Appendix: Evaluating the sensitivity of jurisdictional heterogeneity and jurisdictional mixing in national-level HIV prevention analyses: Context of the U.S. Ending the HIV Epidemic plan.

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### Table A1: List of EHE* and non-EHE jurisdictions (counties and states) modeled [1]

| S. no. | State | County            | FIPS  | Modeled/ why not modeled | S. no. | State         | FIPS  | Modeled/ why not modeled |
|-------|-------|-------------------|-------|--------------------------|-------|--------------|-------|--------------------------|
| 1.    | CA    | Alameda County    | 6001  | Yes                      | 1.    | Alabama      | 1     | Yes                      |
| 2.    | MD    | Baltimore City    | 24510 | Yes                      | 2.    | Alaska       | 2     | Yes                      |
| 3.    | TX    | Bexar County      | 48029 | Yes                      | 3.    | Arizona      | 4     | Yes                      |
| 4.    | NY    | Bronx County      | 36005 | Yes                      | 4.    | Arkansas     | 5     | Yes                      |
| 5.    | FL    | Broward County    | 12011 | Yes                      | 5.    | California   | 6     | Yes                      |
| 6.    | NV    | Clark County      | 32003 | Yes                      | 6.    | Colorado     | 8     | Yes                      |
| 7.    | GA    | Cobb County       | 13067 | Yes                      | 7.    | Connecticut  | 9     | Yes                      |
| 8.    | IL    | Cook County       | 17031 | Yes                      | 8.    | Delaware     | 10    | Yes                      |
| 9.    | OH    | Cuyahoga County   | 39035 | Yes                      | 9.    | District of Columbia | 11    | Yes                      |
| 10.   | TX    | Dallas County     | 48113 | Yes                      | 10.   | Florida      | 12    | Yes                      |
| 11.   | GA    | Dekalb County     | 13089 | Yes                      | 11.   | Georgia      | 13    | Yes                      |
| 12.   | DC    | District of Columbia | 11001 | Modeled as a state   | 12.   | Hawaii       | 15    | Yes                      |
| 13.   | FL    | Duval County      | 12031 | Yes                      | 13.   | Idaho        | 16    | Yes                      |
| 14.   | LA    | East Baton Rouge Parish | 22033 | Yes                   | 14.   | Illinois     | 17    | Yes                      |
| 15.   | NJ    | Essex County      | 34013 | Yes                      | 15.   | Indiana      | 18    | Yes                      |
| 16.   | OH    | Franklin County   | 39049 | Yes                      | 16.   | Iowa         | 19    | Yes                      |
| 17.   | GA    | Fulton County     | 13121 | Yes                      | 17.   | Kansas       | 20    | Yes                      |
| 18.   | GA    | Gwinnett County   | 13135 | Yes                      | 18.   | Kentucky     | 21    | Yes                      |
| 19.   | OH    | Hamilton County   | 39061 | Yes                      | 19.   | Louisiana    | 22    | Yes                      |
| 20.   | TX    | Harris County     | 48201 | Yes                      | 20.   | Maine        | 23    | Yes                      |
| 21.   | FL    | Hillsborough County | 12057 | Yes                   | 21.   | Maryland     | 24    | Yes                      |
| 22.   | NJ    | Hudson County     | 34017 | Yes                      | 22.   | Massachusetts | 25    | Yes                      |
|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 23. | WA | King County | 53033 | Yes | 23. | Michigan | 26 | Yes |
| 24. | NY | Kings County | 36047 | Yes | 24. | Minnesota | 27 | Yes |
| 25. | CA | Los Angeles County | 6037 | Yes | 25. | Mississippi | 28 | Yes |
| 26. | AZ | Maricopa County | 4013 | Yes | 26. | Missouri | 29 | Yes |
| 27. | IN | Marion County | 18097 | Yes | 27. | Montana | 30 | Yes |
| 28. | NC | Mecklenburg County | 37119 | Yes | 28. | Nebraska | 31 | Yes |
| 29. | FL | Miami-Dade County | 12086 | Yes | 29. | Nevada | 32 | Yes |
| 30. | MD | Montgomery County | 24031 | Yes | 30. | New Hampshire | 33 | Data suppressed |
| 31. | NY | New York County | 36061 | Yes | 31. | New Jersey | 34 | Yes |
| 32. | FL | Orange County | 12095 | Yes | 32. | New Mexico | 35 | Yes |
| 33. | CA | Orange County | 6059 | Yes | 33. | New York | 36 | Yes |
| 34. | LA | Orleans Parish | 22071 | Yes | 34. | North Carolina | 37 | Yes |
| 35. | FL | Palm Beach County | 12099 | Yes | 35. | North Dakota | 38 | Yes |
| 36. | PA | Philadelphia County | 42101 | Yes | 36. | Ohio | 39 | Yes |
| 37. | FL | Pinellas County | 12103 | Yes | 37. | Oklahoma | 40 | Yes |
| 38. | MD | Prince George's County | 24033 | Yes | 38. | Oregon | 41 | Yes |
| 39. | NY | Queens County | 36081 | Yes | 39. | Pennsylvania | 42 | Yes |
| 40. | CA | Riverside County | 6065 | Yes | 40. | Rhode Island | 44 | Yes |
| 41. | CA | Sacramento County | 6067 | Yes | 41. | South Carolina | 45 | Yes |
| 42. | CA | San Bernardino County | 6071 | Yes | 42. | South Dakota | 46 | Yes |
| 43. | CA | San Diego County | 6073 | Yes | 43. | Tennessee | 47 | Yes |
| 44. | CA | San Francisco County | 6075 | Data suppressed | 44. | Texas | 48 | Yes |
| 45. | PR | San Juan Municipio | 72127 | Population demographic data not available for counties and state | 45. | Utah | 49 | Yes |
| 46. | TN | Shelby County | 47157 | Yes | 46. | Vermont | 50 | Yes |
|   |   | State          | County    | Zip Code | Data Available |   |   |
|---|---|----------------|-----------|----------|----------------|---|---|
| 47. | MA | Suffolk County | 25025     | Data suppressed | 47. | Virginia | 51 | Yes |
| 48. | TX | Tarrant County | 48439     | Yes | 48. | Washington | 53 | Yes |
| 49. | TX | Travis County  | 48453     | Yes | 49. | West Virginia | 54 | Yes |
| 50. | MI | Wayne County   | 26163     | Yes | 50. | Wisconsin   | 55 | Yes |
|     |   |                |           |        | 51. | Wyoming     | 56 | Yes |
|     |   |                |           |        | 52. | American Samoa | 60 | Data not available |
|     |   |                |           |        | 53. | Guam         | 66 | Data not available |
|     |   |                |           |        | 54. | Northern Mariana Islands | 69 | Data not available |
|     |   |                |           |        | 55. | Puerto Rico  | 72 | Demographic data not available |
|     |   |                |           |        | 56. | U.S. Virgin Islands | 78 | Data not available |

