# Supplement

## PART A: Methods

### 1 Epidemic Model Framework

### 1.1 Main Model Structure

In order to estimate population-wide HIV transmission and progression rates, we developed a deterministic compartmental model, capturing transmission through sexual contact (heterosexual and homosexual), and needle-sharing. This model is an extension of a published HIV transmission model [1].

Based on the current situation in the Chinese HIV epidemic, we subdivided our target population into 7 groups: men who have sex with men (MSM), male injecting drug users (IDU), clients of female sex workers (CSW), low-risk men (M), female IDU (FIDU), female sex workers (FSW) and low-risk women (W). Once infected, individuals will progress though asymptomatic, symptomatic, and AIDS stages. The flow diagram, taking the MSM group as an example, is shown in Figure A-1. Parameters for epidemiological factors, behavior (such as numbers of opposite/same sex partners, condom use, infectiousness of asymptomatic HIV, and needle-sharing), the mortality rate, and the probability of disease transmission were drawn from previous publications (Table A-1). The definition of all symbols can be found in Table A-4.

Table A-1: Key model parameters

| Variable | Value | References |
|---|---|---|
| **Demographic characteristics** | | |
| Annual mortality rate (background) | | |
| Men | 0.00706 | Calculated, [2] |
| Women | 0.00706 | Calculated, [2] |
| IDU | 0.025 | Calculated, [2] |
| Annual mortality rate (due to HIV/AIDS) | | |
| Asymptomatic (CD4 > 350 cells/µl) | 0.02 | [3] |
| Symptomatic (200 ≤ CD4 ≤ 350 cells/µl) | 0.063 | [3] |
| AIDS (CD4 < 200 cells/µl) | 0.22 | [4, 5] |
| Symptomatic with ART | 0.05 | [3, 6] |
| AIDS with ART | 0.075 | [6] |
| Annual maturation rate* | | |
| Men | 0.0195 | Calculated, [2] |
| Women | 0.020 | Calculated, [2] |
| Annual entry rate^ | | |
| Men | 0.0282 | Calculated, [2] |
| Women | 0.0253 | Calculated, [2] |
| Initial population (aged 15-64 years) | | |
| MIDU | 1,474,102 | [2, 7] |
| FIDU | 982,735 | [2, 7] |
| MSM | 3,600,000 | [8] |
| FSW | 2,815,402 | [2, 9] |
| CSW | 27,556,415 | [2, 9] |
| M | 452,799,906 | Calculated, [2] |
| W | 477,571,440 | Calculated, [2] |
| Initial prevalence (aged 15-64 years), % | | |
| MIDU | 9.3 | [10] |
| FIDU | 9.3 | [10] |
| MSM | 5 | [11] |
| FSW | 0.6 | [9] |
| CSW | 0.4 | [9] |
| M | 0.025 | [12] |
| W | 0.025 | [12] |
| **Sexual transmission** | | |
| Transmission probability per partnership | | |
| Heterosexual (female to male) | | |
| Asymptomatic HIV | 0.01 | [13-21] |
| Symptomatic HIV | 0.02 | [13-21] |
| AIDS | 0.03 | [13-21] |
| Heterosexual (male to female) | | |
| Asymptomatic HIV | 0.03 | [13-21] |
| Symptomatic HIV | 0.04 | [13-21] |
| AIDS | 0.08 | [13-21] |

Table A-1 (Continued)

| Variable | Value | References |
|---|---|---|
| Homosexual (male to male) | | |
| Asymptomatic HIV | 0.04 | [17, 22-24] |
| Symptomatic HIV | 0.05 | [17, 22-24] |
| AIDS | 0.12 | [17, 22-24] |
| Annual same-sex partners | | |
| MSM | 5 | [25] |
| Condom use with same-sex partners, % | | |
| MSM | 36% | [25, 26] |
| Annual opposite-sex partners | | |
| MIDU | 2.5 | [27] |
| FIDU | 3.5 | [27, 28] |
| MSM | 0.1 | [29] |
| FSW | 100 | [30, 31] |
| CSW | 11.2 | Calculated[1] |
| M | 1.1 | [32] |
| W | 1.1 | [32] |
| Condom use with opposite-sex partners, % | | |
| MIDU | 35% | [33] |
| FIDU | 42% | [33] |
| MSM | 35% | [12] |
| FSW | 60% | [12, 34] |
| CSW | 50% | [12] |
| M | 20% | Assumed, [34] |
| W | 20% | Assumed, [34] |
| Condom effectiveness | 0.9 | [35-37] |
| **Injecting drug use transmission** | | |
| Transmission probability per shared injection | | |
| Asymptomatic HIV | 0.002 | [38-40] |
| Symptomatic HIV | 0.003 | [38-40] |
| AIDS | 0.003 | [38-40] |
| Average injections per year | 200 | [1, 28, 40] |
| Proportion of injections that are shared, % | 40 | [9] |
| **HIV VCT** | | |
| Proportion of population tested in past 12 months, % | | |
| High-risk groups | 37% | [10] |
| Low-risk groups | 2% | [10] |
| Annual probability of symptom-based case finding, % | | |
| HIV | 10% | [41] |
| AIDS | 20% | [41] |
| Reduction in partner numbers among persons identified as HIV-positive, % | 20% | [42] |
| Reduction in partner numbers among AIDS patients, % | 90% | Assumed |
| **ART** | | |

Table A-1 (Continued)

| Variable | Value | References |
|---|---|---|
| Proportion starting ART at CD4 cell count of 350 cells/μl | 30% | [10] |
| Annual ART entry rate if CD4 cell count <350 cells/μl | 0.05 | [1] |
| Reduction in sexual infectivity due to ART, % | 90% | [20, 43, 44] |
| Reduction in injection infectivity due to ART, % | 50% | [41, 45] |
| **Progression Rates** | | |
| From asymptomatic to symptomatic | 0.152 | [46] |
| From symptomatic to AIDS | | |
| Untreated | 0.303 | [46] |
| Treated | 0.165 | [46] |
| **Quality of life multipliers** | | |
| HIV negative | 1 | |
| Unidentified asymptomatic HIV | 0.90 | [47-50] |
| Identified asymptomatic HIV | 0.85 | [41, 47-50] |
| Unidentified symptomatic HIV | 0.79 | [47-50] |
| Identified symptomatic HIV | 0.72 | [47-50] |
| Symptomatic HIV treated with ART | 0.83 | [47-50] |
| Unidentified AIDS | 0.68 | [47-50] |
| Identified AIDS | 0.68 | [47-50] |
| AIDS treated with ART | 0.82 | [47-50] |
| **Cost, 2010 Int.$** | | |
| Annual HIV-related health care cost | | |
| Untreated asymptomatic HIV | 6,230 | [51] |
| Untreated symptomatic HIV | 10,458 | Interpolated[2] |
| Symptomatic HIV treated with ART | 9,324 | Interpolated[2] |
| Untreated AIDS | 14,108 | [51] |
| AIDS treated with ART | 12,269 | Interpolated[2] |
| Annual non-HIV related health care cost | 264 | [52] |
| Annual cost of ART | 4,781 | [53, 54] |
| Cost of HIV ELISA antibody test | 19 | [55] |
| Cost of confirmatory western blot test | 64 | [55] |
| Cost of behavior counseling | 22 | [56] |
| Annual discount rate, % | 3 | |
| Annual cost of MMT per IDU | 532 | [57] |
| Annual cost of NSP per IDU | 192 | [57] |

MSM = men who have sex with men; MIDU = male injecting drug users; CSW = clients of female sex workers; M = low-risk men; FIDU = female injecting drug users; FSW = female sex workers; W = low-risk women (W); ART = antiretroviral therapy; ELISA = enzyme-linked immunosorbent assay; [*]Entry rate is composed from the background population growth rate and rate of reaching adulthood; [^]Maturation rate is the sum of the background mortality rate and the rate of aging; [1]This is a derived value, calculated in order to balance the total number of partnerships formed by men and women; [2]Calculated by multiplying health care costs of untreated asymptomatic HIV by the ratios of the cost of this disease stage with other stages in published papers [1].

