### The Potential Impact of Ending the Ryan White HIV/AIDS Program on HIV Incidence: A Simulation Study in 31 US Cities

*Technical Supplement*

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### **Model Structure**

**Figure S1: Model Structure**

|  |
| --- |
|  |

This figure depicts the compartments representing HIV status. Each of the five compartments is further stratified by age (13–24, 25–34, 35–44, 45–54, and ≥55 years), race/ethnicity (Black, Hispanic, and other), sex and sexual behavior (female, heterosexual male, and men who have sex with men (MSM), and intravenous drug use history (never used, active use, and prior use). “Acute HIV” refers to the first 2.9 months following infection, during which risk of transmission is high.

### 

### **Ryan White Services**

**Figure S2: Venn Diagram of Ryan White Services**

A diagram of a service

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This depicts the mutually exclusive funding groups explored in these analyses. (1) AIDS Drug Assistance Program grants may be used to pay for antiretroviral therapy directly, pay premiums for health insurance, and help with medication copays; (2) Outpatient Ambulatory Health Services provides direct funding to HIV care facilities for outpatient clinical care; and (3) Other Ryan White services consist primarily of non-medical support services, such as case management, transportation assistance, adherence support, and housing assistance.

### Calibration Targets

**Table S1: Calibration Targets for Base JHEEM Model**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Outcome Target** | **Geography Level** | **Years** | **Stratification** | **Source** |
| Diagnosed HIV Prevalence | MSA | 2008–2023 | Age, Sex, Race,  Risk Factor | CDC Surveillance Reports, AtlasPlus |
| New Diagnoses (HIV Incidence Proxy) | MSA | 2008–2023 | Age, Sex, Race,  Risk Factor | CDC Surveillance Reports, AtlasPlus |
| HIV Suppression | MSA, State, County | 2008–2023 | Age, Sex, Race,  Risk Factor | AtlasPlus |
| HIV Mortality (all-cause among PWH) | MSA | 2008–2023 | Sex | CDC Surveillance Reports, AtlasPlus |
| General Mortality | MSA | 2007–2019 | Total | US Census |
| AIDS Diagnoses | MSA | 1985–1993 | Sex, Race Risk Factor | CDC Surveillance Reports, CDC WONDER |
| AIDS Deaths | MSA | 1981–2001 | Sex, Race, Risk Factor | CDC Surveillance Reports, CDC WONDER |
| Awareness of HIV Status | State | 2008–2023 | Total | AtlasPlus |
| Proportion Tested for HIV | MSA, State | 2010–2023 | Age, Sex, Race,  Risk Factor | BRFSS |
| Positivity among CDC-funded HIV Tests | MSA, State | 2014–2020 | Total | CDC Surveillance Reports |
| Number of People Prescribed PrEP | MSA | 2007–2023 | Age, Sex, Race | AIDSVu, AtlasPlus |
| PrEP Indications | MSA, State | 2017–2018 | Age, Sex | AtlasPlus |
| Proportion Using Heroin | State, NSDUH Substate Regions | 2008–2023 | Age | NSDUH |
| Proportion Using Cocaine | State, NSDUH Substate Regions | 2008–2023 | Age | NSDUH |
| Immigration | MSA | 2011–2023 | Age, Race, Sex | American Communities Survey |
| Emigration | MSA | 2011–2023 | Age, Race, Sex | American Communities Survey |
| Population | MSA | 2010–2023 | age, sex, race | US Census |

**Table S2: Ryan White Specific Calibration Targets**

| **Outcome Target** | **Geography Level** | **Years** | **Stratification** | **Source** |
| --- | --- | --- | --- | --- |
| Proportion receiving ADAP | State | 2017–2021 | Age, Sex, Race,  Risk Factor | Ryan White AIDS Drug Assistance Program Annual Client-Level Data Reports (HRSA) |
| Viral Suppression among ADAP Clients | State | 2017–2023 | Total | National Ryan White HIV/AIDS Program Part B & ADAP Monitoring Project Annual Report (NASTAD) |
| Non-ADAP RWHAP Clients | MSA | 2017–2023 | Age, Sex, Race  Risk Factor | Ryan White HIV/AIDS Program Services Annual Report |
| OAHS Clients | MSA | 2017–2023 | Age, Race | Ryan White HIV/AIDS Program Services Annual Report |
| Viral Suppression among OAHS Clients | MSA | 2017–2023 | Age, Race | Ryan White HIV/AIDS Program Services Annual Report |

### **Ryan White Survey Details**

**Figure S3:** **Survey Instrument Used to Estimate Loss of Viral Suppression Among Ryan White Clients Following Program Disruption**

|  |
| --- |
| A |
| B |

A) Introductory text and Venn diagram shown to survey respondents, illustrating the three Ryan White service categories used to frame suppression loss estimates. B) Survey questions asking respondents to estimate the percentage of clients who would lose viral suppression by service category, percent from rural areas, and states of origin for patients treated, with an optional comment box.

**Figure S4: Ryan White Survey Respondent Summary**

|  |  |
| --- | --- |
| A | B |
| C | D |
| E |  |

A) Counts of respondents by state, colored by Medicaid expansion status. B) Histogram of the % of rural patients respondents treat. Boxplot comparing respondent responses for estimated % loss of ADAP, OAHS and other support services based on respondents C) location in a Medicaid expansion state, D) whether treating a majority of rural patients (> 50%), and E) which US census region they are located.