CDC: Centers for Disease Control and Prevention
* EHE jurisdictions are in blue; states that have EHE counties within them are excluded
### A2: Disease, care continuum, and death related parameters for both compartmental models

**Table A2:** Rates of care continuum and disease progression used in the matrix $G_t$

| From† | To† | Progression type | Rate† | Source |
|-------|-----|------------------|-------|--------|
| (A-U) (1) | (A-ANA) (2) | Care | Diagnosis rate$^i \times \theta_{d, risk}$ | Estimated |
| (U) >500 (3) | Disease | 5.88 | [3,5,8] |
| (A-ANA) (2) | (ANA) >500 (4) | Disease | Diagnosis rate$^i \times (1\text{-}\text{linkage to care}^j) \times \theta_{d, risk}$ | Estimated |
| (ANV) >500 (5) | Care | Diagnosis rate$^i \text{linkage to care}^j \times \theta_{d, risk}$ | Estimated |
| (U) 351-500 (7) | Disease | 0.286 | [3,5–8] |
| (ANA) >500 (4) | (ANA) 351-500 (8) | Care | Diagnosis rate$^i \text{linkage to care}^j \times \theta_{d, risk}$ | Estimated |
| (ANV) >500 (5) | (VLS) >500 (6) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
| (VLS) >500 (6) | (ANA) >500 (4) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
| (U) 351-500 (7) | (ANA) 351-500 (8) | Care | Diagnosis rate$^i \times (1\text{-}\text{linkage to care}^j) \times \theta_{d, risk}$ | Estimated |
| (ANV) 351-500 (9) | Care | Diagnosis rate$^i \text{linkage to care}^j \times \theta_{d, risk}$ | Estimated |
| (U) 201-350 (11) | Disease | 0.286 | [3,5–8] |
| (ANA) 351-500 (8) | (ANA) 201-350 (12) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
| (ANV) 351-500 (9) | (VLS) 351-500 (10) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
| (VLS) 351-500 (10) | (ANA) 351-500 (8) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
| (U) 201-350 (11) | (ANV) 201-350 (12) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
| (ANA) 201-350 (13) | (VLS) <200 (15) | Disease | 0.33 | [3,6,11–14] |
| (ANA) 201-350 (12) | (ANV) 201-350 (13) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
| (ANV) 201-350 (13) | (VLS) <200 (17) | Disease | 0.33 | [3,6,11–14] |
| (VLS) 201-350 (14) | (VLS) <200 (17) | Disease | 0.385 | [3] |
| (U) <200 (15) | (ANA) <200 (16) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
| (ANA) <200 (16) | (ANV) <200 (17) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
| (VLS) <200 (15) | (ANV) <200 (17) | Care | Dropout rate$^i \times \varphi_d$ | Estimated |
\( \theta_{d,risk} \) = scaling factor for diagnosis rate in disease-stage \( d \), varies by risk group. The total scaling factor = average annual rate of diagnosis in each disease stage \( \times ( \text{scaling factor for conventional test} + \text{scaling factor for rapid test}) \).

Scaling factor for each test type (conventional or rapid) is calculated as percentage of test type \( \times \text{test sensitivity} \times \text{notification probability} \), and annual diagnosis rates are obtained from [3].

\( \phi_d \) = scaling factor for drop-out rate in disease-stage \( d \). Scaling factor is 1 for all CD4 counts above 200 and 0 for CD4 below 200.

*Rates in table represent annual rates input to the simulation model.

† Diagnosis rate and Dropout rate are rates of care metrics estimated monthly for each risk group.

‡ Data on linkage to care changes across risk groups, time, and jurisdictions [16].

§ Numbers within parenthesis “()” refer to compartment numbers as seen in Figure 1.

### Table A3: Death rates for HIV infected without ART [17]

| Disease stage | Death rate |
|---------------|------------|
| CD4 <200      | 0.117      |
| CD4 200-350   | 0.024      |
| CD4 350-500   | 0.012      |
| CD4 >500      | 0.008      |
| Acute         | 0.008      |

### Table A4: Death rates for HIV infected after ART initiation by disease stages [18]

| Age group | Disease stage CD4 > 350 | Disease stage CD4 > 200-350 | Disease stage CD4 < 200 |
|-----------|-------------------------|-----------------------------|-------------------------|
| 13-29     | 0.004                   | 0.005                       | 0.015                   |
| 30-39     | 0.005                   | 0.006                       | 0.019                   |
| 40-49     | 0.006                   | 0.008                       | 0.025                   |
| 50-100    | 0.046                   | 0.016                       | 0.011                   |

### A3: Estimation of incidence using Bernoulli Equation

We estimate the number of persons transitioning from the susceptible to infected compartments, i.e., the number of newly persons using a Bernoulli model, developed for both, the National-Model and the Jurisdictional-Model.