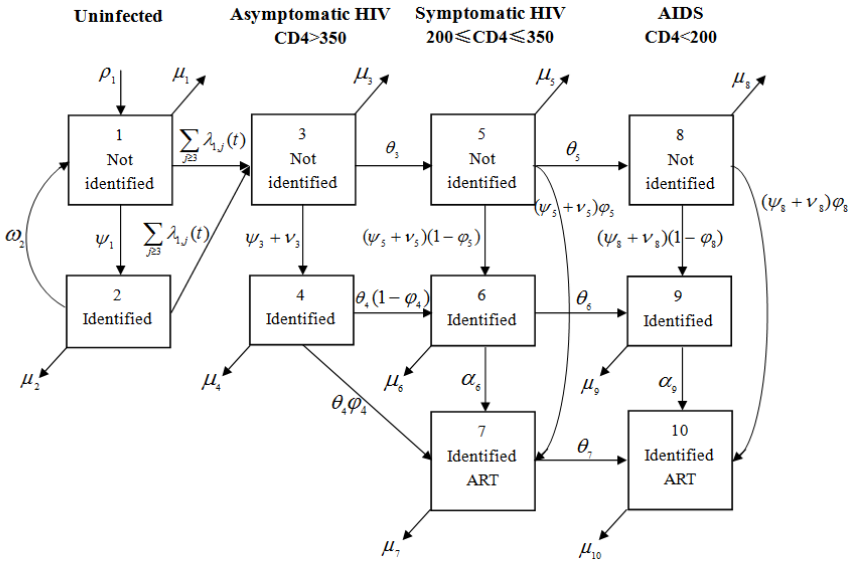



Figure A-1: HIV transmission compartmental model structure [1]

Based on the framework of our model, we developed differential equations for each risk group. The complete model comprises 70 equations. We coded these equations, initial values and parameters using MATLAB R2010a. We ran our program for 30 years. The 10 equations for each risk group are:

$$\frac{dX_{i,1}}{dt} = \rho_1^i \sum_{\forall j} X_{i,j} - \psi_1^i X_{i,1} + \omega_2^i X_{i,2} - \left( \sum_{j\geq 3} \lambda_{i,j}(t) \right) X_{i,1} - (\mu_1^i + b_1^i) X_{i,1} \quad \text{(A-1)}$$

$$\frac{dX_{i,2}}{dt} = \psi_1^i X_{i,1} - \omega_2^i X_{i,2} - \left( \sum_{j\geq 3} \lambda_{i,j}(t) \right) X_{i,2} - (\mu_2^i + b_2^i) X_{i,2} \quad \text{(A-2)}$$

$$\frac{dX_{i,3}}{dt} = \left( \sum_{j\geq 3} \lambda_{i,j}(t) \right) X_{i,1} + \left( \sum_{j\geq 3} \lambda_{i,j}(t) \right) X_{i,2} - (\psi_3^i + \nu_3^i) X_{i,3} - (\theta_3^i + \mu_3^i + b_3^i) X_{i,3} \quad \text{(A-3)}$$

$$\frac{dX_{i,4}}{dt} = (\psi_3^i + \nu_3^i) X_{i,3} - (\theta_4^i + \mu_4^i + b_4^i) X_{i,4} \quad \text{(A-4)}$$

$$\frac{dX_{i,5}}{dt} = \theta_3^i X_{i,3} - (\psi_5^i + \nu_5^i) X_{i,5} - (\theta_5^i + \mu_5^i + b_5^i) X_{i,5} \quad \text{(A-5)}$$

$$\frac{dX_{i,6}}{dt} = \theta_4^i (1-\varphi_4^i) X_{i,4} + (\psi_5^i + \nu_5^i)(1-\varphi_5^i) X_{i,5} - (\theta_6^i + \alpha_6^i + \mu_6^i + b_6^i) X_{i,6} \quad \text{(A-6)}$$

$$\frac{dX_{i,7}}{dt} = \theta_4^i \varphi_4^i X_{i,4} + (\psi_5^i + \nu_5^i) \varphi_5^i X_{i,5} + \alpha_6^i X_{i,6} - (\theta_7^i + \mu_7^i + b_7^i) X_{i,7} \quad \text{(A-7)}$$

$$\frac{dX_{i,8}}{dt} = \theta_5^i X_{i,5} - (\psi_8^i + \nu_8^i) X_{i,8} - (\mu_8^i + b_8^i) X_{i,8} \quad \text{(A-8)}$$

$$\frac{dX_{i,9}}{dt} = \theta_6^i X_{i,6} + (\psi_8^i + \nu_8^i)(1-\varphi_8^i) X_{i,8} - \alpha_9^i X_{i,9} - (\mu_9^i + b_9^i) X_{i,9} \quad \text{(A-9)}$$

$$\frac{dX_{i,10}}{dt} = \theta_7^i X_{i,7} + (\psi_8^i + \nu_8^i)\varphi_8^i X_{i,8} + \alpha_9^i X_{i,9} - (\mu_{10}^i + b_{10}^i) X_{i,10} \quad \text{(A-10)}$$

Where the index i corresponds to 1: MSM, 2: MIDU, 3: CSW, 4: M, 5: FIDU, 6: FSW, and 7: W.

## 1.2 Target Population

Our target population is adults aged 15-64 years old. The rate at which people enter the target group is composed from the background population growth rate and the speed of reaching adulthood. In the same way, the maturation rate is the sum of the background mortality rate and the rate of ageing.

HIV prevalence in risk group i:

$$p_i = \frac{\text{Number of People living with HIV in risk group i}}{\text{Population of risk group i}} \quad \text{(A-11)}$$

Entry Rates:

$$\rho = -\ln\left(1 - \frac{\text{15 years old population}}{\text{15-64 years old population}}\right) + \text{growth rate} \quad \text{(A-12)}$$

Maturation Rates:

$$\mu = -\ln\left(1 - \frac{\text{64 years old population}}{\text{15-64 years old population}}\right) + \text{mortality rate} \quad \text{(A-13)}$$

Initial values for the population of each group are shown in Table A-2, calculated from population size and prevalence information in existing studies [2, 7-9].

Table A-2: Initial values for the populations of risk groups

| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 |
|---|---|---|---|---|---|---|---|---|---|---|
| MIDU | 935,907 | 401,103 | 43,184 | 25,362 | 25,910 | 13,695 | 1,522 | 17,274 | 9,130 | 1,014 |
| FIDU | 623,938 | 267,402 | 28,789 | 16,908 | 17,274 | 9,130 | 1,014 | 11,516 | 6,087 | 676 |
| MSM | 2,394,000 | 1,026,000 | 56,700 | 33,300 | 34,020 | 17,982 | 1,998 | 22,680 | 11,988 | 1,332 |
| FSW | 1,958,957 | 839,553 | 5,321 | 3,125 | 3,193 | 1,688 | 188 | 2,128 | 1,125 | 125 |
| CSW | 19,212,333 | 8,233,857 | 34,721 | 20,392 | 20,833 | 11,012 | 1,224 | 13,888 | 7,341 | 816 |
| Low-risk Man | 443,632,972 | 9,053,734 | 55,468 | 1,132 | 33,281 | 611 | 68 | 22,187 | 408 | 45 |
| Low-risk Woman | 467,903,006 | 9,549,041 | 58,503 | 1,194 | 35,102 | 645 | 72 | 23,401 | 430 | 48 |

## 1.3 Transmission Forces

Susceptible individuals can become infected in three ways: heterosexual contact, homosexual contact, and needle-sharing among IDUs. Table A-3 shows the details of potential modes of infection between any two risk groups. We consider heterosexual transmission to be possible for MSM as well.

### 1.3.1 Common transmission formula

- The probability that men are not infected by HIV-positive women in risk group i, and compartment j, though one heterosexual contact, $N\_M_{i,j}$ ($i$=5~7, $j$=3~10) is：

$$N\_M_{i,3}=\left[1-\left(\frac{X_{i,3}n_i^O(1-u_i^O\kappa)}{CT_F}\sigma_{f,m}^a\right)\right];N\_M_{i,4}=\left[1-\left(\frac{X_{i,4}n_i^O(1-r_1)(1-u_i^O\kappa)}{CT_F}\sigma_{f,m}^a\right)\right]$$

$$N\_M_{i,5}=\left[1-\left(\frac{X_{i,5}n_i^O(1-u_i^O\kappa)}{CT_F}\sigma_{f,m}^S\right)\right];N\_M_{i,6}=\left[1-\left(\frac{X_{i,6}n_i^O(1-r_1)(1-u_i^O\kappa)}{CT_F}\sigma_{f,m}^S\right)\right]$$

$$N\_M_{i,7}=\left[1-\left(\frac{X_{i,7}n_i^O(1-r_1)(1-u_i^O\kappa)}{CT_F}\sigma_{f,m}^S(1-r_2)\right)\right];N\_M_{i,8}=\left[1-\left(\frac{X_{i,8}n_i^O(1-u_i^O\kappa)}{CT_F}\sigma_{f,m}^{AIDS}\right)\right]$$

$$N\_M_{i,9}=\left[1-\left(\frac{X_{i,9}n_i^O(1-r_1')(1-u_i^O\kappa)}{CT_F}\sigma_{f,m}^{AIDS}\right)\right];N\_M_{i,10}=\left[1-\left(\frac{X_{i,10}n_i^O(1-r_1')(1-u_i^O\kappa)}{CT_F}\sigma_{f,m}^{AIDS}(1-r_2)\right)\right]$$

where $CT_F$ is the total heterosexual contacts among women:

$$CT_F = \sum_{i=5,6,7}\left[ (\sum_{j=1,2,3,5,8} X_{i,j}) n_i^O (1-u_i^O\kappa) + (\sum_{j=4,6,7} X_{i,j}) n_i^O (1-r_1)(1-u_i^O\kappa) + (\sum_{j=9,10} X_{i,j}) n_i^O (1-r_1')(1-u_i^O\kappa) \right]$$