**Table S3: Differences in Expected Suppression Loss by Respondent Characteristic.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Outcome | N |  | Mean & 95% CI | |  |
|  |  | % ADAP Loss | 168 |  | 63.9% [59.9-67.9%] | |  |
|  | Total | % OAHS Loss | 144 |  | 49.8% [45.6-54.1%] | |  |
|  |  | % Support Loss | 139 |  | 37.4% [32.6-42.1%] | |  |
| Group\_1 | Group\_2 | Outcome | N  (Group 1) | N  (Group 2) | Mean & 95% CI  (Group 1) | Mean & 95% CI  (Group 2) | Wilcoxon-rank sum P-value |
| Medicaid Expansion | Non-  Expansion | % ADAP Loss | 127 | 50 | 61.1% [56.2-66.0%] | 70.9% [64.2-77.7%] | 0.032\* |
| Medicaid Expansion | Non-  Expansion | % OAHS Loss | 107 | 46 | 47.3% [42.2-52.3%] | 55.7% [48.1-63.3%] | 0.094 |
| Medicaid Expansion | Non-  Expansion | % Support Loss | 105 | 43 | 36.6% [31.1-42.2] | 39% [29.7-48.3%] | 0.702 |
| West | South | % ADAP Loss | 29 | 81 | 62.6% [51.2-73.9%] | 66.3% [60.7-71.9%] | 0.742 |
| Northeast | South | % ADAP Loss | 34 | 81 | 56.1% [46.0-66.2%] | 66.3% [60.7-71.9%] | 0.058 |
| Midwest | South | % ADAP Loss | 29 | 81 | 66.1 [57.4-74.7%] | 66.3% [60.7-71.9%] | 0.799 |
| West | South | % OAHS Loss | 22 | 75 | 46.0% [34.5-57.6%] | 51.1% [45.1-57.0%] | 0.602 |
| Northeast | South | % OAHS Loss | 28 | 75 | 51.0% [39.5-62.4%] | 51.1% [45.1-57.0%] | 0.940 |
| Midwest | South | % OAHS Loss | 24 | 75 | 47.9% [39.1-56.8%] | 51.1% [45.1-57.0%] | 0.563 |
| West | South | % Support Loss | 22 | 26 | 35.2% [24.0-46.4%] | 37.3% [30.6-43.9%] | 0.816 |
| Northeast | South | % Support Loss | 26 | 26 | 40.6% [26.8-54.3%] | 37.3% [30.6-43.9%] | 0.747 |
| Midwest | South | % Support Loss | 23 | 26 | 36.3% [25.8-46.9%] | 37.3% [30.6-43.9%] | 0.979 |
| Rural ≥50% | Rural <50% | % ADAP Loss | 23 | 81 | 73.4% [65.2–81.7%] | 60.8% [55.4-66.2%] | 0.030\* |
| Rural ≥50% | Rural <50% | % OAHS Loss | 18 | 75 | 56.2% [47.3-65.1%] | 45.3% [40.1-50.6%] | 0.003\*\* |
| Rural ≥50% | Rural <50% | % Support  Loss | 19 | 72 | 44.1% [31.4-56.8%] | 31.8% [26.3-37.3%] | 0.791 |

Two-sided Wilcoxon rank-sum tests were used to compare the distributions of expected viral suppression loss between respondent subgroups. While group medians with interquartile ranges(IQR) and means with 95% confidence intervals (CI) are reported for interpretability, the Wilcoxon test non-parametrically evaluates whether one group tends to report systematically higher or lower values than the other without distributional assumptions. Sample sizes (N) reflect the number of unique respondents with non-missing data for each outcome. P-values are shown; \*p < 0.05 and \*\*p < 0.01 indicates statistical significance.

**Figure S5: Ryan White Survey Attrition Bias Analysis**

|  |  |
| --- | --- |
| A | B |
| C |  |

Boxplots show the distribution of estimated service losses across three questions; (A) Q1: ADAP, (B) Q2: OAHS, (C) Q3: Support Services stratified by survey completion level. Groups include: all respondents to that question, partial responders (those who did not answer the listed question), and complete responders (completed through Q4). Median estimates were generally higher among partial responders, suggesting a potential attrition bias in perceived loss severity. Sample sizes for each group are noted beneath the x-axis.

**Table S4: Attrition Analysis Statistical Test Results**

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **N Complete Responses** | **N Partial Responses** | **Wilcoxon Rank Sum P-Value** |
| Q1 (ADAP loss) | 177 | 3 | 0.008\*\* |
| Q2 (OAHS loss) | 153 | 27 | 0.015\* |
| Q3 (Support loss) | 148 | 32 | 0.002\*\* |

Wilcoxon rank-sum tests were conducted to compare service loss estimates from partial and complete responders to those of all respondents for each survey question. Partial responders reported significantly higher loss estimates across all three domains compared to complete responders, suggesting upward bias among partial responses.

