time t and linearly varied (as suggested by data on ART coverage) from 0 in 2000, to 0.018 in 2003 (2399/133143), to 1 in 2015. Individuals with low CD4 cell counts (i.e., <200 CD4 cells/μL) could be more likely to exhibit clinical symptoms and, thereby, to be recruited on ART. A linear relation was thus assumed between CD4 count stage and recruitment rate using parameter ι. This parameter was given a non-informative prior, uniformly distributed between 0 and 1 so that lower CD4 cell counts had higher recruitment rates. The model was calibrated using the <200 CD4 cells/μL stage as the referent category. For this stage, it was assumed that the recruitment rate into ART (in 2015) would be between 0.5 and 4 years (ρ_5). Recruitment rate was hence modeled using the following equation:

$$\rho_s(t) = \rho_s \sigma(t)$$

where

$$m = \left((0 - \rho_5)/9.25\right)\iota$$

$$\rho_4 = 3m + \rho_5$$

$$\rho_3 = 6m + \rho_5$$

$$\rho_2 = 9m + \rho_5$$

$$\iota \sim U(0,1)$$

$$\rho_5 \sim U(0.5,4)$$

Text S6. Statistical adjustments for the imperfect accuracy of diagnostic assays.

The sensitivity and specificity of the diagnostic assays of all HIV surveys used for model fitting were reviewed. It was found that some of those conducted prior to 1990 used an ELISA (Elavia, Diagnostic Pasteur) which has a low specificity of 89% (95% Confidence Interval (CI): 81-96%) on African sera [60]. Because concerns regarding false positives, these surveys performed Western blots as a confirmatory assay on the positive sera. When the disease is relatively rare, however, an imperfect specificity could overestimate HIV prevalence. Further, despite being described as having high specificity, Western blots are technically challenging to perform, with results that are subjectively assessed and cumbersome to interpret, and the methodology lacks standardization [61, 62]. There is thus the possibility that suboptimal laboratory conditions and/or training of laboratory technicians could have compromised specificity of these confirmatory Western Blots.

The HIV prevalence estimates prior to 1990 were adjusted for potential misclassification using a Bayesian latent class model that accounts for the conditional dependence between the ELISA and the Western Blots [63, 64]. Since these two tests targeted some of the same antibodies, high correlation between the two tests are expected [65]. The model takes the following form:

$$\text{Likelihood:}$$
$$y_i \sim binomial(p_i, N_i)$$
$$p_i = \pi_i(Se_1 Se_2 + \gamma_{Se}) + (1-\pi_i)\left((1-Sp_1)(1-Sp_2) + \gamma_{Sp}\right)$$

where y_i is the number of individuals with reactive HIV assays in population i; N_i is the total number of individuals tested; p_i is the probability of having a reactive assay; π_i is the true (unobserved) probability of being HIV positive; Se_1 and Se_2 are the sensitivities of the ELISA and Western Blots, respectively; Sp_1 and Sp_2 are the specificities of the ELISA and Western Blots, respectively; and γ_{Se} and γ_{Sp} are the conditional covariance for sensitivity and specificity, respectively. The model specification is completed by the following priors:

$$\text{Priors:}$$
$$\pi_i \sim dbeta(\text{a},\text{b}) \quad [\text{Pior varies according to population}]$$
$$Se_1 \sim dbeta(286.83, 1.03) \quad [\text{Corresponds to a 95\%CI: 98.7-99.99\%}]$$
$$Se_2 \sim dbeta(94.46, 0.81) \quad [\text{Corresponds to a 95\%CI: 96.6-99.99\%}]$$
$$Sp_1 \sim dbeta(54.1, 6.18) \quad [\text{Corresponds to a 95\%CI: 81.0-96.0\%}]$$
$$Sp_2 \sim dbeta(154.36, 1.69) \quad [\text{Corresponds to a 95\%CI: 96.8-99.9\%}]$$
$$\rho_{Se} \sim dbeta(5.97, 1.26) \quad [\text{Corresponds to a 95\%CI: 50-99\%}]$$
$$\rho_{Sp} \sim dbeta(5.97, 1.26) \quad [\text{Corresponds to a 95\%CI: 50-99\%}]$$
$$\lambda_{Se} = \min(Se_1, Se_2) - Se_1 Se_2$$
$$\lambda_{Sp} = \min(Sp_1, Sp_2) - Sp_1 Sp_2$$
$$\gamma_{Se} = \rho_{Se}\lambda_{Se}$$
$$\gamma_{Sp} = \rho_{Sp}\lambda_{Sp}$$