- The probability that MSM are not infected by HIV-positive MSM in compartment j though one homosexual contact, $N\_MSM_j$ ($j$=3~10) is：

$$N\_MSM_3 = \left[1-\left(\frac{X_{1,3} n_1^S (1-u_1^S\kappa)}{CT_{MSM}} \sigma_{m,m}^a\right)\right]; N\_MSM_4 = \left[1-\left(\frac{X_{1,4} n_1^S (1-r_1)(1-u_1^S\kappa)}{CT_{MSM}} \sigma_{m,m}^a\right)\right]$$

$$N\_MSM_5 = \left[1-\left(\frac{X_{1,5} n_1^S (1-u_1^S\kappa)}{CT_{MSM}} \sigma_{m,m}^S\right)\right]; N\_MSM_6 = \left[1-\left(\frac{X_{1,6} n_1^S (1-r_1)(1-u_1^S\kappa)}{CT_F} \sigma_{m,m}^S\right)\right]$$

$$N\_MSM_7 = \left[1-\left(\frac{X_{1,7} n_1^S (1-r_1)(1-u_1^S\kappa)}{CT_{MSM}} \sigma_{m,m}^S (1-r_2)\right)\right]; N\_MSM_8 = \left[1-\left(\frac{X_{1,8} n_1^S (1-u_1^S\kappa)}{CT_{MSM}} \sigma_{m,m}^{AIDS}\right)\right]$$

$$N\_MSM_9 = \left[1-\left(\frac{X_{1,9} n_1^S (1-r_1')(1-u_1^S\kappa)}{CT_{MSM}} \sigma_{m,m}^{AIDS}\right)\right]; N\_MSM_{10} = \left[1-\left(\frac{X_{1,10} n_1^S (1-r_1')(1-u_1^S\kappa)}{CT_{MSM}} \sigma_{m,m}^{AIDS} (1-r_2)\right)\right]$$

where $CT_{MSM}$ is the total number of homosexual contacts.

$$CT_{MSM} = (\sum_{j=1,2,3,5,8} X_{1,j}) n_1^S (1-u_1^S\kappa) + (\sum_{j=4,6,7} X_{1,j}) n_1^S (1-r_1)(1-u_1^S\kappa) + (\sum_{j=9,10} X_{1,j}) n_1^S (1-r_1')(1-u_1^S\kappa)$$

- The probability that IDU are not infected by HIV positive IDU in risk group i, and compartment j, through one needle-sharing contact, $N\_IDU_{i,j}$ ($i$=2 or 5, $j$=3~10) is：

$$N\_IDU_{i,3} = \left[1-\left(\frac{X_{i,3} d_i S_i}{CT_{IDU}} \tau^a\right)\right];\ N\_IDU_{i,4} = \left[1-\left(\frac{X_{i,4} d_i S_i}{CT_{IDU}} \tau^a\right)\right];\ N\_IDU_{i,5} = \left[1-\left(\frac{X_{i,5} d_i S_i}{CT_{IDU}} \tau^S\right)\right]$$

$$N\_IDU_{i,6} = \left[1-\left(\frac{X_{i,6} d_i S_i}{CT_{IDU}} \tau^S\right)\right];\ N\_IDU_{i,7} = \left[1-\left(\frac{X_{i,7} d_i S_i}{CT_{IDU}} \tau^S (1-r_2')\right)\right];\ N\_IDU_{i,8} = \left[1-\left(\frac{X_{i,8} d_i S_i}{CT_{IDU}} \tau^S\right)\right]$$

$$N\_IDU_{i,9} = \left[1-\left(\frac{X_{i,9} d_i S_i}{CT_{IDU}} \tau^S\right)\right];\ N\_IDU_{i,10} = \left[1-\left(\frac{X_{i,10} d_i S_i}{CT_{IDU}} \tau^S (1-r_2')\right)\right]$$

Where $CT_{IDU}$ is the total number of needle-sharing contacts in IDUs:

$$CT_{IDU} = (\sum_{\forall j} X_{2,j}) d_2 s_2 + (\sum_{\forall j} X_{5,j}) d_5 s_5,\ j = 1,2,3,4,..10$$

- $N\_F_{i,j}$ ($i$=1~4, $j$=3~10) is the probability that women are not infected by HIV-positive men in risk group i, and compartment j, though one heterosexual contact.

$$N\_F_{i,3}=\left[1-\left(\frac{X_{i,3}n_i^O(1-u_i^O\kappa)}{CT_M}\sigma_{m,f}^a\right)\right];N\_F_{i,4}=\left[1-\left(\frac{X_{i,4}n_i^O(1-r_1)(1-u_i^O\kappa)}{CT_M}\sigma_{m,f}^a\right)\right]$$

$$N\_F_{i,5}=\left[1-\left(\frac{X_{i,5}n_i^O(1-u_i^O\kappa)}{CT_M}\sigma_{m,f}^S\right)\right];N\_F_{i,6}=\left[1-\left(\frac{X_{i,6}n_i^O(1-r_1)(1-u_i^O\kappa)}{CT_M}\sigma_{m,f}^S\right)\right]$$

$$N\_F_{i,7}=\left[1-\left(\frac{X_{i,7}n_i^O(1-r_1)(1-u_i^O\kappa)}{CT_M}\sigma_{m,f}^S(1-r_2)\right)\right];N\_F_{i,8}=\left[1-\left(\frac{X_{i,8}n_i^O(1-u_i^O\kappa)}{CT_M}\sigma_{m,f}^{AIDS}\right)\right]$$

$$N\_F_{i,9}=\left[1-\left(\frac{X_{i,9}n_i^O(1-r_1')(1-u_i^O\kappa)}{CT_M}\sigma_{m,f}^{AIDS}\right)\right];N\_F_{i,10}=\left[1-\left(\frac{X_{i,10}n_i^O(1-r_1')(1-u_i^O\kappa)}{CT_M}\sigma_{m,f}^{AIDS}(1-r_2)\right)\right]$$

Where $CT_M$ is the total number of heterosexual contacts for men.

$$CT_M=\sum_{i=1,2,3,4}\left[(\sum_{j=1,2,3,5,8}X_{i,j})n_i^O(1-u_i^O\kappa)+(\sum_{j=4,6,7}X_{i,j})n_i^O(1-r_1)(1-u_i^O\kappa)+(\sum_{j=9,10}X_{i,j})n_i^O(1-r_1')(1-u_i^O\kappa)\right]$$

Again i corresponds to 1: MSM, 2: MIDU, 3: CSW, 4: M, 5: FIDU, 6: FSW, and 7: W; and j corresponds to the 10 compartments reflecting HIV progression ( 1: unidentified uninfected, 2: Identified uninfected, 3:unidentified asymptomatic, 4: Identified asymptomatic, 5: unidentified symptomatic, 6: Identified symptomatic, 7: Identified symptomatic with ART, 8: unidentified AIDS, 9: Identified AIDS, 10: Identified AIDS with ART).

Table A-3: Modes of HIV transmission between risk groups

| | Male MSM | Male IDU | Male CSW | Male Other | Female IDU | Female FSW | Female Other |
|---|---|---|---|---|---|---|---|
| Male MSM | Homosexual | | | | Heterosexual | Heterosexual | Heterosexual |
| Male IDU | | Needle-sharing | | | Heterosexual<br>Needle-sharing | Heterosexual | Heterosexual |
| Male CSW | | | | | Heterosexual | Heterosexual | Heterosexual |
| Male Other | | | | | Heterosexual | Heterosexual | Heterosexual |
| Female IDU | Heterosexual | Heterosexual<br>Needle-sharing | Heterosexual | Heterosexual | Needle-sharing | | |
| Female FSW | Heterosexual | Heterosexual | Heterosexual | Heterosexual | | | |
| Female Other | Heterosexual | Heterosexual | Heterosexual | Heterosexual | | | |

### 1.3.2 Transmission rates for each group

Transmission forces $\sum_{j\geq 3}\lambda_{i,j}(t)$, quoted in equations (A-1) to (A-10), for the seven risk groups are:

$$\sum_{j\geq 3}\lambda_{1,j}(t)=\sum_{i=5,6,7}\sum_{j\geq 3}\left\{1-N\_M_{i,j}{}^{n_1^O(1-u_1^O\kappa)}\right\}+\sum_{j\geq 3}\left\{1-N\_MSM_j{}^{n_1^S(1-u_1^S\kappa)}\right\} \quad \text{(A-14)}$$

$$\sum_{j\geq 3}\lambda_{2,j}(t)=\sum_{i=5,6,7}\sum_{j\geq 3}\left\{1-N\_M_{i,j}{}^{n_2^O(1-u_2^O\kappa)}\right\}+\sum_{i=2,5}\sum_{j\geq 3}\left\{1-N\_IDU_{i,j}{}^{d_2S_2}\right\} \quad \text{(A-15)}$$

$$\sum_{j\geq 3}\lambda_{3,j}(t)=\sum_{i=5,6,7}\sum_{j\geq 3}\left\{1-N\_M_{i,j}{}^{n_3^O(1-u_3^O\kappa)}\right\} \quad \text{(A-16)}$$

$$\sum_{j\geq 3}\lambda_{4,j}(t)=\sum_{i=5,6,7}\sum_{j\geq 3}\left\{1-N\_M_{i,j}{}^{n_4^O(1-u_4^O\kappa)}\right\} \quad \text{(A-17)}$$

$$\sum_{j\geq 3}\lambda_{5,j}(t)=\sum_{i=1,2,3,4}\sum_{j\geq 3}\left\{1-N\_F_{i,j}{}^{n_5^O(1-u_5^O\kappa)}\right\}+\sum_{i=2,5}\sum_{j\geq 3}\left\{1-N\_IDU_{i,j}{}^{d_5S_5}\right\} \quad \text{(A-18)}$$

$$\sum_{j\geq 3}\lambda_{6,j}(t)=\sum_{i=1,2,3,4}\sum_{j\geq 3}\left\{1-N\_F_{i,j}{}^{n_6^O(1-u_6^O\kappa)}\right\} \quad \text{(A-19)}$$

$$\sum_{j\geq 3}\lambda_{7,j}(t)=\sum_{i=1,2,3,4}\sum_{j\geq 3}\left\{1-N\_F_{i,j}{}^{n_7^O(1-u_7^O\kappa)}\right\} \quad \text{(A-20)}$$

## 1.4 Intervention types

We compared four different intervention types against a control situation that was defined to match the current situation in China. The control situation (the “base

case") and the four intervention types are defined as follows:

1) The Base Case: all parameters and assumptions match the current situation in China. Assume current testing rates of 37% for high-risk groups and 2% for low-risk groups, with an ART utilization rate of 30%, and without MMT and NSP.