#### National-Model

We apply the following Bernoulli equation for calculating the number of new infections as follows.

Let,

\[ p_{v,x1} = \text{probability of transmission for vaginal acts for risk group } x_1 \text{ per sexual act,} \]
\[ p_{a,x1} = \text{probability of transmission for anal acts for risk group } x_1 \text{ per sexual act,} \]
\[ \epsilon = \text{probability of condom effectiveness,} \]
\[ n_{v,x1,y1} = \text{number of annual vaginal acts for risk group } x_1, \text{ and age group } y_1 (\text{number of acts } \times \text{ proportion of anal acts}), \]
\[ n_{a,x1,y1} = \text{number of annual anal acts for risk group } x_1, \text{ and age group } y_1 (\text{number of acts } \times (1-\text{ proportion of anal acts})), \]
\[ c_i = \text{proportion reduction in number of unprotected acts when aware in infected compartment } i, \]
\[ d_{x1,y1} = \text{number of partners for risk group } x_1, \text{ and age group } y_1 (\text{calculated as weighted average of median number of partners for each partnership type and proportion of partnership type}), \]
\[ p_e = \text{proportion of persons having only casual partners,} \]
\[ p_c+m = \text{proportion of persons having casual and main partners,} \]
\[ p_m = \text{proportion of persons having only main partners,} \]
\( c_c = \text{proportion of condom use among casual partners,} \)
\( c_m = \text{proportion of condom use among main partners,} \)
\( m_{c+m} = \text{number of annual casual partners among persons with casual and main partnerships,} \)
\( S_c = \text{number of annual sexual acts with each casual contact (assumed 2, median between 1 and 3), and} \)
\( S_{acts} = \text{number of annual sexual acts per person.} \)

We calculate the number of new infections in risk group \( x_i \) and age group \( y_i \) as
\[
q_{x_i,y_i} = S_{x_i,y_i} \sum_{i=1}^{100} \left( 1 - \prod_{i=1}^{13} \left( M_{x_i,y_i} \right)^4_{x_i,y_i} \right)
\]

where,
\( S_{x_i,y_i} \) is the number of susceptible individuals in risk group \( x_i \), and age group \( y_i \);
\( 1 - M_{x_i,y_i} \) is the transmission probability per partnership for a susceptible person in risk group \( x_i \) and age group \( y_i \) from interactions with an infected person in compartment \( i \), and is calculated as,
\[
M_{x_i,y_i} = \left\{ 1 - \left[ \left( 1 - \left[ \tilde{p}_{v_i,x_i,y_i} \right] m_{v_i} \right)^{m_{v_i}} \left( 1 - \left[ \tilde{p}_{a_i,x_i,y_i} \right] m_{a_i} \right)^{m_{a_i}} \right] \right\}
\]
\( \tilde{p}_{v_i,x_i} = p_{v_i,x_i} \) is probability of transmission per protected sexual act (vaginal) for risk group \( x_i \),
\( p_{a_i,x_i} = p_{a_i,x_i} \) is probability of transmission per protected sexual act (anal) for risk group \( x_i \),
\( p_i \) is factor for transmission probability based on infected compartment \( i \),
\( m_{v_i} = \sum_{d_{x_i,y_i}} n_{v_i,x_i,y_i} \) = number of annual protected sexual acts (vaginal) per partner,
\( m_{a_i} = \sum_{d_{x_i,y_i}} n_{a_i,x_i,y_i} \) = number of annual protected sexual acts (anal) per partner,
\( n_{v_i} = \sum_{d_{x_i,y_i}} n_{v_i,x_i,y_i} \) = number of annual unprotected sexual acts (vaginal) per partner,
\( n_{a_i} = \sum_{d_{x_i,y_i}} n_{a_i,x_i,y_i} \) = number of annual unprotected sexual acts (anal) per partner,
\( c_{x_i,y_i} = p_c c_c + p_{c+m} n_c c_c + p_{c+m} n_m c_m + p_m c_m \) = proportion of condom usage by risk group \( x_i \), and age group \( y_i \),
\( n_m = 1 - n_c \) = proportion of acts with main partners,
\( n_c = m_{c+m} \) = proportion of acts with casual partners,
\( (\text{note:} \left( (1 - c_{x_i,y_i}) c_i + c_{x_i,y_i} \right) \left( (1 - c_{x_i,y_i}) (1 - c_i) \right) = 1 \) and \( p_c + p_{c+m} + p_m = 1); \)
\( q_{x_i,y_i} \) is the number of infected partners from compartment \( i \) that a susceptible person in risk group \( x_i \) and age group \( y_i \) has, and is calculated as,
\[
q_{x_i,y_i} = d_{x_i,y_i} \sum_{x_2=1}^{100} \sum_{y_2=13}^{100} \text{risk}_{x_1,x_2} \text{age}_{y_1,y_2} \text{risk}_{x_1,x_2} \text{age}_{y_1,y_2}
\]
\( d_{x_i,y_i} = \text{number of partners for risk group} \ x_i \), and age group \( y_i \) (calculated as weighted average of median number of partners for each partnership type and proportion of partnership type),
\( \text{risk}_{x_1,x_2} = \text{risk specific mixing proportion between risk group} \ x_1 \) and \( x_2 \),
\( \text{age}_{y_1,y_2} = \text{age specific mixing proportion between age group} \ y_1 \) and \( y_2 \),
\( I_{x_2,y_2} = \text{number of infected in risk group} \ x_2 \), age group \( y_2 \), and infected compartment \( i \), and
\( N_{x_2,y_2} = \text{number of people in risk group} \ x_2 \), age group \( y_2 \).

Data related to the above parameters are presented in Tables A5 to A14.