### **Calibration Fit to Ryan White Program Metrics**

**Figure S6: Simulation Fit to Ryan White Clients and Viral Suppression in Houston, TX**

|  |  |
| --- | --- |
| A. Non-AIDS Drug Assistance Clients in Houston, TX | B. Ratio of AIDS Drug Assistance to non-AIDS Drug Assistance Clients in Texas |
| C. Outpatient Ambulatory Health Services Clients in Houston, TX | D. Viral Suppression Among AIDS Drug Assistance Clients in Texas |
| E. Viral Suppression Among Outpatient Ambulatory Health Services Clients in Houston, TX |  |

Each line represents a single simulation; 1000 simulations are shown. Circles represent reported data from Ryan White Program Services reports. Panels A and C show city-level numbers of clients. Panel B shows the state-level ratio of AIDS Drug Assistance clients to non-AIDS Drug Assistance clients in Texas (ADAP numbers are reported only at the state level); the lines are the analogous city-level ratios. from the model. Panel D shows the state-level rate of viral suppression among AIDS Drug Assistance recipients in Texas; the lines are the analogous city-level rates of suppression from the model. Panel E shows the city-level rate of viral suppression among Outpatient Ambulatory Health Services clients. Results for every city are available at [www.jheem.org/ryan-white](http://www.jheem.org/ryan-white)