2) Expanded Voluntary Counseling and Testing (VCT) Only: this case assumes that testing is expanded to a larger proportion of the population, with no change in ART treatment provision or harm reduction programs. VCT was modeled as being offered at different rates to high- and low-risk groups. Four sub-strategies are included under this strategy, defined by the testing rates for low- and high-risk groups: one time low-risk and annual high-risk VCT; low-risk every three years and annual high-risk VCT; everyone screened every three years; and everyone screened annually.

3) Expanded ART Treatment Only: in this case, utilization of ART treatment is improved, with no expansion of the VCT or harm reduction programs. As ART treatment is expanded, more and more people enter treatment once their CD4 count is less than $350\,cells/\mu l$.

4) Harm Reduction Program: this strategy included methadone maintenance treatment (MMT) and needle/syringe programs (NSP). In this paper, a harm

reduction program is considered to be a combination of NSP and MMT. IDUs covered by harm reduction programs are in either NSP or MMT, which means that those who drop out of MMT will inject drugs without a high needle-sharing risk. The VCT rate and ART utilization rate remained the same as the base case. We did not expect the coverage of access to NSP or MMT to reach 100% immediately upon implementation, so we assumed that coverage would increase gradually to 5% at year 5, 50% at year 15, and would reach 95% at year 25, in the pattern shown in Figure A-2. Twelve month retention in MMT is assumed to be 50% [58, 59].

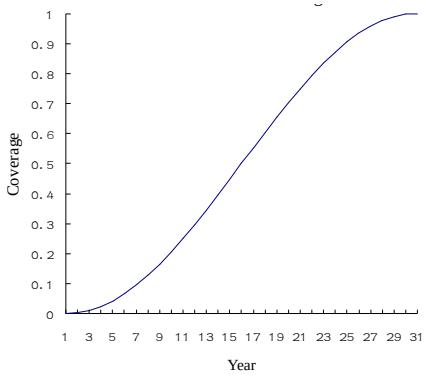



Figure A-2: The Coverage of NSP or MMT over 30 Years

5) Combination Strategies: combination strategies of any two of Expanded VCT, ART Treatment and Harm Reduction Program, or a combination strategy of all three.

2 Model Outputs

In order to capture the HIV epidemiological trend we calculated prevalence,

incidence, and cumulative incidence. For economic outcomes, we calculated QALYs.

## 2.1 Epidemiological Outcomes

The key epidemiological outcomes of the model are:

The number of susceptible individuals in risk-group *i*, $S_i = X_{i,1}(t) + X_{i,2}(t)$ (A-21)

The number of PLWHA in risk-group *i*, $I_i = \sum_{j=3}^{10} X_{i,j}(t)$; (A-22)

HIV prevalence in risk-group *i*, $P_i = \sum_{j=3}^{10} X_{i,j}(t) \Big/ \sum_{\forall j} X_{i,j}(t)$ (A-23)

New infections in risk-group *i*, $NI_i = \left( \sum_{j \geq 3} \lambda_{i,j}(t) \right) \times \left( X_{i,1}(t) + X_{i,2}(t) \right)$; (A-24)

Cumulative new infections in risk-group *i*,

$$CI_i = \int_0^t \left( \left( \sum_{j \geq 3} \lambda_{i,j}(t) \right) \times \left( X_{i,1}(t) + X_{i,2}(t) \right) \right) dt \quad \text{(A-25)}$$

## 2.2 Economic Outcomes

We measured economic outcomes as QALYs, which were in turn based on cost calculations for the different intervention types. These are calculated in equations (A-26) to (A-32).

QALYs in risk-group $i$ : $\mathrm{Q}^{\mathrm{i}} = \int_0^{30} e^{-rt} \sum_{\forall j} q_j{}^i X_{i,j}(t) dt$ (A-26)

Total QALYs: $\mathrm{TQ} = \sum_{\forall \mathrm{i}} \mathrm{Q}^{\mathrm{i}}$ (A-27)

Cost of ART in risk-group *i*: $\mathrm{C}^i_{\mathrm{ART}} = \int_0^{30} e^{-rt} \sum_{\forall j} c_j{}^i X_{i,j}(t) dt$ (A-28)

Cost of VCT in risk-group *i*:

$$C^{i}_{\text{screen}} = \int_0^{30} e^{-rt}\left[\left(c_{neg}\psi^{i}_{1}X_{i,1}(t)\right) + \sum_{j=3,5,8} c_{pos}(\psi^{i}_{j} + \nu^{i}_{j})X_{i,j}(t)\right]dt \quad \text{(A-29)}$$

Cost for NSP: $C_{\text{NSP}} = \int_0^{30} e^{-rt} c_{NSP}\left(\sum_{\forall j}(X_{2,j}(t) + X_{5,j}(t))\right)Cover(t)dt$ (A-30)

Cost for MMT: $C_{\text{MMT}} = \int_0^{30} e^{-rt} c_{MMT}\left(\sum_{\forall j}(X_{2,j}(t) + X_{5,j}(t))\right)Cover(t)dt$ (A-31)

Health care cost in risk-group *i*: $C^{i}_{\text{HC}} = \int_0^{30} e^{-rt}\sum_{\forall j} c'^{i}_{j} X_{i,j}(t)dt$ (A-32)

We calculated QALYs over the 30 year life of the project, with an annual discount rate of 3%.

Table A-4: Summary and Description of Model Variables

| Variables/Symbols | Definition |
|---|---|
| **Demographic characteristics** | |
| $X_{i,j}$ | Number of people in risk group *i* with status *j* |
| $b_j^i$ | Annual background mortality rate |
| $\mu_j^i$ | Annual mortality rate due to HIV/AIDS |
| $\mu_1^i, \mu_2^i$ | Annual maturation rate |
| $\rho_1^i$ | Annual entry rate |
| | |
| **Sexual transmission** | |
| $\sigma_{f,m}^z$ | Annual transmission probability per partnership from female to male, where z= asymptomatic HIV, symptomatic HIV, and AIDS |
| $\sigma_{m,f}^z$ | Annual transmission probability per partnership from male to female, where z= asymptomatic HIV, symptomatic HIV, and AIDS |
| $\sigma_{m,m}^z$ | Annual transmission probability per partnership from male to male, where z= asymptomatic HIV, symptomatic HIV, and AIDS |
| $n_1^S$ | Annual same-sex partners of MSM |
| $u_1^S$ | Condom use with same-sex partners, percent |
| $n_i^O$ | Annual opposite-sex partners in risk group *i* |
| $u_i^O$ | Condom use with opposite-sex partners in risk group *i* |
| $\kappa$ | Condom effectiveness |
| | |
| **Injection drug use transmission** | |
| $\tau^z$ | Transmission probability per shared injection, where z= asymptomatic HIV, symptomatic HIV, and AIDS |
| $d_i$ | Average injections per year, i=2 or 5,(count) |
| $s_i$ | Fraction of injections that are shared, i=2 or 5, percent |
| | |
| **Voluntary Counseling and Testing** | |
| $\psi_j^i$ | Fraction of population tested in past 12 months for risk group *i* with status *j*, percent |

| | |
|---|---|
| $1/\omega_2^i$ | Average duration (years) that uninfected individuals remain identified after testing in risk group *i* |
| $v_j^i$ | Annual probability of symptom-based case finding in risk group *i* with status *j*, percent |
| $r_1$ | Reduction in sexual behavior among persons identified as HIV-positive, percent |
| $r_1'$ | Reduction in sexual behavior among people with AIDS, percent |
| | |
| **ART Treatment** | |
| $\varphi_j^i$ | Fraction starting ART at CD4 cell count of 350 in risk group *i* with status *j* |
| $\alpha_j^i$ | Annual ART entry rate if CD4 cell count <350 of risk group *i* with status *j* |
| $r_2$ | Reduction in sexual infectivity due to ART, percent |
| $r_2'$ | Reduction in injection infectivity due to ART, percent |
| | |
| **Cost-effectiveness** | |
| $q_j^i$ | Quality-of-life adjustment of individuals in risk group *i* with status *j* |
| $c_j^i$ | Annual ART cost per person |
| $c_j'^i$ | Annual health care cost per individual in risk group *i* with status *j* |
| $c_{neg}$ | VCT cost per HIV-negative person, including cost of counseling, ELISA test |
| $c_{pos}$ | VCT cost per HIV-positive person, including cost of counseling, ELISA test and Western blot test |
| $c_{NSP}$ | Annual cost per IDU of NSP program, including Human Resource (HR), capital, and needle costs. |
| $c_{MMT}$ | Annual cost per IDU of MMT program, including HR, capital, and methadone costs. |
| $Cover(t)$ | Coverage of NSP or MMT at time *t* |
| $R$ | Discount rate |
| | |
| **Others** | |
| $\theta_j^i$ | HIV disease progression rate for individuals in risk group *i* with status *j* |
| $\sum_{j\geq 3}\lambda_{i,j}(t)$ | Transmission forces for each risk groups *i* |