The total number of new infections in the National-Model for all risk groups and age groups, can then be calculated as follows:
\[
\sum_{x=1}^{3} \sum_{y=1}^{100} S_{x,y} \left( 1 - \prod_{i=1}^{13} \left( M_{x,y} \right)^4_{x,y} \right)
\]
Jurisdictional-Model

We estimate the number of new infections as in (2) but now also include jurisdictional mixing of sexual partnerships as follows.

Number of new infections in risk group $x_1$, age group $y_1$, and jurisdiction $j = \sum_{i}^{\text{partnership}} \sum_{j=1}^{\text{jurisdictions}} q_{j,x_1,y_1,i} M_{x_1,y_1,i} S_{x_1,y_1,j} (1 - \prod_{i=1}^{18} (M_{x_1,y_1,i} \sum_{j=1}^{\text{partnership}} m_{mix(x_1,j,i)} q_{j,x_1,y_1,i}))$, \hspace{1cm} (6)

where,

- $S_{x_1,y_1,j}$ is the number of susceptible persons in risk group $x_1$, age group $y_1$, and jurisdiction $j$
- $M_{x_1,y_1,i}$ is the same as in (3), and
- $q_{j,x_1,y_1,i}$ is the number of infected partners from compartment $i$ and jurisdiction $j$ that a susceptible person in risk group $x_1$, age group $y_1$, and jurisdiction $j$ has, and is calculated as,

\begin{equation}
q_{j,x_1,y_1,i} = d_{x_1,y_1} \sum_{x_2=1}^{3} \sum_{y_2=1}^{100} \left( \text{risk}_{x_1,x_2}^y \text{age}_{y_1,y_2}^x \right) \left( l_{x_2,y_2,i} \right) \left( N_{x_2,y_2} \right)
\end{equation}

- $l_{x_2,y_2,i}$ = number of infected in risk group $x_2$, age group $y_2$, compartment $i$, and jurisdiction $j$,
- $N_{x_2,y_2}$ = number of people in risk group $x_2$, age group $y_2$, and jurisdiction $j$,
- $m_{mix(x_1,j,i)} = \frac{\text{mixing}_{x_1,j,i}}{\text{age}_{y_1}^x}$ proportion of mixing of risk group $x_1$ located in jurisdiction $j$ with PWH located in jurisdiction $j$, and
- $j$ and $j$ ∈ \{1, 2, ..., 30\}.

Table A5: Age group specific mixing of sexual partnerships by risk group

| Risk group | Age group | 13-17 | 18-24 | 25-29 | 30-24 | 35-39 | 40-44 | 45-64 | 65-100 |
|------------|-----------|-------|-------|-------|-------|-------|-------|-------|--------|
| HM         | 13-17     | 91.1% | 4.2%  | 1.1%  | 1.1%  | 1.1%  | 1.1%  | 0.2%  | 0.0%   |
|            | 18-24     | 6.8%  | 2.3%  | 92.1% | 1.1%  | 1.1%  | 1.1%  | 1.1%  | 0.0%   |
|            | 25-29     | 14.1% | 14.1% | 14.1% | 54.1% | 1.1%  | 1.1%  | 1.1%  | 1.1%  |
|            | 30-24     | 5.4%  | 5.4%  | 5.4%  | 76.2% | 1.1%  | 1.1%  | 1.1%  | 0.0%   |
|            | 35-39     | 4.5%  | 4.5%  | 4.5%  | 4.5%  | 4.5%  | 76.2% | 1.1%  | 0.0%   |
|            | 40-44     | 3.9%  | 3.9%  | 3.9%  | 3.9%  | 3.9%  | 76.2% | 1.1%  | 0.0%   |
|            | 45-64     | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%   |
|            | 65-100    | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%   |
| HF         | 13-17     | 91.1% | 6.9%  | 0.5%  | 0.5%  | 0.5%  | 0.5%  | 0.0%  | 0.0%   |
|            | 18-24     | 5.4%  | 5.4%  | 5.4%  | 76.2% | 1.1%  | 1.1%  | 1.1%  | 0.0%   |
|            | 25-29     | 39.8% | 39.8% | 39.8% | 76.2% | 1.1%  | 1.1%  | 1.1%  | 0.0%   |
|            | 30-24     | 43.0% | 43.0% | 43.0% | 43.0% | 43.0% | 76.2% | 1.1%  | 0.0%   |
|            | 35-39     | 15.7% | 15.7% | 15.7% | 15.7% | 15.7% | 15.7% | 15.7% | 15.7%  |
|            | 40-44     | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%   |
|            | 45-64     | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%   |
|            | 65-100    | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%   |
| MSM        | 13-17     | 91.1% | 4.7%  | 0.5%  | 0.5%  | 0.5%  | 0.5%  | 0.5%  | 0.0%   |
|            | 18-24     | 48.0% | 48.0% | 48.0% | 32.9% | 1.1%  | 1.1%  | 1.1%  | 0.0%   |
|            | 25-29     | 55.9% | 55.9% | 55.9% | 55.9% | 55.9% | 55.9% | 55.9% | 55.9%  |
|            | 30-24     | 37.6% | 37.6% | 37.6% | 37.6% | 37.6% | 37.6% | 37.6% | 37.6%  |
|            | 35-39     | 24.6% | 24.6% | 24.6% | 24.6% | 24.6% | 24.6% | 24.6% | 24.6%  |
|            | 40-44     | 7.4%  | 7.4%  | 7.4%  | 7.4%  | 7.4%  | 7.4%  | 7.4%  | 7.4%   |
|            | 45-64     | 11.0% | 11.0% | 11.0% | 11.0% | 11.0% | 11.0% | 11.0% | 11.0%  |
|            | 65-100    | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%  | 0.0%   |

Diagonal estimates from [3] [19] and off diagonal elements were calibrated to match incidence by age groups