### **Results Secondary Analyses**

**Figure S7: City-Level Excess HIV Infections from 2025-2030 If Ryan White Programs are Stopped or Interrupted, *Conservative Secondary Analysis***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Continuation** | **Cessation** | | **Prolonged Interruption** | | **Brief Interruption** | |
| **City** | Number of  Incident Infections | Number of Excess Infections | Relative Excess Infections\* | Number of Excess Infections | Relative Excess Infections\* | Number of Excess Infections | Relative Excess Infections\* |
| Baltimore, MD | 1,579 | 860 | 55% | 335 | 21% | 673 | 43% |
| [1,257-1,965] | [550-1,223] | [34-80%] | [212-488] | [14-31%] | [426-966] | [27-63%] |
| New Orleans, LA | 1,162 | 514 | 45% | 192 | 17% | 388 | 34% |
| [940-1,452] | [333-716] | [28-65%] | [125-268] | [10-24%] | [251-541] | [21-49%] |
| Boston, MA | 2,961 | 1,075 | 37% | 406 | 14% | 823 | 28% |
| [2,466-3,685] | [658-1,567] | [22-53%] | [248-600] | [8-20%] | [501-1,207] | [17-41%] |
| Seattle, WA | 3,014 | 1,082 | 36% | 403 | 13% | 830 | 28% |
| [2,458-3,810] | [678-1,524] | [21-54%] | [253-567] | [8-20%] | [524-1,168] | [17-41%] |
| Miami/Fort Lauderdale, FL | 9,171 | 1,956 | 32% | 770 | 13% | 1,515 | 25% |
| [7,367-11,116] | [1,239-2,776] | [20-46%] | [493-1,106] | [8-18%] | [969-2,169] | [16-35%] |
| Houston, TX | 9,211 | 2,777 | 31% | 1,130 | 12% | 2,192 | 24% |
| [7,648-10,904] | [1,701-4,204] | [18-44%] | [686-1,700] | [8-18%] | [1,328-3,313] | [15-35%] |
| Austin, TX | 1,878 | 1,686 | 30% | 641 | 11% | 1,303 | 23% |
| [1,544-2,296] | [1,025-2,558] | [16-48%] | [391-957] | [6-18%] | [797-1,959] | [12-37%] |
| Chicago, IL | 6,139 | 2,713 | 30% | 974 | 11% | 2,024 | 22% |
| [5,273-7,122] | [1,685-4,005] | [18-44%] | [606-1,430] | [6-16%] | [1,255-2,986] | [13-33%] |
| New York, NY | 14,232 | 4,021 | 29% | 1,641 | 12% | 3,163 | 23% |
| [11,110-20,471] | [2,564-5,824] | [18-42%] | [1,008-2,567] | [7-17%] | [1,974-4,689] | [14-33%] |
| Philadelphia, PA | 5,743 | 514 | 28% | 195 | 10% | 393 | 21% |
| [4,405-7,391] | [318-748] | [17-42%] | [120-283] | [6-16%] | [243-573] | [13-32%] |
| Dallas/Fort  Worth, TX | 11,414 | 575 | 27% | 231 | 11% | 455 | 21% |
| [9,403-13,295] | [361-814] | [16-40%] | [146-329] | [7-16%] | [287-646] | [13-31%] |
| Columbus, OH | 2,203 | 552 | 26% | 215 | 10% | 430 | 21% |
| [1,706-2,807] | [341-811] | [16-38%] | [134-314] | [6-15%] | [267-633] | [13-30%] |
| Indianapolis, IN | 2,106 | 251 | 26% | 84 | 9% | 181 | 19% |
| [1,769-2,522] | [144-376] | [13-41%] | [47-130] | [4-14%] | [100-275] | [9-30%] |
| Baton Rouge, LA | 982 | 2,748 | 24% | 1,003 | 9% | 2,073 | 18% |
| [796-1,219] | [1,753-3,966] | [15-36%] | [641-1,450] | [6-13%] | [1,324-3,015] | [12-27%] |
| Memphis, TN | 1,871 | 790 | 23% | 302 | 9% | 609 | 18% |
| [1,547-2,289] | [470-1,180] | [14-35%] | [185-435] | [5-13%] | [367-895] | [11-26%] |
| San Antonio, TX | 2,781 | 656 | 21% | 247 | 8% | 507 | 16% |
| [2,204-3,410] | [401-961] | [13-30%] | [147-374] | [5-11%] | [304-762] | [10-23%] |
| Charlotte, NC | 3,452 | 390 | 21% | 145 | 8% | 298 | 16% |
| [2,733-4,045] | [246-568] | [12-32%] | [91-212] | [5-12%] | [188-430] | [9-24%] |
| San Francisco, CA | 3,107 | 465 | 20% | 170 | 7% | 356 | 16% |
| [2,420-3,901] | [271-696] | [11-33%] | [96-260] | [4-12%] | [207-533] | [8-25%] |
| Tampa, FL | 4,474 | 524 | 19% | 205 | 7% | 408 | 15% |
| [3,482-5,303] | [297-819] | [11-30%] | [118-316] | [4-11%] | [231-633] | [9-23%] |
| Atlanta, GA | 14,608 | 330 | 18% | 121 | 7% | 255 | 14% |
| [12,199-16,871] | [162-508] | [8-36%] | [60-193] | [2-14%] | [127-394] | [6-28%] |
| Detroit, MI | 2,334 | 811 | 18% | 325 | 7% | 635 | 14% |
| [1,880-3,016] | [480-1,258] | [11-28%] | [195-502] | [4-11%] | [376-980] | [8-22%] |
| Phoenix, AZ | 4,678 | 833 | 18% | 329 | 7% | 649 | 14% |
| [3,948-5,600] | [547-1,193] | [11-26%] | [213-467] | [5-11%] | [422-924] | [9-21%] |
| Jacksonville, FL | 3,167 | 2,571 | 18% | 983 | 7% | 1,978 | 14% |
| [2,618-3,578] | [1,379-4,016] | [10-28%] | [534-1,528] | [4-11%] | [1,057-3,090] | [8-21%] |
| Washington, DC | 4,743 | 624 | 17% | 241 | 7% | 484 | 13% |
| [3,737-5,810] | [395-895] | [11-25%] | [148-370] | [4-10%] | [303-708] | [8-20%] |
| San Diego, CA | 3,605 | 811 | 17% | 310 | 7% | 635 | 14% |
| [2,884-4,376] | [521-1,164] | [11-25%] | [199-444] | [4-9%] | [407-918] | [8-19%] |
| Sacramento, CA | 2,425 | 414 | 17% | 166 | 7% | 327 | 14% |
| [1,900-2,894] | [252-613] | [10-26%] | [101-247] | [4-10%] | [200-483] | [8-20%] |
| Cleveland, OH | 1,999 | 1,635 | 16% | 680 | 7% | 1,301 | 13% |
| [1,120-3,466] | [889-2,489] | [9-25%] | [365-1,041] | [4-10%] | [703-1,980] | [7-20%] |
| Los Angeles, CA | 10,241 | 505 | 16% | 149 | 5% | 361 | 11% |
| [8,929-12,439] | [300-741] | [9-23%] | [80-229] | [2-7%] | [209-536] | [7-17%] |
| Orlando, FL | 6,163 | 687 | 11% | 285 | 5% | 545 | 9% |
| [4,828-7,417] | [430-1,015] | [7-17%] | [178-418] | [3-7%] | [341-806] | [5-13%] |
| Las Vegas, NV | 5,239 | 379 | 7% | 159 | 3% | 303 | 6% |
| [4,345-6,202] | [229-599] | [4-12%] | [96-247] | [2-5%] | [182-478] | [3-10%] |
| Riverside, CA | 7,747 | 302 | 4% | 130 | 2% | 243 | 3% |
| [5,056-10,073] | [165-494] | [2-8%] | [71-210] | [1-4%] | [133-398] | [1-7%] |
| **Medicaid Expansion Cities** | 89,690 | 19,810 | 22% | 7,773 | 9% | 15,429 | 17% |
| [83,648-95,859] | [13,408-26,792] | [15-30%] | [5,186-10,499] | [6-12%] | [10,415-20,776] | [12-23%] |
| **Medicaid Non-Expansion Cities** | 64,739 | 14,242 | 22% | 5,393 | 8% | 10,906 | 17% |
| [61,248-67,872] | [9,404-19,936] | [15-31%] | [3,574-7,643] | [6-12%] | [7,208-15,299] | [11-24%] |
| **Total** | 154,429 | 34,051 | 22% | 13,166 | 9% | 26,336 | 17% |
| [147,165-161,767] | [23,902-45,147] | [15-29%] | [9,290-17,439] | [6-11%] | [18,477-34,908] | [12-23%] |
|  |  | |  |  |  | | --- | --- | --- | | 0% | A yellow and orange rectangular object  AI-generated content may be incorrect. | 100% | | | | | | |

The “Continuation” column gives the mean and 95% credible interval, across 1,000 simulations, projected incident HIV infections from 2025-2030 if Ryan White programs continue uninterrupted. The columns labeled “Number of Excess Infections” give the mean and 95% interval of the absolute number of excess HIV infections expected from 2025-2030 under three scenarios where Ryan White programs are stopped in July 2025. Cities in Medicaid non-expansion states are denoted by orange labels, those in expansion states by purple labels.