## PART B: Calibration Analysis

We calibrated our model against the number of PLWHA, annual deaths due to HIV/AIDS, and annual new infections in China using figures published in the UNAIDS Global Report on HIV/AIDS. We ran the model for 30 years using the initial population and HIV prevalence of China in 2002, using base case parameters. Figure B-1 compares the number of people living with HIV/AIDS, annual death due to HIV/AIDS and new infections estimated by our model with the published values from the UNAIDS Global Report on HIV/AIDS [33, 60, 61]. All of the predictions of these indicators based on our model are within the range of the values published by UNAIDS.

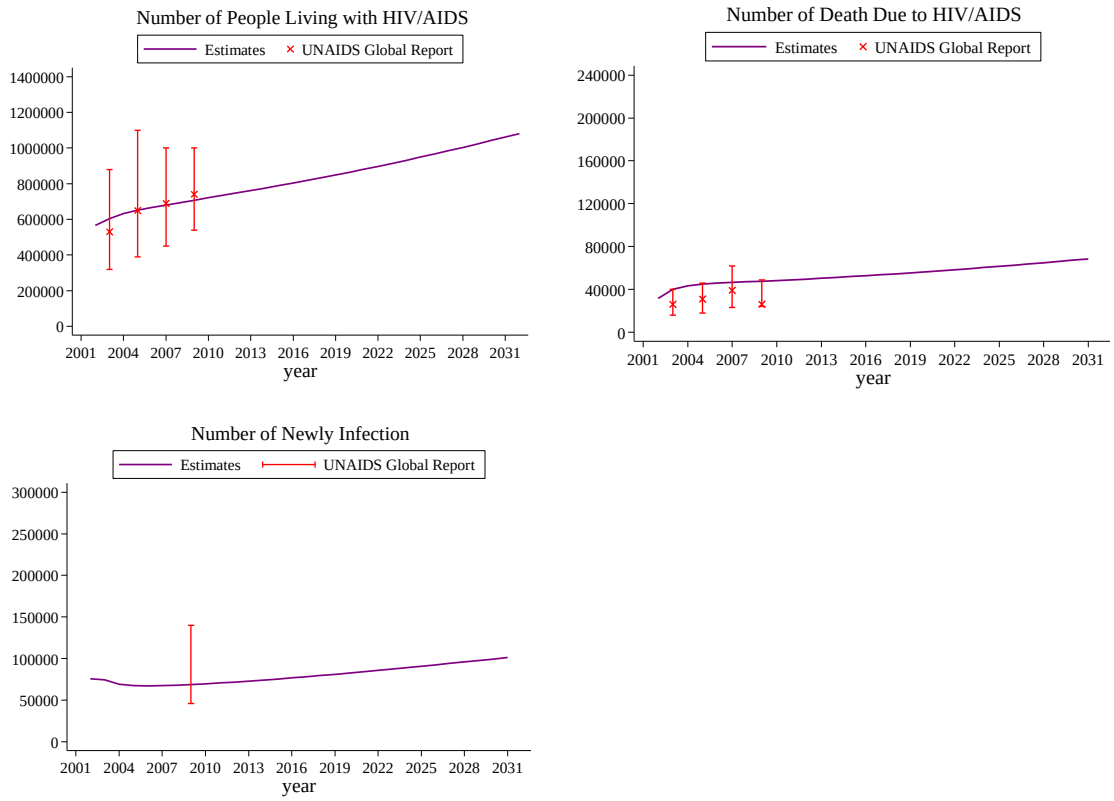



Figure B-1: The number of PLWHA, annual deaths and new infections under the model estimates and published UNAIDS data

## Part C: Sensitivity Analysis

1 Method

*Multivariate Sensitivity Analysis*

We used Latin Hypercube sampling to randomly generate one thousand sets of values of key parameters. Latin Hypercube Sampling draws random values without replacement from across the range of the distribution for each parameter of interest, and provides an efficient way to conduct multivariate sensitivity analysis [62]. Because distributions for many of the parameters are difficult to quantify, and values outside of certain ranges were impossible, triangular distributions were used for all parameters, with the peak of the distribution centered at the point estimate used in the primary model. The parameters that we varied and the range within which the triangular distribution was sampled are shown in Table C-1. We ran the model a thousand times with these sets of parameters and calibrated each run against the number of people living with HIV/AIDS, reported by UNAIDS. Model fit was tested using the Modeling efficiency statistic, EF (Equation C-1), which is conceptually similar in meaning to the R-squared statistic from linear regression, and indicates better fit for larger values of EF.

We kept the 200 runs with the largest EF values, and calculated the epidemiological trends for the base case, percentage of HIV infections prevented

over 30 years and incremental cost-effectiveness ratios (ICERs) relative to the base case for ten selected interventions using these 200 sets of parameters.

Table C-1: Ranges of Key Parameters for Sensitivity Analysis

| Variables | Value | Range |
|---|---|---|
| Annual same-sex partners of MSM | 5 | 3.5 - 7 |
| Condom use with same-sex partners of MSM | 36% | 20 - 50% |
| Annual opposite-sex partners | | |
| MIDU | 2.5 | 1.5 - 3.5 |
| FIDU | 3.5 | 2 - 5 |
| MSM | 0.1 | 0.05 - 0.15 |
| FSW | 100 | 50 - 150 |
| CSW | 11.2 | 5 - 17 |
| Low-risk men | 1.1 | 0.5 - 1.5 |
| Low-risk women | 1.1 | 0.5 - 1.5 |
| Condom use with opposite-sex partners | | |
| MIDU | 35% | 20 - 50% |
| FIDU | 42% | 21 - 63% |
| MSM | 35% | 20 - 50% |
| FSW | 60% | 30 - 90% |
| CSW | 50% | 25 - 75% |
| Low-risk men | 20% | 10 - 30% |
| Low-risk women | 20% | 10 - 30% |
| Average injections per year | 200 | 100 - 300 |

| | | |
|---|---|---|
| Proportion of injections that are shared | 40% | 20 - 60% |
| Cost, 2010 int.$ | | |
| Annual cost of ART | 4,949 | 3464 - 6434 |
| Cost of HIV ELISA antibody test | 19 | 13 - 25 |
| Cost of confirmatory western blot test | 64 | 45 - 83 |
| Cost of behavior counseling | 22 | 16 - 28 |
| Annual cost of MMT per IDU | 532 | 372 - 692 |
| Annual cost of NSP per IDU | 192 | 134 - 250 |

The formula for the EF score for comparing a set of values from a model to a set of observed values is:

$$EF = 1 - \frac{\sum_{i=1}^{n}(O_i - E_i)^2}{\sum_{i=1}^{n}(O_i - \overline{O})^2} \quad \text{(C-1)}$$

Where $O_i$ is the observed value, $\overline{O}$ is the mean of the observed values, and $E_i$ represents the estimated value from the model. EF is very similar in structure to the R-squared statistic from linear regression, and has an upper bound of one. Because the modeled values are not derived from an ordinary least squares model-fitting process, the EF has no lower bound (unlike the R-squared, which has a minimum value of 0) and the EF score is thus not fully analogous with the R-squared statistic [63].

*Scenario-based Sensitivity Analysis*

I also tested the robustness of my primary findings to my assumptions about the

effectiveness of the different interventions using scenario-based sensitivity analysis. In the model, I assumed that HIV-positive individuals would reduce their sexual partners by 20% after identification, and that the sexual transmission infectivity of infected persons would decrease by 90% after treatment with ART. I also assumed one-year retention in MMT was 50%. In addition to the multivariate sensitivity analysis of the behavior and costs parameters, I also conducted scenario-based sensitivity analysis of the number of HIV infections prevented and cost-effectiveness against variations in these assumptions about VCT, ART and MMT effectiveness.