The priors for the true (unobserved) HIV prevalence varies according to the population under consideration and were specified using beta distributions. For the general population, we assumed that in 1989 the 95% CI of HIV prevalence would lie in the 0.5% to 7.5% interval. A beta distribution was used to model this prior by matching the percentile of this distribution to the beta distribution. For female sex workers surveyed in 1986-1990, we assumed that the 95% CI of HIV

prevalence would be in the 10% to 90% range. The priors for the sensitivity and specificity of the first assay (Elavia) correspond to the sensitivity and specificity estimated using African sera by Van Kerckhoven [60]. Information on the sensitivity and specificity of the Western Blots performed in Côte d'Ivoire prior to 1991 could not be found. Further, the sensitivity and specificity of the Western Blots vary according to laboratory conditions and the technicians' level of expertise. To be conservative, we used the minimum (discarding one extreme value for sensitivity and two extreme values for specificity) and maximum sensitivity and specificity of now discontinued Western blots reported by the World Health Organization [66] as the lower and upper bound of a 95% confidence intervals. Finally, the conditional covariances of the sensitivities and specificities are expressed as a proportion (ρ_{Se} and ρ_{Sp}) of the maximum degree of dependence (λ_{Se} and λ_{Sp}). Because both ELISA and Western Blots targets similar antibodies for reactivity, we assumed a high degree of dependence between the two tests, where the 95% CI for the proportion of dependence lies in the 50-99% interval.

The model was fitted using Markov chain Monte Carlo simulations and the posterior distributions of the parameters were estimated using JAGS [67, 68]. Inferences are based on three chains of 50,000 iterations, after an initial burn-in of 10,000 iterations (totaling 150,000 iterations). Medians and 95% credible intervals are reported as the summary estimates. The results of the unadjusted (frequentist) and adjusted for imperfect sensitivity and specificity are presented in Table 16. When prevalence of HIV is low, the imperfect specificity has a noticeable impact on prevalence estimates. Hence, these adjusted estimates will be used for model fitting.

Table A. Unadjusted and adjusted HIV prevalence estimates for studies conducted prior to 1991 in Côte d'Ivoire.

Population (year)	Unadjusted	Adjusted for imperfect Sensitivity and Specificity
General population (1989) [48]*		
Women aged 15-24	4.9% (3.4-6.8%)	2.5% (0.9-4.4%)
Women aged 25-54	5.0% (3.7-6.5%)	2.5% (1.0-4.3%)
Women aged 55-64	3.7% (1.5-7.4%)	1.9% (0.4-4.4%)
Men aged 15-24	4.8% (3.3-6.7%)	2.4% (0.8-4.3%)
Men aged 25-54	10.6% (8.6-12.8%)	7.7% (5.5-10.0%)
Men aged 55-64	3.6% (1.7-6.4%)	1.7% (0.4-3.9%)
Overall (15-54; women)	5.0% (4.0-6.1%)	2.5% (1.1-4.1%)
Overall (15-54; men)	8.0% (6.7-9.5%)	5.5% (3.8-7.3%)
Overall (15-54; both sexes)	6.4% (5.6-7.3%)	4.0% (2.6-5.4%)
Female Sex Workers [49]		
1986	37.6% (28.2-47.8%)	36.9% (27.5-46.7%)
1987	39.7% (30.7-49.2%)	38.9% (30.1-48.2%)
1989	48.3% (39.1-57.6%)	47.6% (38.4-56.7%)
1990	69.4% (57.5-79.58%)	68.4% (57.0-78.6%)

*Urban and rural areas were combined to provide nationally representative estimate of HIV prevalence in 1989. This was achieved by assuming that 39% of the population lived in urban areas in 1989 [69]. The numerator and denominator of the combined category were obtained by substituting the original sample size for an effective sample size adjusted for the correct number of degrees of freedom [70]. This was achieved by having calculated the average design effect of the cluster-sampling design of the 2005 AIS and 2011-12 DHS (for rural and urban area separately).