**Figure S8: City-Level Relative Excess HIV Infections from 2025-2030 If Ryan White Programs are Stopped or Interrupted, *Conservative Secondary Analysis***

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Boxplots display the projected percentage increase in new infections under three scenarios in which all Ryan White services stop in July 2025: “Cessation” (red) – viral suppression among Ryan White clients never recovers; “Prolonged Interruption” (orange) – viral suppression among Ryan White clients recovers from January to December 2029; “Brief Interruption” (green) – viral suppression among Ryan White clients recovers from January to December 2027. The value along the x-axis represents the relative increase in cases vs. a scenario where Ryan White services continue uninterrupted. The dark vertical lines indicate the median projection across 1,000 simulations, the boxes indicate interquartile ranges (IQR), and whiskers cover the 95% credible interval. Cities in Medicaid non-expansion states are denoted by orange labels, those in expansion states by purple labels.

**Figure S9: City-Level Variation in the Projected Relative Increase in HIV Infections if Ryan White Programs End in July 2025**

|  |  |
| --- | --- |
|  |  |
|  |  |
|  | A graph showing the number of states  AI-generated content may be incorrect.  A graph showing the number of states  AI-generated content may be incorrect. |

Each circle represents one city. The y-axis represents the average relative increase in projected HIV infections from 2025 to 2030 if Ryan White programs end in July 2025 vs. if they continue, averaged across 1,000 simulations. The x-axis represents the average proportion of people with HIV who are Ryan White clients in 2024 (Panel A); average transmission rate (Panel B); average viral suppression among all people with HIV in 2024 (Panel C); or average new diagnoses per 100,000 population (Panel D). The size of the circle is proportional to the number of projected new diagnoses in 2024. Panel E shows a histogram of average relative increase in incidence, shaded by Medicaid expansion status. Cyan shading indicates that the city falls principally in a Medicaid expansion state; purple indicates that the city falls principally in a non-expansion state. PRCC = Partial Rank Correlation Coefficient, a measure of the strength of the association between the variable and the outcome.

### **Sensitivity Analyses**

#### Use of Partial Rank Correlation Coefficients

We use partial rank correlation coefficients (PRCCs), a multivariate measure of the correlation between an outcome and variables. PRCCs assume that the outcome and a particular variable are monotonically related, adjusting for other variables.

In our analysis of between city-variation, we considered four continuous variables - (a) the proportion of people with HIV receiving Ryan White services, (b) baseline rates of suppression and (c) sexual transmission, (d) number of new diagnoses – and one binary variable – (e) whether the city falls principally in a Medicaid expansion state. For the four continuous variables, the monotonic assumption is *approximately* true.

Consider a model with a single demographic compartment (ie, one that does not stratify the population by demographics and risk factors). If we lump all three forms of Ryan White services into one, and let *pclient*be the proportion of diagnosed people with HIV who are Ryan White clients, in the “continuation” scenario (with no disruptions to Ryan White services):

In disruption scenarios, let *rw\_effect* denote the effect of ending Ryan White programs on viral suppression of Ryan White clients. Then:

The number of new infections in 2025 will be approximately proportional to rcontinuation, and the relative number of excess infections will be monotonically related to the difference between rcontinuation and rcessation. This means that the relative excess infections will be monotonically related to *pclient*, baseline suppression, sexual transmission, number of new diagnoses.

In actuality, our model has different transmission rates for 135 different strata of age, race, sex, and HIV risk factor. Thus it is possible that aggregate measures of these four variables are not strictly monotonically related to the outcome. For example, city A might have lower suppression than city B and thus a greater relative excess infections from stopping Ryan White. But city C might have greater overall suppression than city B, but lower suppression among high-risk demographic groups averaged out with much higher suppression among low-risk groups. City C might thus have greater relative excess infections than city B despite higher suppression, violating the monotonicity assumption.

Despite this theoretical way in which our four variables might not be strictly monotonic with respect to the outcome, we feel that city-level variations in the average are likely usually greater than swings in stratifications, and we prefer the PRCCs to other methods that don’t assume monotonicity because they are simpler and more intuitive for non-technical readers.

**Figure S10: Partial Rank Correlation Coefficients (PRCCS) for Highly Influential Model Parameters**

|  |
| --- |
|  |

PRCCs are a multivariate measure of the correlation between the outcome and parameters; values close to 1 or -1 indicate a strong correlation between the parameter and the outcome; values near 0 indicate a weak correlation. The vertical line of the boxplots gives the mean value of the PRCC across simulations; the box indicates the interquartile range; the whiskers indicate the 95% confidence interval.

**Figure S11: Influence of Key Parameters on Projected Increase In HIV Infections from 2025-2035 across 31 Cities if Ryan White Programs End**

|  |
| --- |
| A |
| B |
| C |

The dark vertical lines indicate the median projection across 1,000 simulations, the boxes indicate interquartile ranges (IQR), and whiskers cover the 95% credible interval. Panel A , B and C compares median relative HIV incidence between the top 20% and bottom 20% of simulations for each key parameter. Boxplots display the variation in relative increase in HIV infections, with the purple distribution representing the highest parameter values and the orange distribution representing the lowest. The dashed vertical line represents the median for the 32 cities in panel A, only cities in non medicaid expansion states for panel B, and medicaid expansion states for panel C.