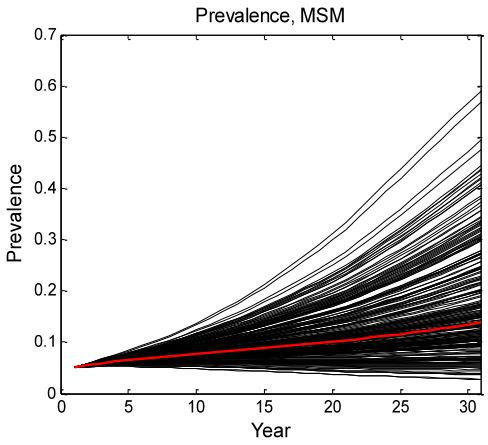
# 2 Results

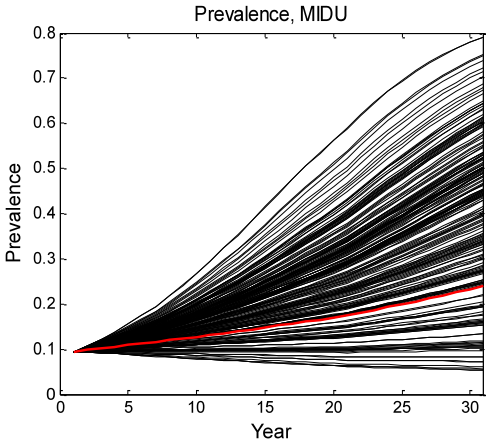
## 2.1 Sensitivity analysis on the epidemiological trends

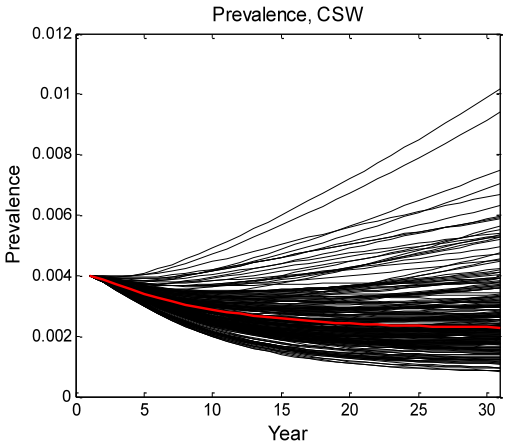
We explored trends in new HIV infections and the total number of PLWHA amongst the seven risk groups during the next three decades for the base case.

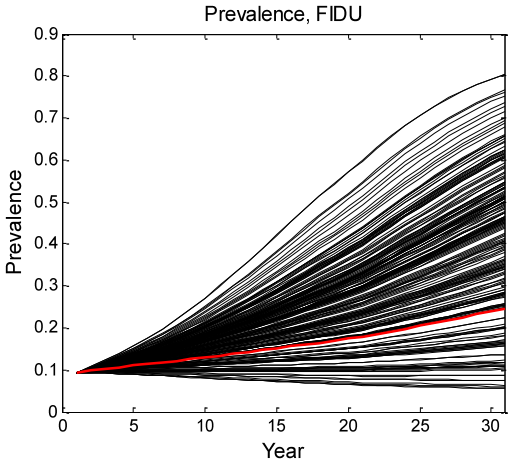
### 2.1.1 Prevalence in each risk group

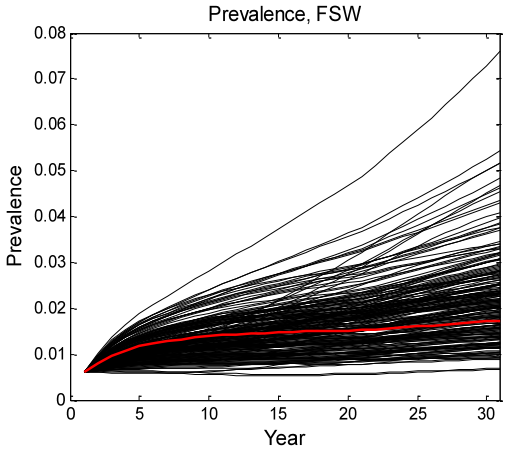
Figure C-1 shows the prevalence amongst the main risk groups for the base case, under the best 200 scenarios. The primary model is plotted in red in each chart.

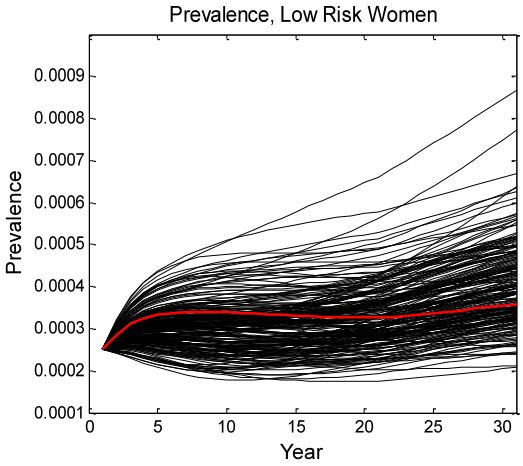

Prevalence, MSM
Prevalence
Year
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
5
10
15
20
25
30


Prevalence, MIDU
Prevalence
Year
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
5
10
15
20
25
30


Prevalence, CSW
Prevalence
Year
0
0.002
0.004
0.006
0.008
0.01
0.012
0
5
10
15
20
25
30


Prevalence, FIDU
Prevalence
Year
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
5
10
15
20
25
30


Prevalence, FSW
Prevalence
Year
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0
5
10
15
20
25
30


Prevalence, Low Risk Women
Prevalence
Year
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.0007
0.0008
0.0009
0
5
10
15
20
25
30

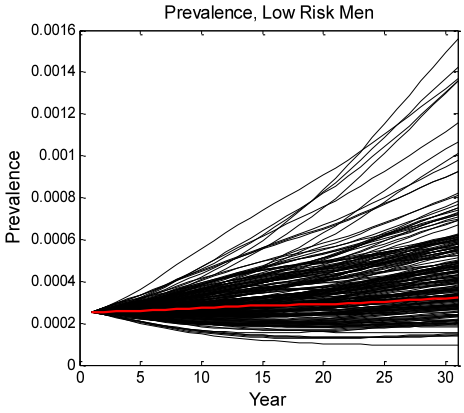



Figure C-3: Sensitivity Analysis for Prevalence by Risk Groups under the Base Case.

For the base case, the HIV prevalence amongst CSW, FSW and low-risk groups appears to be robust under the sensitivity analysis, while the values in MSM and IDU are relatively sensitive to the parameters of numbers of same sex partners and annual injections, resulting in wide sensitivity ranges.

### 2.1.2 The number of PLWHA

Figure C-2 shows the total number of people living with HIV/AIDS under the best 200 scenarios for the base case. The primary model is plotted in red.

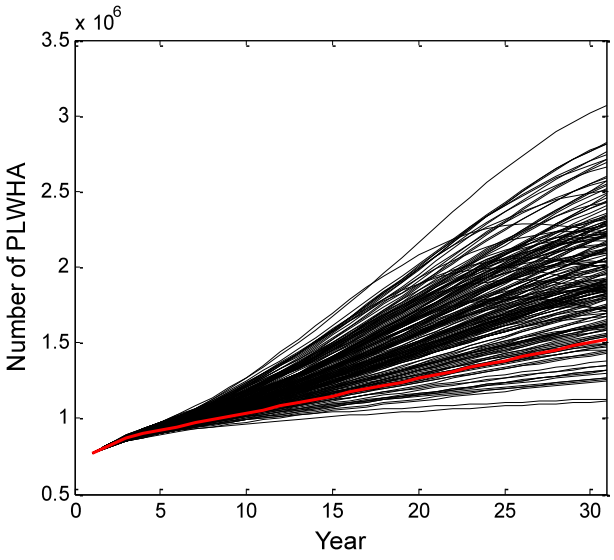



Figure C-4: Sensitivity Analysis for PLWHA under the Base Case.

At year 30, the number of PLWHA would be 1.50 million, with a sensitivity range of 1.25 - 3.00 million.

## 2.2 Sensitivity analysis on the cost-effectiveness

### 2.2.1 New HIV infections prevented

The sensitivity ranges of percentage of HIV infections averted over 30 years for all the intervention types are shown in Table C-2. Expanded VCT Only (low-risk once and high-risk annually) would prevent 2.8 - 11.2% of the total new HIV infections, while the Harm Reduction Program strategy would prevent 3.2 - 33.6% of the total new infections. Under a combination strategy of Expanded VCT (low-risk once and high-risk annually), ART and Harm Reduction Programs, 21.1 - 42.5% of the total new infections over 30 years would be averted.

Table C-2: Percentage of HIV infections prevented over 30 years.

| Strategy | Percentage of HIV infections prevented over 30 years, % | |
|---|---|---|
| | Value | Range |
| **Expanded VCT Only** | | |
| VCT (low-risk once, high-risk annually) | 6.6 | 2.8 - 11.2 |
| VCT (low-risk every 3 years, high-risk annually) | 7.3 | 3.0 - 12.8 |
| VCT (every 3 years) | 4.0 | 1.6 - 8.0 |
| VCT (annually) | 8.2 | 3.2 - 16.1 |
| **Expanded ART Only** | | |
| ART (50% utilization) | 10.0 | 5.2 - 14.0 |
| **Harm Reduction Program Only** | 20.7 | 3.2 - 33.6 |
| **Combination Strategies** | | |
| harm reduction, expanded ART and VCT (low-risk once, high-risk annually) | 35.3 | 21.1 - 42.5 |
| harm reduction, expanded ART and VCT (low-risk every 3 years, high-risk annually) | 36.0 | 21.7 - 43.0 |
| harm reduction, expanded ART and VCT (everyone every 3 years) | 33.1 | 17.0 - 41.5 |
| harm reduction, expanded ART and VCT (everyone annually) | 36.8 | 22.3 - 44.1 |

### 2.2.2 Incremental cost-effectiveness ratios

Figure C-3 shows the incremental costs and QALYs of the different interventions relative to the base case, charted on the cost-effectiveness plane.