HM: heterosexual male; HF: heterosexual female; MSM: men who have sex with men
Table A6: Mixing of sexual partnership by risk group [3]

| Risk group | HM  | HF  | MSM |
|------------|-----|-----|-----|
| HM         | 0   | 100.00% | 0   |
| HF         | 98.20% | 0  | 1.80% |
| MSM        | 0   | 40%  | 60% |

HM: heterosexual male; HF: heterosexual female; MSM: men who have sex with men

Table A7: Number of annual median partners by partnership type [23–25]

| Risk group | Casual-main* | Main only | Casual only |
|------------|--------------|-----------|-------------|
| HM         | 1            | 1         | 4           |
| HF         | 1            | 1         | 4           |
| MSM        | 2            | 1         | 5           |

HM: heterosexual male; HF: heterosexual female; MSM: men who have sex with men

* Main partners in casual and main relationship type

Table A8: Proportion of partnership type* by risk group [20–22]

| Risk group | Casual | Casual only |
|------------|--------|-------------|
| HM         | 0.579  | 0.144       |
| HF         | 0.579  | 0.144       |
| MSM        | 0.652  | 0.307       |

HM: heterosexual male; HF: heterosexual female; MSM: men who have sex with men

* Proportion of main only partnerships = 1 - proportion casual only partnerships and proportion of casual-main partnerships = proportion casual – proportion of casual only

Table A9: Proportion of condom usage* by risk group, partnership type and age group [28,29]

| Age group | HF-main | HF-casual | HM-main | HM-casual | MSM-main | MSM-casual |
|-----------|---------|-----------|---------|-----------|----------|------------|
| 13-17     | 51.3%   | 72.1%     | 76.5%   | 84.4%     | 28.1%    | 61.3%      |
| 18-24     | 26.9%   | 41.7%     | 23.1%   | 48.9%     | 28.1%    | 61.3%      |
| 25-29     | 18.4%   | 39.3%     | 18.4%   | 49.6%     | 25.0%    | 54.5%      |
| 30-39     | 12.4%   | 24.9%     | 14.2%   | 48.9%     | 22.2%    | 48.4%      |
| 40-49     | 10.1%   | 18.4%     | 12.6%   | 30.6%     | 21.7%    | 47.3%      |
| 50-59     | 7.0%    | 14.9%     | 1.6%    | 20.8%     | 21.3%    | 46.6%      |
| 60-100    | 3.8%    | 17.4%     | 2.0%    | 12.5%     | 20.1%    | 43.8%      |

HM: heterosexual male; HF: heterosexual female; MSM: men who have sex with men

* Condom efficiency is assumed to be 80% [30–32]

Table A10: Annual sexual acts* by age group and risk group

| Age group | HM  | HF  | MSM |
|-----------|-----|-----|-----|
| 13-14     | 45  | 24  | 45  |
| 15-17     | 45  | 24  | 45  |
| 18-19     | 84  | 94  | 107 |
| 20-24     | 84  | 94  | 107 |
| 25-29     | 81  | 78  | 99  |
| 30-34     | 73  | 66  | 93  |
| 35-39     | 73  | 66  | 93  |
| 40-44     | 70  | 67  | 82  |
| 45-49     | 77  | 67  | 61  |
| 50-54     | 54  | 59  | 56  |
| 55-59     | 54  | 47  | 56  |
| 60-64     | 55  | 48  | 37  |
| 65-70     | 55  | 48  | 37  |

HM: heterosexual male; HF: heterosexual female; MSM: men who have sex with men

* Ranges for sexual acts from [24–27]
Table A11: Proportion of annual sexual acts*, by risk group and age group [24–27]

| Age group | HF   | HM   | MSM   |
|-----------|------|------|-------|
| 13-24     | 6.6% | 4.8% | 50%   |
| 25-29     | 7.5% | 8.4% | 50%   |
| 30-39     | 5.9% | 4.2% | 50%   |
| 40-49     | 3.9% | 6.1% | 50%   |
| 50-59     | 2.5% | 2.8% | 50%   |
| 60-100    | 4.2% | 3.7% | 50%   |

HM: heterosexual male; HF: heterosexual female; MSM: men who have sex with men
* Proportion of vaginal acts = 1-proportion of anal acts

Table A12: Scalar risk factor* for transmission in various stages of care and disease [15,33–36]

| Compartment                  | Transmission risk scalar factor |
|------------------------------|--------------------------------|
| Acute stages                 | 8.1                            |
| Non-acute with viral load suppression | 0.01                        |
| Non-acute without viral load suppression | 1                             |

* Usage of PrEP reduces transmission risk by 99% [37]

Table A13: Calibrated values of probability of HIV transmission* per sexual act for risk groups

| Risk group | Vaginal acts | Anal acts |
|------------|--------------|-----------|
| HM         | 0.0007       | 0.00160   |
| HF         | 0.0004       | 0.00831   |
| MSM        | 0.0018       | 0.00586   |

HM: heterosexual male; HF: heterosexual female; MSM: men who have sex with men
* Initial estimates and ranges for transmission probability were taken from [38–40]

Table A14: Proportion of men who have sex with men* among male population by county [41]

| County                      | Proportion |
|-----------------------------|------------|
| Maricopa County             | 0.06       |
| Alameda County              | 0.07       |
| Los Angeles County          | 0.07       |
| Orange County               | 0.06       |
| Riverside County            | 0.09       |
| Sacramento County           | 0.07       |
| San Bernardino County       | 0.03       |
| San Diego County            | 0.07       |
| Broward County              | 0.09       |
| Duval County                | 0.05       |
| Hillsborough County         | 0.06       |
| Miami-Dade County           | 0.06       |
| Orange County               | 0.07       |
| Palm Beach County           | 0.05       |
| Pinellas County             | 0.07       |
| Cobb County                 | 0.04       |
| Dekalb County               | 0.08       |
| Fulton County               | 0.09       |
| Gwinnett County             | 0.04       |
| Cook County                 | 0.07       |
| Marion County               | 0.06       |
| East Baton Rouge Parish     | 0.03       |
Orleans Parish 0.03
Baltimore City 0.04
Montgomery County 0.04
Prince George's County 0.04
Wayne County 0.05
Mecklenburg County 0.06
Essex County 0.04
Hudson County 0.07
Clark County 0.06
Bronx County 0.05
Kings County 0.07
New York County 0.14
Queens County 0.05
Cuyahoga County 0.06
Franklin County 0.07
Hamilton County 0.03
Philadelphia County 0.06
Shelby County 0.05
Bexar County 0.05
Dallas County 0.08
Harris County 0.06
Tarrant County 0.05
Travis County 0.08
King County 0.08
National 0.04