### **Details of Ryan White Extension:**

This section describes the mathematical specification of the Ryan White HIV model, which evaluates the impact of program components - the AIDS Drug Assistance Program (ADAP), Outpatient Ambulatory Health Services (OAHS), and other supportive services - on HIV viral suppression. The model differentiates between Medicaid expansion and non-expansion states, and uses survey-derived priors to inform scenario simulations under various scenarios.

#### Ryan White Service Category Definitions

We model three Ryan White (RW) recipient categories among people with HIV (PWH):

1. ADAP recipients: may or may not receive other RW services.

2. OAHS/non-ADAP recipients: receive OAHS but not ADAP.

3. RW support-only: receive services but neither ADAP nor OAHS services.

#### Narrative Description of Model Extension

The JHEEM contains 135 compartments of people with diagnosed HIV, one for each stratum of age, race, sex, and HIV risk factor (see Figure S1). Our Ryan White extension did not change the compartments, but rather modeled three proportions for each of those 135 diagnosed-HIV compartments: the proportion receiving services from each of the three categories above. Each of these proportions was governed by a set logistic equations (see “Mathematical Formulation of Subgroup Populations” below).

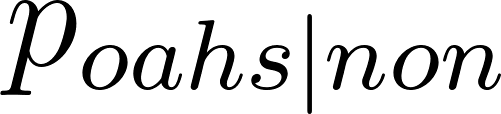
Prior to this analysis, the JHEEM calibrated parameters governing transmission, overall viral suppression among diagnosed people with HIV, pre-exposure prophylaxis uptake, HIV testing rates, mortality, immigration, and emigration (Supplement Table S1). This calibration was performed to recapitulate city-level data from CDC reporting and population surveys in each of 32 cities containing a priority urban county for the “Ending the HIV Epidemic” initiative.

That calibration was unchanged for this analysis. However, we performed an additional, secondary calibration: for each calibrated simulation from the original model, we calibrated the parameters of the logistic equations governing the proportions receiving Ryan White services to match outcomes from Ryan White program reports (Supplement Table S2).

Once the proportions receiving Ryan White services were calibrated, we were able to apply effects of terminating services by reducing viral suppression among the proportion in each stratum who received each category of Ryan White services (see “Viral Suppression Calculations” below).

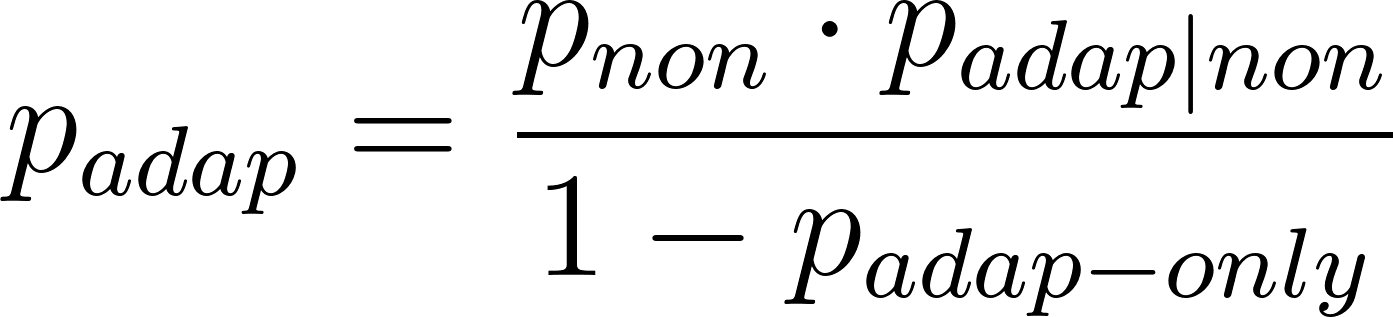
#### Mathematical Formulation of Subgroup Proportions

Let [](https://www.codecogs.com/eqnedit.php?latex=p_%7Bnon%7D#0) be the proportion of PWH receiving non-ADAP RW services.

Let [](https://www.codecogs.com/eqnedit.php?latex=p_%7Boahs%7Cnon%7D#0) be the proportion of non-ADAP RW clients receiving OAHS.

Let [](https://www.codecogs.com/eqnedit.php?latex=p_%7Badap%7Cnon%7D#0) be the proportion of non-ADAP clients who also receive ADAP.