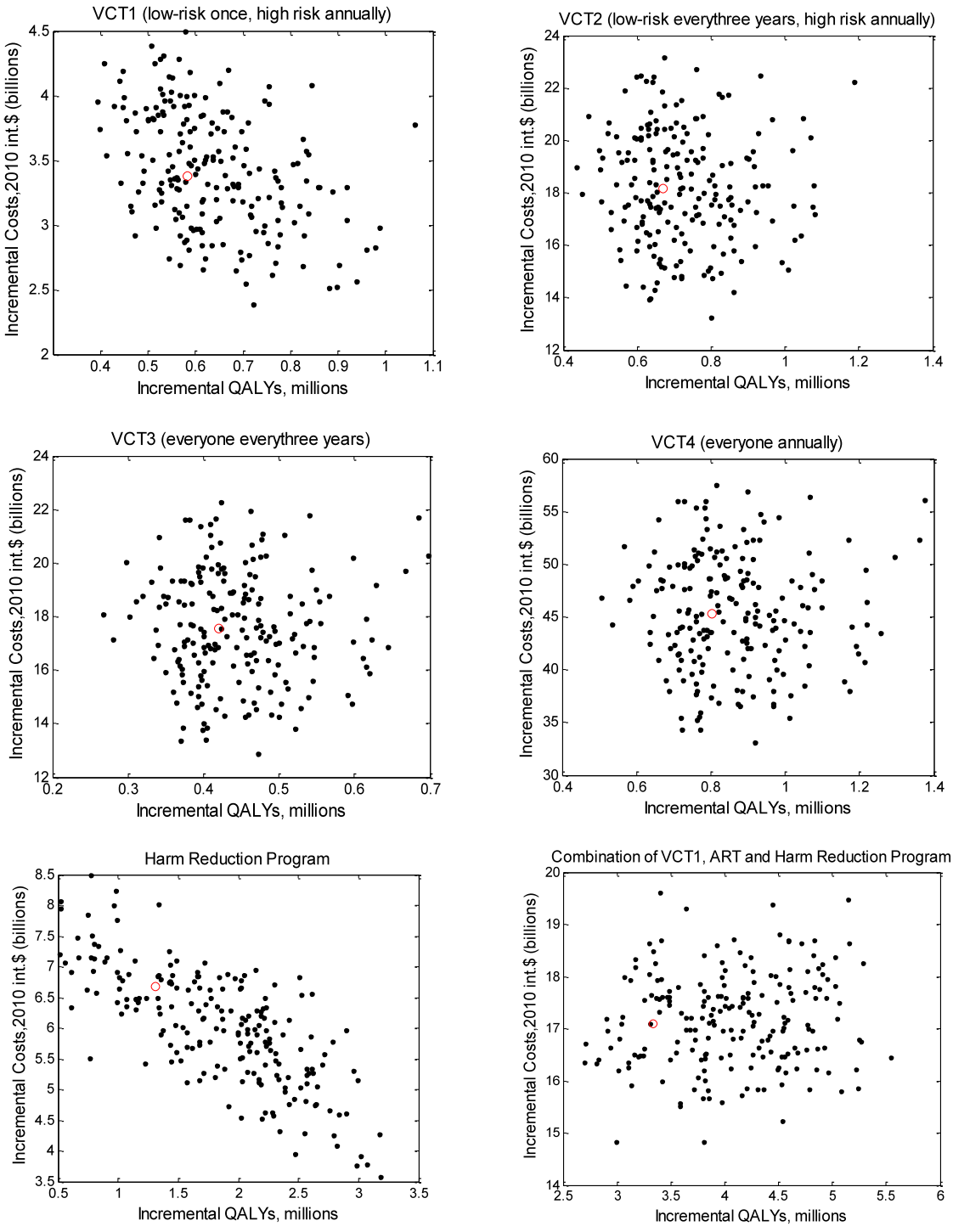



Figure C-5: Sensitivity Analysis for ICER of Selected Interventions Relative to the Base Case.

Because all sets of values for all interventions lie entirely in one quadrant, it is

possible to calculate meaningful sensitivity ranges for the ICER (Table C-3).

Table C-3: ICER of Selected Interventions Relative to the Base Case.

| Strategy | Incremental Cost-effectiveness Ratio, 2010 int.$/QALY | |
|---|---|---|
| | Value | Range |
| **Expanded VCT Only** | | |
| VCT (low-risk once, high-risk annually) | 5,810 | 2,730 - 10,430 |
| VCT (low-risk every 3 years, high-risk annually) | 27,110 | 14,970 - 44,620 |
| VCT (every 3 years) | 41,670 | 24,770 - 67,630 |
| VCT (annually) | 56,440 | 32,440 - 92,410 |
| **Expanded ART Only** | | |
| ART (50% utilization) | 4,840 | 3,960 - 5,980 |
| **Harm Reduction Program Only** | 5,090 | 1,120 - 15,380 |
| **Combination Strategies** | | |
| harm reduction, expanded ART and VCT (low-risk once, high-risk annually) | 5,130 | 2,970 - 6,180 |
| harm reduction, expanded ART and VCT (low-risk every 3 years, high-risk annually) | 9,310 | 4,930 - 11,460 |
| harm reduction, expanded ART and VCT (everyone every 3 years) | 9,860 | 5,080 - 12,410 |
| harm reduction, expanded ART and VCT (everyone annually) | 16,490 | 8,410 - 20,960 |

All selected strategies remain cost-effective relative to the base case under all ranges of sensitivity values. Note that the Harm Reduction Program shows a wide range of possible values for the ICER, possibly because it focuses on IDU, whose prevalence and incidence trends are highly sensitive to a single value (number of injections).

## 2.3 Modeling efficiency

Modeling efficiency of the best 200 fits by key parameters is shown in Figure C-4 for the base case. The modeling efficiency statistic scores are greater than 0.7, which could be interpreted as evidence of good fits.

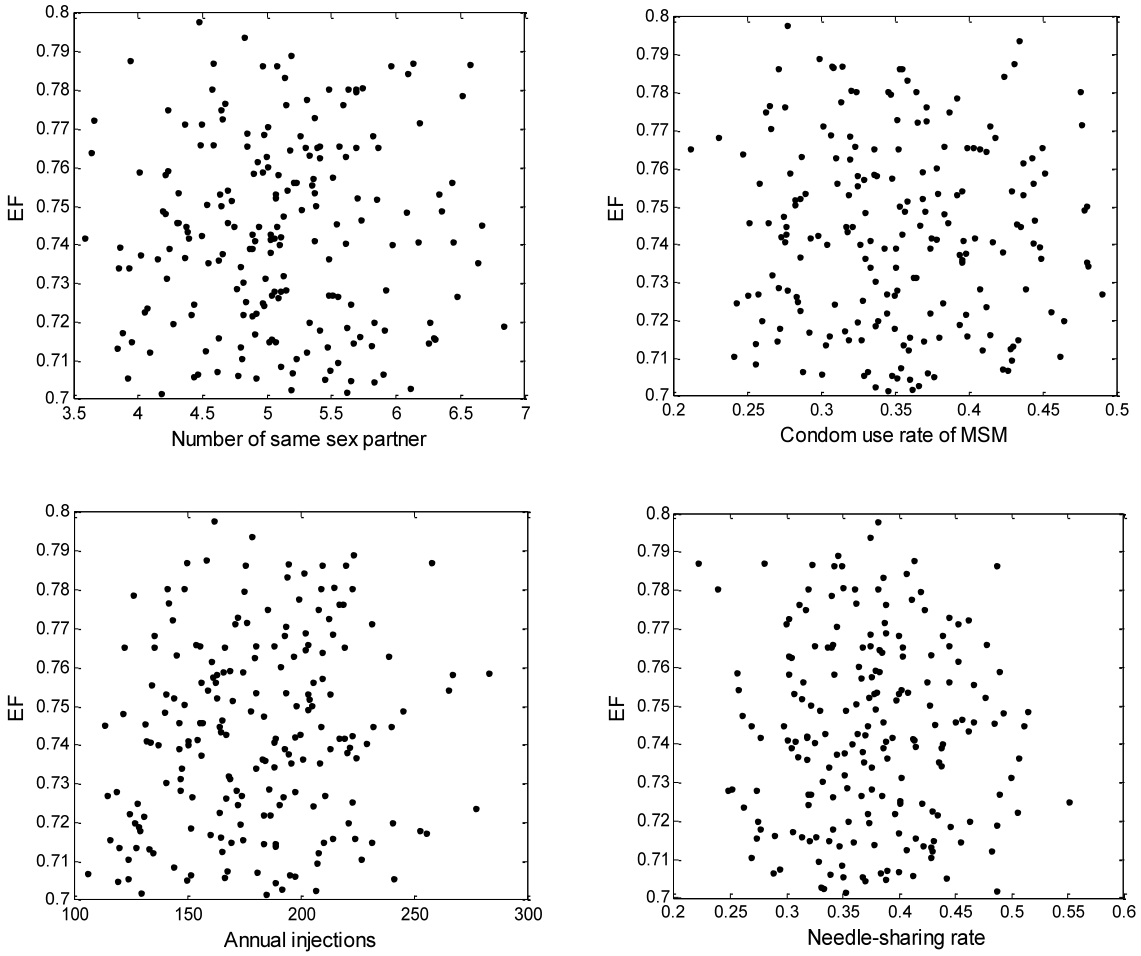



Figure C-6: Modeling Efficiency EF by Key Parameters.