* Data for some counties is not available in [41], for such counties, we use the same percentage as the state. For states that have multiple EHE counties, MSM population in counties was removed to calculate the proportion of MSM population within a state.

A4: Estimation of diagnosis and retention-in-care rates

As care parameters change over time, the diagnosis and retention in care rates also change. Therefore, we analytically estimate these in the model, by calibrating it to the expected targets for the care continuum metrics, specifically, the % aware, and % VLS. We calculate diagnosis rate and retention-in-care rate specific to risk group and jurisdiction only (and not specific to age or disease stage), and thus use a collapsed/simplified state of the Markov process (Eqn. 1 in Section A1) as follows (see Figure A1).
**Figure A1:** Flow diagram for disease incidence and transition* along the stages of care continuum**

*δ*: diagnosis rate, *γ*: rate of entering care and treatment among those not in care, and *ρ*: rate of dropping out of care, and *L*: proportion linked-to-care at diagnosis

**Susceptible: Population susceptible, *U*: population Unaware, *A*: population Aware no ART, *V*: population with ART no VLS and ART VLS

For a sufficiently small incremental time-step, *t* + 1 (we use monthly increments), we can write the generalized compartmental model for the number of people in each stage by formulating it as a system of differential equations.

\[
p_{t+1,s,risk}I_{t+1} = p_{t,s,risk}I_t + \frac{dp_{t,s,risk}}{dt},
\]

(8)

Where,

\[p_{t,s,risk}\] is the proportion of people in care continuum stage *s*; at time *t* for risk group *risk*,

\[I_t\] = number of PWH at time *t* (estimated prevalence),

\[\frac{dp_{t,s,risk}}{dt}\] is the rate of change in \[p_{t,s,risk}\] *I* *t*, i.e., the change in the number of infected persons in stage *s* at time *t*,

\[dt = \frac{1}{12}\] (monthly),

\[s = \text{care continuum stage; } s \in \{U, A, V\} \; \text{U = unaware; A = aware; V = prescribed ART (with VLS + no VLS).}

We estimate rates *δ* and *ρ* by expansion of the above equations as discussed in following sub-sections. We estimate these rates specific to risk group for the National-Model and specific to both risk group and jurisdiction for the Jurisdictional-Model but exclude the jurisdictional notation for clarity.

**A4.1 Estimation of diagnosis rates**

Expanding (8) for *s = U* (Unaware stage), we can write,

\[l_t p_{t,U,risk} = l_{t-1} p_{t-1,U,risk} + i_{t,risk} - \delta_{t,risk} \sum_d \theta_{d,risk} l_{t-1} p_{t-1,U,risk,d} - \sum_d m_{t,U,risk}
\]

(9)

Where,

\[l_t\] = total number of people living with HIV (PWH) (estimated prevalence),

\[p_{t,U,risk}\] is the proportion of people in care continuum stage *U* (here *s = \{U\}) for risk group *risk* at time *t*,

\[i_{t,risk}\] = new infections generated at time *t* in risk group *risk*,

\[\delta_{t,risk}\] = diagnosis rate at time *t* for each risk group *risk*,

\[\theta_{d,risk}\] = scaling factor for diagnosis rate in disease-stage *d* for each risk group *risk* (see footnotes for Table A2); *d* \(\in \{\text{Acute, CD4} > 500, \text{CD4} 350 – 500, \text{CD4} 200 – 350, \text{CD4} < 200\},

\[p_{t,U,risk,d}\] is the proportion of people in care continuum stage *U* (here *s = \{U\}) for risk group *risk* at time *t* and for disease stage *d*, and

\[m_{t,U,d,risk}\] = number of deaths in the care-stage *U* (here *s = \{U\}) and disease-stage *d* at time *t* in each risk group *risk*.

Rearranging (9) we can solve for diagnostic rate *δ*_{t,risk} as

\[
\delta_{t,risk} = \frac{i_{t,risk} + l_{t-1} p_{t-1,U,risk} - \sum_d \theta_{d,risk} l_{t-1} p_{t-1,U,risk,d} - \sum_d m_{t,U,d,risk}}{\sum_d \theta_{d,risk} l_{t-1} p_{t-1,U,risk,d}}
\]

(10)

and the corresponding number of people that are diagnosed as

\[
\delta_{t,risk} \sum_d \theta_{d,risk} l_{t-1} p_{t-1,U,risk,d}
\]

Each term on the right-hand-side of (10) is computationally calculated in the simulation as follows:

- *i_{t,risk}* is number of new infection for each risk group and is calculated using the Bernoulli equations (Section A2),
- \[\sum_d (m_{t,U,d,risk})\] is the number of deaths and tracked in the simulation (death rates presented in Tables A3 and A4),
- *l_{t-1} p_{t-1,U,risk}* is the number of people in compartment *U* at previous time-step and is tracked in the simulation (initial data for distribution of population in care stages, i.e., *p_{t,s,risk}* for both National-Model
and Jurisdictional-Model, are taken from NHSS data [16] and projections over time are tracked in the
simulation),