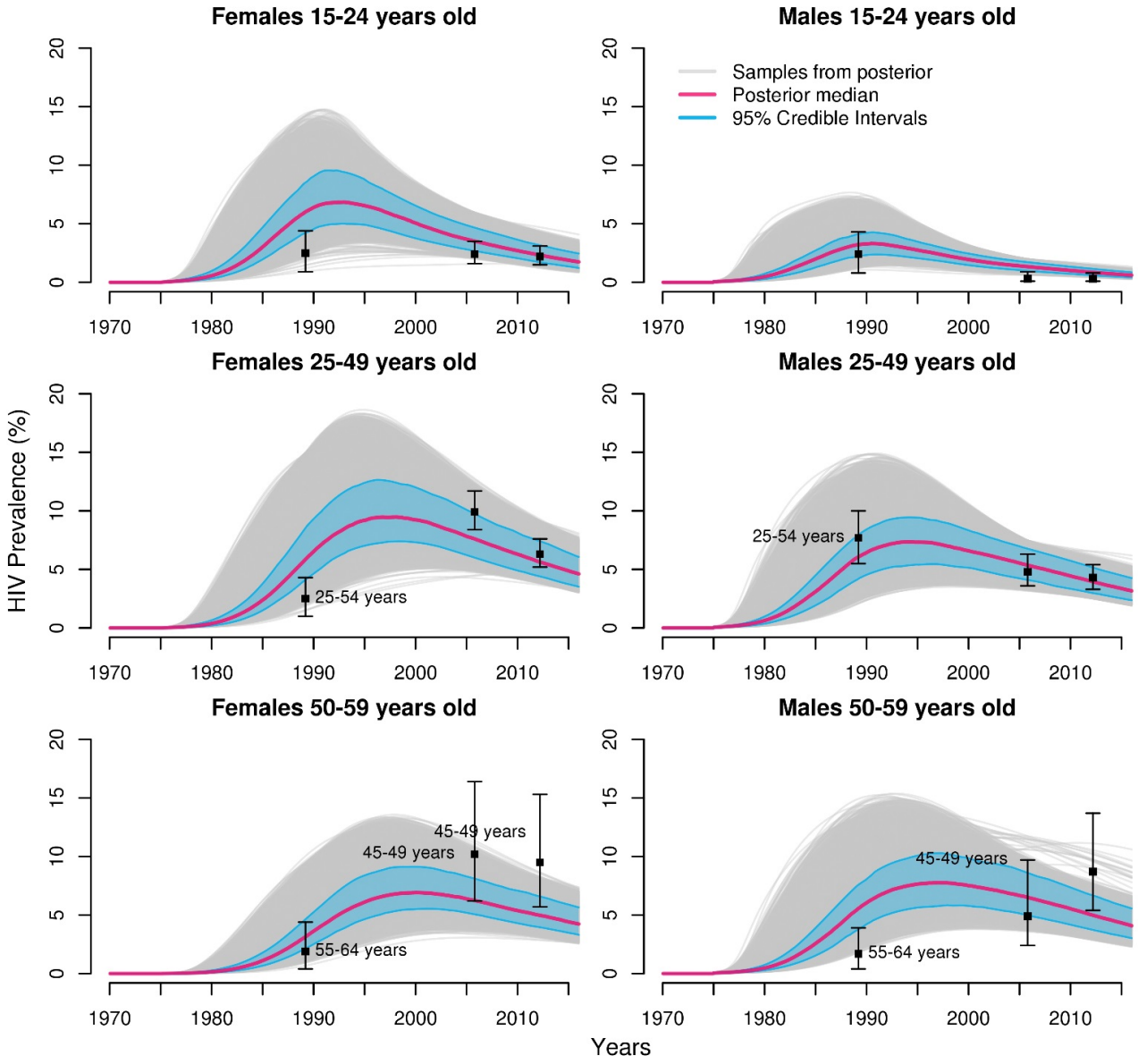

Figure S4. Observed HIV prevalence, to which the model was calibrated to (mean and 95% confidence intervals), and predicted HIV prevalence in the general population of Côte d'Ivoire, stratified by age and sex. FSW are not assumed to be sampled in the household-based HIV prevalence surveys and were excluded in calculating model-based overall prevalence estimates. The 1989 survey grouped together individuals aged 25 to 54 years of age. For the 50-59 age groups, the 1989 survey lumped individuals aged 55 to 64 together. The 2005 AIDS Indicator Survey and the 2012-12 Demographic and Health survey did not sample individuals aged above 50 years (except in 2011-12 for men) and prevalence in the 45-49 years old was used as a proxy. Incremental Mixture Importance Sampling (IMIS) resulted in 41,146 unique sets of parameters labelled samples from posterior (grey curves). One thousand of these curves were resampled with probability proportional to their importance weights to derive the median (red) and 95% credible intervals (shaded blue area). The specific references for the data points plotted on the figures can be found in Table S9.