Then:

- Proportion receiving ADAP: [](https://www.codecogs.com/eqnedit.php?latex=p_%7Badap%7D%20%3D%20%5Cfrac%7Bp_%7Bnon%7D%20%5Ccdot%20p_%7Badap%7Cnon%7D%7D%7B1%20-%20p_%7Badap-only%7D%7D#0)

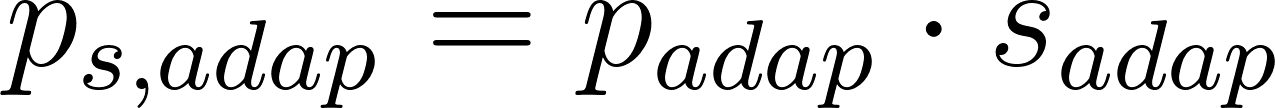
- Proportion receiving OAHS: [](https://www.codecogs.com/eqnedit.php?latex=p_%7Boahs%7D%20%3D%20p_%7Bnon%7D%20%5Ccdot%20p_%7Boahs%7Cnon%7D#0)

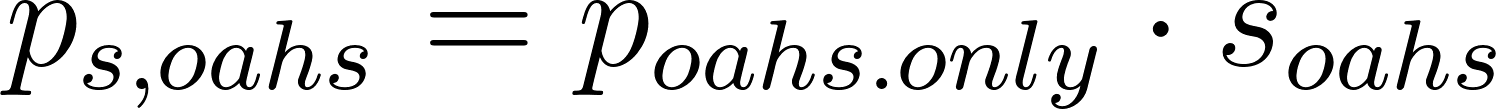
- Proportion receiving supportive services only: [](https://www.codecogs.com/eqnedit.php?latex=p_%7Bsupport%7D%20%3D%20p_%7Bnon%7D%20%5Ccdot%20(1%20-%20p_%7Badap%7Cnon%7D)%20%5Ccdot%20(1%20-%20p_%7Boahs%7Cnon%7D)#0)

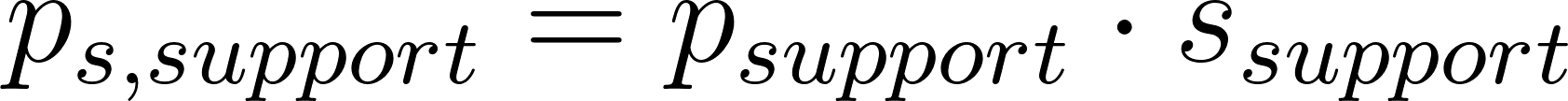
- Total RW coverage: [](https://www.codecogs.com/eqnedit.php?latex=p_%7Brw%7D%20%3D%20p_%7Badap%7D%20%2B%20p_%7Boahs.only%7D%20%2B%20p_%7Bsupport%7D#0)

#### Viral Suppression Calculations

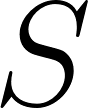
Suppression is modeled separately as a proportion of the total number of people with diagnosed HIV. We calculated the suppression among Ryan White client subgroups, conditional on the total viral suppression among all people with HIV in the calibrated base version of the model.

- Suppressed and ADAP Client: [](https://www.codecogs.com/eqnedit.php?latex=p_%7Bs%2Cadap%7D%20%3D%20p_%7Badap%7D%20%5Ccdot%20s_%7Badap%7D#0)

- Suppressed and OAHS Client but not ADAP Client: [](https://www.codecogs.com/eqnedit.php?latex=p_%7Bs%2Coahs%7D%20%3D%20p_%7Boahs.only%7D%20%5Ccdot%20s_%7Boahs%7D#0)

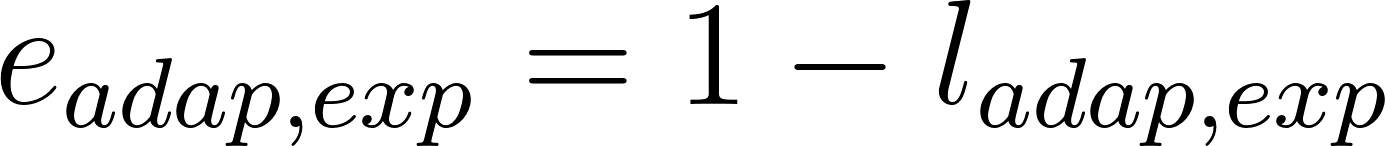
- Suppressed and receiving supportive services only: [](https://www.codecogs.com/eqnedit.php?latex=p_%7Bs%2Csupport%7D%20%3D%20p_%7Bsupport%7D%20%5Ccdot%20s_%7Bsupport%7D#0)

- Suppressed and not receiving any RW services: [](https://www.codecogs.com/eqnedit.php?latex=p_%7Bs%2CnoRW%7D%20%3D%20S%20-%20p_%7Bs%2Cadap%7D%20-%20p_%7Bs%2Coahs%7D%20-%20p_%7Bs%2Csupport%7D#0)

where [](https://www.codecogs.com/eqnedit.php?latex=S#0) is the total suppression rate among diagnosed PWH.

#### Scenario Effects

We model complete or temporary losses of RW services. For instance, the loss of ADAP in expansion states is:

[](https://www.codecogs.com/eqnedit.php?latex=e_%7Badap%2Cexp%7D%20%3D%201%20-%20l_%7Badap%2Cexp%7D#0)

where [](https://www.codecogs.com/eqnedit.php?latex=l_%7Badap%2Cexp%7D#0) is the loss effect drawn from a kernel density estimate (KDE) of survey data.

Temporary lapses are modeled by changing [](https://www.codecogs.com/eqnedit.php?latex=e_g#0) over a time interval between interruption and restart.