- \( p_{t,U,\text{risk}} \) is the expected proportion of people in compartment \( U \) at time-step \( t \) for each risk group,
- \( I_t \) \( p_{t,U,\text{risk}} \) is the expected number of people in compartment \( U \) in time-step \( t \) to match the expected value of
\( p_{t,U,\text{risk}} \) and is calculated as
\[
p_{t,U,\text{risk}} = p_{t-1,U,\text{risk}} + \frac{a_{U,T-1,\text{risk}} - a_{U,T-1,\text{risk}}}{1/d_t},
\]

  - \( a_{U,T-1,\text{risk}} \) is the proportion of people unaware in previous year \( T-1 \) and risk group \( \text{risk} \),
  - \( a_{U,T,\text{risk}} \) is the proportion of people unaware in year \( T \) and risk group \( \text{risk} \) (for baseline scenarios, proportion unaware is the actual value in the U.S. in year 2018; for EHE plan scenarios, proportion unaware is scaled up every year from current value in 2018 to reach EHE target of 5% unaware by 2025 for EHE jurisdictions and by 2030 for non-EHE jurisdictions), and
  - \( \frac{a_{U,T,\text{risk}} - a_{U,T-1,\text{risk}}}{1/d_t} \) is the expected change in proportion of persons unaware of infection.

### A4.2 Estimation of dropout rates

We are only estimating the dropout rate for CD4 count >200. For CD4 count <200, we assume dropout is 0 and this
is modeled by making \( \varphi_d = 0 \) for CD4 count < 200.

Expanding (8) for \( s = V \) (prescribed ART) we can write,
\[
l_t p_{t,V,\text{risk}} = l_{t-1} p_{t-1,V,\text{risk}} + \delta_{t,\text{risk}} l_{t,\text{risk}} \sum_d I_{t-1} p_{t-1,U,d,\text{risk}} \theta_{d,\text{risk}} + \sum_d \gamma_d l_{t-1} p_{t-1,A,d,\text{risk}} -
\]
\[
\rho_{t,\text{risk}} \sum_d I_{t-1} p_{t-1,V,d,\text{risk}} \varphi_d - \sum_d (m_{t,V,d,\text{risk}})
\]
\[
(11)
\]

Where,
- \( l_t \) is the total number of people living with HIV (PWH) (estimated prevalence),
- \( p_{t,V,\text{risk}} \) is the proportion of people in care continuum stage \( V \) (here \( s = \{V\} \)) for risk group \( \text{risk} \) at time \( t \),
- \( \delta_{t,\text{risk}} \) is the diagnosis rate at time \( t \) for each risk group \( \text{risk} \) (as estimated in section A3.1),
- \( l_{t,\text{risk}} \) is the proportion linked-to-care at diagnosis at time \( t \) for each risk group \( \text{risk} \) (data for both
National-Model and Jurisdictional-Model are taken from NHSS data [16]),
- \( \theta_{d,\text{risk}} \) is the scaling factor for diagnosis rate in disease-stage \( d \) for each risk group \( \text{risk} \) (see footnotes for
Table A2); \( d \in \{\text{Acute}, CD4 > 500, CD4 350 - 500, CD4 200 - 350, CD4 < 200\} \),
- \( \gamma_d \) is the re-entry rate for disease stage \( d \) (assumed 0.5 per year for CD4 >= 200 and 1 per year for CD4 <
200 [9]),
- \( p_{t-1,A,d,\text{risk}} \) is the proportion of people in care continuum stage \( A \) (here \( s = \{A\} \)) for risk group \( \text{risk} \) at time
\( t - 1 \),
- \( \rho_{t,\text{risk}} \) is the dropout rate at time \( t \) (dropout rate for CD4 < 200 = 0, because <200 is opportunistic
infection/AIDS so we assume they will stay in care) for each risk group \( \text{risk} \),
- \( \varphi_d \) is the scaling factor for drop-out rate in disease-stage \( d \) (see footnotes for Table A2), and
- \( m_{t,V,d,\text{risk}} \) is the number of deaths in the care-stage \( V \) (here \( s = \{V\} \)) and disease-stage \( d \) at time \( t \) in each
risk group \( \text{risk} \).

Rearranging (11) we can solve for dropout rate \( \rho_{t,\text{risk}} \) as
\[
\rho_{t,\text{risk}} = \frac{l_{t-1} p_{t-1,V,\text{risk}} \delta_{t,\text{risk}} l_{t,\text{risk}} \sum_d I_{t-1} p_{t-1,U,d,\text{risk}} \theta_{d,\text{risk}} + \sum_d \gamma_d l_{t-1} p_{t-1,A,d,\text{risk}} - \sum_d (m_{t,V,d,\text{risk}}) - l_{t-1} p_{t-1,V,\text{risk}} \varphi_d}{l_{t-1} p_{t-1,V,d,\text{risk}} \varphi_d}
\]
\[
(12)
\]

and the corresponding number of people that drop out of care as \( \rho_{t,\text{risk}} \sum_d \varphi_d l_{t-1} p_{t-1,V,d,\text{risk}} \).