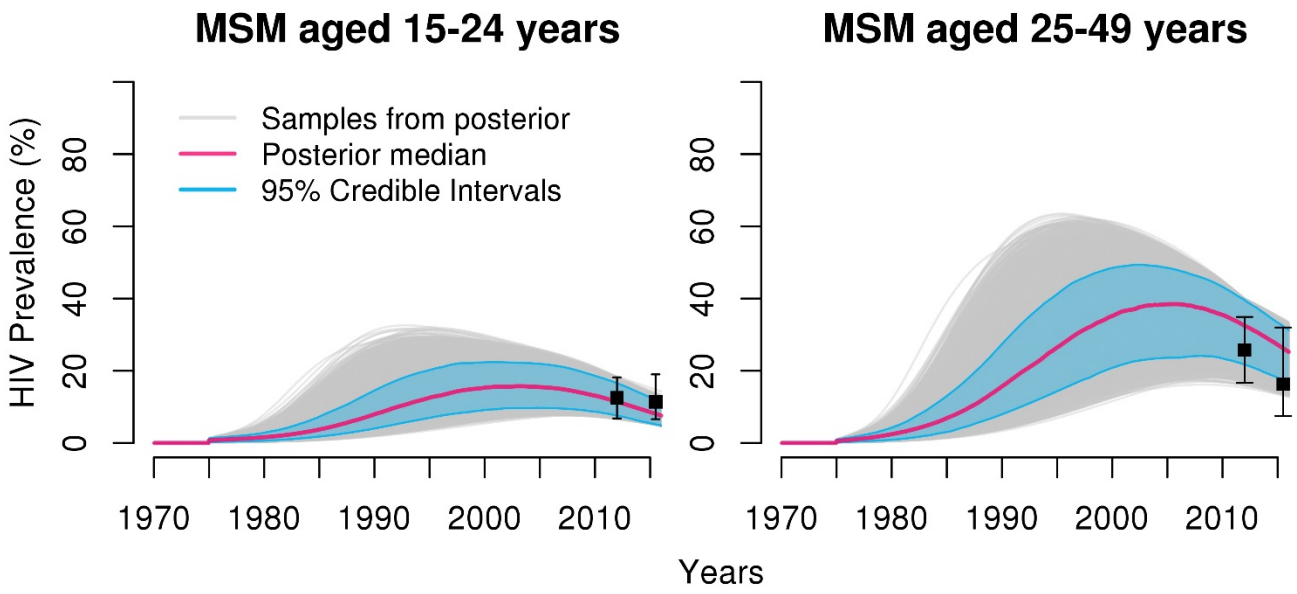

Figure S5. Observed HIV prevalence (points, mean and 95% confidence intervals) and predicted (lines/shaded area) HIV prevalence among men who have sex with men (MSM) in Côte d'Ivoire.

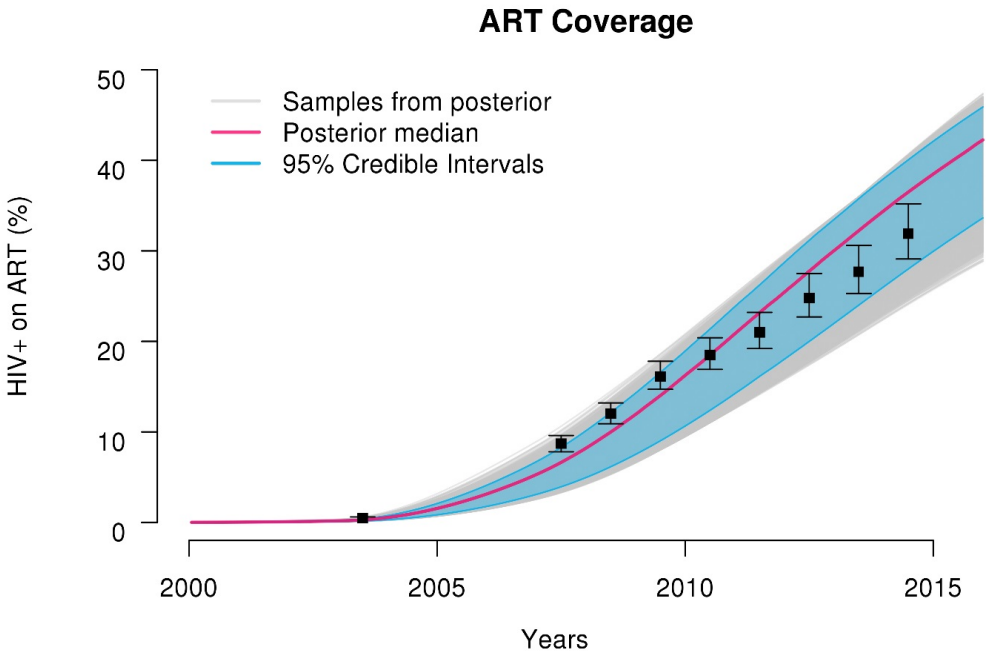

Figure S6. Model predicted ART coverage in Côte d'Ivoire with ART coverage data to which the model was calibrated to. The plotted points refer to UNAIDS estimates of ART coverage which are themselves based on data from the *Direction de l'information, de la planification et de l'évaluation* [34-39, 47] (see Table S9).

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