## 2.4 Scenario-based sensitivity analysis

### 2.4.1 Screening and counseling effectiveness

Compared to the base case, 6.6% of future new HIV infections are avoided with the Expanded VCT Only strategy (low-risk once and high-risk annually). Under

the extreme assumption of no reduction in sex partners after screening and counseling (screening effectiveness is 0), 0.20 million infections, 4.7% of the total (Figure C-5), are still prevented by this strategy, at a cost of 7,208 int.$ per QALY gained. This benefit can be attributed to more infected individuals being identified and referred to ART treatment under the expanded VCT program. If screening and counseling reduce the number of sex partners of PLWHA by 50%, 8.0% of new infections could be prevented by implementing expanded one time low-risk and annual high-risk VCT (Figure C-5). This can be attributed not only to improved identification of PLWHAs and referral to ART, but also to a reduction in sex partners after screening and counseling. With the combination strategy of Expanded VCT (one time low-risk and annual high-risk) and Expanded ART (50% utilization), the ICERs range from 4,891 to 5,289 int.$ per QALY gained.

### 2.4.2 ART effectiveness

ART treatment has a preventative effect on the HIV epidemic through a reduction in blood plasma viral load in infected individuals, which reduces their infectivity. ART treatment also significantly reduces morbidity and mortality among PLWHAs. Figure C-6 presents the results of sensitivity analysis of various assumptions about ART's effectiveness in reducing sexual transmission infectivity. If there is no reduction in infectivity due to ART treatment, an additional 0.08 million new HIV infections, 1.9% of the total, would occur over 30 years (Figure

C-6), because infected persons with ART are expected to live much longer than those without ART and subsequently have a longer period of exposure to the susceptible population. If instead of 90% effectiveness (in the base case), ART treatment reduces to 50% effectiveness, over 30 years, 0.18 million new infections, 4.6% of the total will be prevented, at a cost of 6,681 int.$ per QALY gained, under the Expanded ART (50% utilization) strategy.

With a decrease in ART effectiveness from 90% to 0%, the costs for the Expanded ART strategy (50% Utilization) increase from 4,840 int.$ to 11,619 int.$ per QALY gained. With the extreme assumption that ART has no effect in reducing sexual infectivity, infections will increase by 1.9%, because people on ART are living longer and then have longer periods of exposure to susceptible individuals. Furthermore, the cost of the joint strategy of one time low-risk and annual high-risk VCT and 50% ART utilization varies from 4,958 int.$ to 9,691 int.$ per QALY gained with different ART effectiveness.

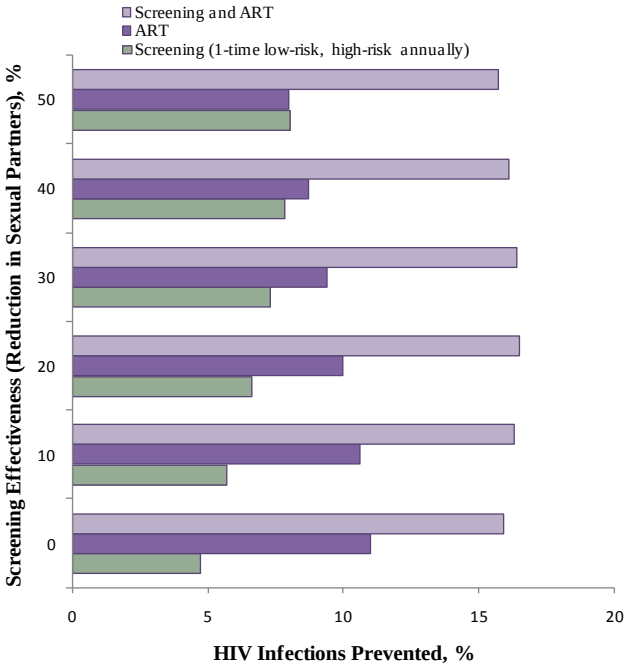



Figure C-5: Percentage of HIV Infections Prevented with Various Screening and Counseling Effectiveness

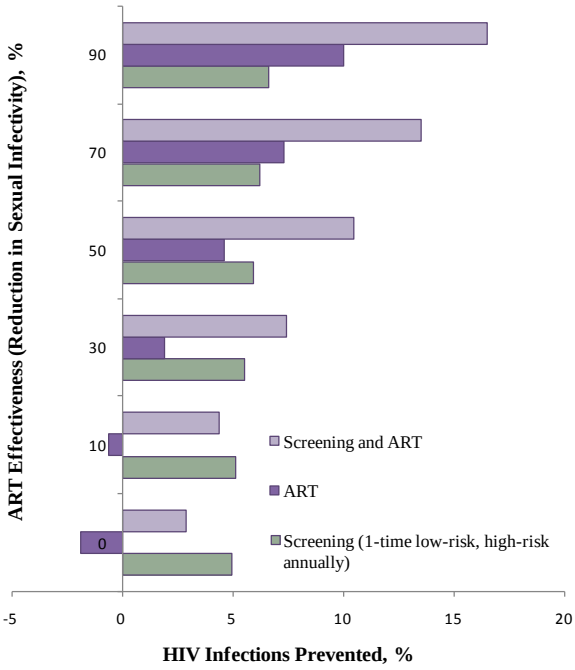



Figure C-6: Percentage of HIV Infections Prevented with Various ART Effectiveness

### 2.4.3 HIV infectiousness

Including acute HIV infection in HIV epidemic model is important, although interventions aimed at affecting the immediate post-infection stage are difficult to implement, especially amongst marginalized populations such as IDU and in countries that do not yet have mature test-and-treat strategies (such as China). Because of this, and in order to avoid excessive complexity, we chose to focus the compartmental structure of the model on treatment and testing rather than directly attempting to model interventions aimed at the acute post-infection phase. However, because the effect of including acute infection in this study can be approximated by increasing the infectiousness of HIV during the asymptomatic stage, we included the infectiousness of HIV during the asymptomatic stage in our

scenario-based sensitivity analysis. In our main model, the joint strategy of one time low-risk and annual high-risk VCT, ART and harm reduction will prevent 1.2 million infections, 35.4% of the total over the next 30 years, at a cost of 5,080 int.$ per QALY gained. If the infectiousness of HIV during the asymptomatic stage increases to 200% of the main model, 25.5% of the total infections will still be prevented (Figure C-7). If the infectiousness of HIV during the asymptomatic stage varies from 70% to 200% of the main model, the combined strategy of ART and VCT (one time low-risk and annual high-risk) will range in cost from 4,290 int.$ to 5,640 int.$ per QALY gained, and will prevent 10.6 - 15.8% of the total infections over the next three decades.

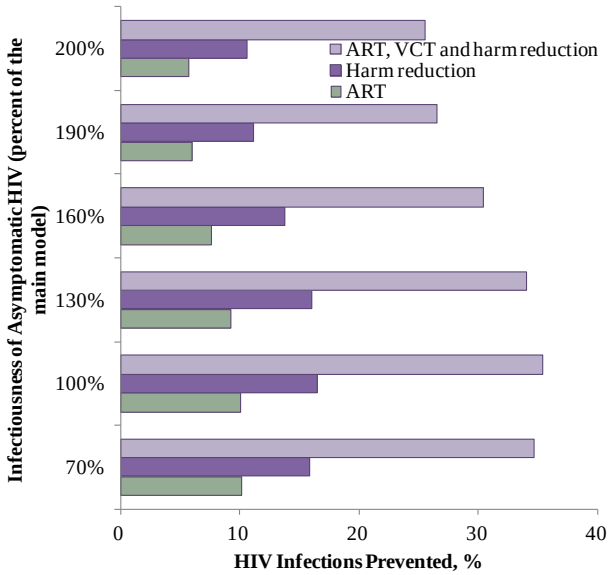



Figure C-7: Effect of varying infectiousness of asymptomatic HIV on percentage of HIV infections prevented.

## 3 Summary

We conducted sensitivity analysis of both epidemiological trends and cost-effectiveness for a wide range of parameters. The overall sensitivity range of the number of PLWHA is concentrated around the estimate from the primary model. However, the prevalence amongst MSM and IDU for the base case are relatively sensitive to the parameters of numbers of same sex partners and annual injections, having wide sensitivity ranges. Thirdly, under a combination strategy of Expanded VCT (low-risk once and high-risk annually), ART and Harm Reduction Programs, 35.3% (21.1 - 42.5%) of the total new infections over 30 years would be averted. Finally, all selected strategies remain cost-effective relative to the base case under all ranges of sensitivity values.

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