Each term in the right-hand-side of (12) is computationally calculated in the simulation as follows:

- \( l_{t-1} p_{t-1,V,\text{risk}} \) is the number of people in compartment \( V \) at previous time-step and is tracked in the
simulation (initial data for distribution of population in care stages, i.e., \( p_{t,s,\text{risk}} \) for both National-Model
and Jurisdictional-Model, are taken from NHSS data [16] and projections over time are tracked in the
simulation).
\( \delta_{t,\text{risk}} l_{t,\text{risk}} \sum_d l_{t-1,p_{t-1,0,d,\text{risk}}} \theta_d \) is the number of people linked-to-care at diagnosis and is calculated from estimation of diagnosis rates (section A3.1) and tracked in the simulation,

\( \sum_d y_d l_{t-1,1,d,\text{risk}} \) is the number of people who enter care in the previous time step and is tracked in the simulation,

\( \sum_d \left( m_{t,V,d,\text{risk}} \right) \) is the number of deaths and is tracked in the simulation (death rates presented in Tables A3 and A4),

\( p_{t,V,\text{risk}} \) is the expected proportion of people in compartment \( V \) at time-step \( t \) for each risk group,

\( l_t p_{t,V,\text{risk}} \) is the expected number of people in compartment \( V \) in time-step \( t \) to match the expected value of \( p_{t,V,\text{risk}} \), which we can calculate as

\[
p_{t,V,\text{risk}} = p_{t-1,V,\text{risk}} + \frac{a_{V,T-1,\text{risk}} - a_{V,T-\text{risk}}}{1/dt},
\]

- \( a_{V,T-1,\text{risk}} \) is the proportion of people on ART (with and without VLS) for previous year T-1 and risk group \( \text{risk} \),
- \( a_{V,T,\text{risk}} \) is the proportion of people on ART (with and without VLS) for year T and risk group \( \text{risk} \) (for baseline scenarios, proportion ART (with and without VLS) is the actual value in the U.S. in year 2018; for EHE plan scenarios, proportion ART (with and without VLS) is scaled up every year from current value in 2019 to reach EHE target of 85.7% (calculated as 0.95*0.95*0.95, as per the 95-95-95 care continuum targets of reach 95% aware, 95% linkage-to-care among aware, and 95% VLS among those in care) by 2025 for EHE jurisdictions and by 2030 for non-EHE jurisdictions, and
- \( \frac{a_{V,T,\text{risk}} - a_{V,T-\text{risk}}}{1/dt} \) is the expected change in proportion of persons on ART (with and without VLS).

### A5: Estimation of jurisdiction-specific proportion aware categorized by risk group

Data on jurisdiction-specific care continuum distributions categorized by risk group are not available. Therefore, we made approximate estimations as discussed below for proportion aware. We use similar calculations for proportion Aware no ART, and ART (which combines ART no VLS and ART VLS).

Let,

\( \text{unaware}_{j,r} = \) proportion of people unaware in jurisdiction \( j \), for risk group \( r \),

\( \text{unaware}_{j} = \) proportion of people unaware in jurisdiction \( j \),

\( \text{unaware}_{\text{nat},r} = \) proportion of people unaware in national data, for risk group \( r \),

\( \text{unaware}_{\text{nat}} = \) proportion of people unaware in national data,

\( r \in \{ \text{Heterosexual males}, \text{Heterosexual females}, \text{Men who have sex with men} \} \), and \( j \in \{ \text{jur}_1, \text{jur}_2, ..., \text{jur}_{96} \} \).

Then we can write,

\[
\frac{\text{unaware}_{j,r}}{\text{unaware}_{j}} = \frac{\text{unaware}_{\text{nat},r}}{\text{unaware}_{\text{nat}}}
\]

(5)

\[
\text{unaware}_{j,r} = \frac{\text{unaware}_{\text{nat},r}}{\text{unaware}_{\text{nat}}} \text{unaware}_{j}
\]

(6)

we can calculate \( \text{unaware}_{j,r} \) from the equation (4).
Figure A2a: Percentage change in incidence in mixing scenario compared to no-mixing (Heterosexual males, EHE jurisdictions*, baseline intervention, 2018)

Level-1: Scenario S14; Level-2: Scenario S15; and Level-3: Scenario S16

* The title on each subplot is the EHE jurisdiction (county or state) along with values of incidence in year 2018 under the no-mixing scenario [S13]
Figure A2b: Percentage change in incidence in mixing scenario compared to no-mixing (Heterosexual males, non-EHE jurisdictions*, baseline intervention, 2018)

Level-1: Scenario S14; Level-2: Scenario S15; and Level-3: Scenario S16

* The title on each subplot is the non-EHE jurisdiction (state) along with values of incidence in year 2018 under the no-mixing scenario [S13]
Figure A3a: Percentage change in incidence in mixing scenario compared to no-mixing (Heterosexual females, EHE jurisdictions*, baseline intervention, 2018)

Level-1: Scenario S14; Level-2: Scenario S15; and Level-3: Scenario S16

* The title on each subplot is the EHE jurisdiction (county or state) along with values of incidence in year 2018 under the no-mixing scenario [S13]
Figure A3b: Percentage change in incidence in mixing scenario compared to no-mixing (Heterosexual females, non-EHE jurisdictions*, baseline intervention, 2018)

Level-1: Scenario S14; Level-2: Scenario S15; and Level-3: Scenario S16

* The title on each subplot is the non-EHE jurisdiction (state) along with values of incidence in year 2018 under the no-mixing scenario [S13]
Figure A4a: Percentage change in incidence in mixing scenario compared to no-mixing (Men who have sex with men, EHE jurisdictions*, baseline intervention, 2018)

Level-1: Scenario S14; Level-2: Scenario S15; and Level-3: Scenario S16

* The title on each subplot is the EHE jurisdiction (county or state) along with values of incidence in year 2018 under the no-mixing scenario [S13]
Figure A4b: Percentage change in incidence in mixing scenario compared to no-mixing (Men who have sex with men, non-EHE jurisdictions*, baseline intervention, 2018)

* The title on each subplot is the non-EHE jurisdiction (state) along with values of incidence in year 2018 under the no-mixing scenario [S13]
Figure A5: Comparing annual incidence projections of modified EHE-plan-intervention†; jurisdiction-heterogeneity in care scenarios
†Scenarios S13, S14, S15, and S16, implement the EHE plan where EHE jurisdiction reach EHE targets by 2025 and non-EHE jurisdictions reach EHE targets by 2030. Modified scenario S13’, S14’, S15’, and S16’, implement the EHE plan where both, EHE and non-EHE jurisdiction, reach EHE targets by 2025.
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