#### Prior Construction via KDE

Survey responses on expected suppression losses (in %) are transformed using the arcsine-square root:

[](https://www.codecogs.com/eqnedit.php?latex=x'%20%3D%20%5Carcsin(%5Csqrt%7Bx%7D)#0)

KDE is performed in this transformed space, and values are sampled then inverted as:

[](https://www.codecogs.com/eqnedit.php?latex=x%20%3D%20%5Csin%5E2(x')#0)

This transformation normalizes variance in bounded data and prevents edge effects.

### **Details of “Conservative” Secondary Analysis:**

In our “conservative” secondary analysis, we used results from Erly et al. and Diepstra et al. to update the distribution of reductions in viral suppression among Ryan White clients in three service categories if Ryan White services end.

#### Overview Approach

We used a sampling-resampling procedure to generate 1,000 samples of the effects for each of the three service categories. The results of this procedure a shown in Figure 1 of the main manuscript.

We used a uniform(0,1) as our proposal distribution, with 1 million initial samples.

We weighted these by the product of:

1. A prior: the KDE estimated from survey responses, conditional on Medicaid expansion (as described above)
2. A likelihood based on Erly et al. or Diepstra et al., as detailed below

We resampled 1,000 values based on these weights.

#### AIDS Drug Assistance Program Likelihood

For the effect of losing AIDS Drug Assistance Program services, we used a beta-binomial likelihood:

We used *y* = 31 and *n* = 143 based on long-term disenrollees described by Erly et al. *p* was the sampled parameter.

We conceived of uncertainty in beta component of the beta-binomial as representing the uncertainty around how findings from a study in Washington state would apply to other states. We derived the α and β such that the mean of a Beta(α, β) was equal to the 22% loss of suppression observed by Erly and the variance of the distribution was based on the state-to-state variation in viral suppression among ADAP recipients. Specifically:

* Variance for expansion states = the average, across years 2019 to 2022, of the sample variance of reported proportion of ADAP clients virally suppressed in Medicaid expansion states
* Variance for non-expansion states = the average, across years 2019 to 2022, of the sample variance of reported proportion of ADAP clients virally suppressed in Medicaid non-expansion states PLUS the square of the difference between the average ADAP suppression in expansion states minus non-expansion states

#### Outpatient Ambulatory Health Services Likelihood

For the effect of losing Outpatient Ambulatory Health Services, we took the product of two log-normal likelihoods for the reported odds ratios of (1) core services vs no services and (2) core + support services vs no services in Diepstra et al:

* The OR for each component was the reported OR in the study
* The mean, μ, was the log of the reported odds of suppression in Diepstra et al. with services minus the log odds of the product of the proportion suppressed in Diepstra et al. times one minus the sampled reduction in suppression
* The variance, 2, was the sum of the variance reported in Diepstra et al. (calculated as half the log confidence interval width divided by 1.96) plus the variance in state-level proportions of OAHS clients who were suppressed
  + For Medicaid expansion states, the variance in state-level proportions was = the average, across years 2013 to 2023, of the sample variance of reported log odds of OAHS clients virally suppressed in Medicaid expansion states
  + For Medicaid non-expansion states, the variance in state-level proportions was = the average, across years 2013 to 2023, of the sample variance of reported log odds of OAHS clients virally suppressed in Medicaid non-expansion states PLUS the square of the difference between the average OAHS log-odds of suppression in expansion states minus non-expansion states

#### Support Services Likelihood

For the effect of losing Ryan White Support Services, we formulated a likelihood analogous to the OAHS likelihood with four components based on Diepstra et al.:

* The odds ratio of suppression for clients receiving support services vs no services
* The odds ratio of suppression for clients receiving support + core services vs core services only
* The odds ratio of suppression for clients receiving support + ADAP services vs ADAP services only
* The odds ratio of suppression for clients receiving support + core + ADAP services vs core + ADAP services only

### **Sample Size Calculations for the Number of Simulations Needed**

In determining the optimal sample size, we balance two competing concerns: (1) model simulations are computationally expensive to run, so we want the lowest number necessary, (2) we will be reporting credible intervals, and we want enough simulations to accurately characterize the tails of the posterior distribution.

Fundamentally, we find a balance by calculating **the probability that the reported empiric 97.5th percentile is “close” to the actual 97.5th percentile of the posterior distribution** (and, by analogy, the 2.5th percentile).

There are a number of methods to calculate empiric quantiles which report the weighted average of two ordered samples. Specifically, if we let *y1, …, yn*denote ordered samples, then the empiric quantile *qp* is:

We can thus state that the probability of drawing a value less than *qp* falls between the probability of drawing a value less than *yi* and the probability of drawing a values less than *yi+1*

For some weight 0≤*w≤1*. The default for R’s *quantile* function uses *i = floor( (n-1) \* p + 1 ),* where *p* is the desired probability for the quantile.

If samples are drawn from the posterior distribution, then for a single sample *y*, the probability of drawing a value from the posterior distribution ≤ *y* is distributed Uniform(0,1):

From this it follows that the probability of drawing a value ≤ the ith ordered sample, pi, is:

The joint distribution of p*i* and pi+1, for p*i* ≤ pi+1, is given by:

Which is n-choose-i times the product of two beta densities.

We can integrate this density to compute a lower bound on the probability that our empiric quantile, *qp*, falls between bounds *l* and *u***:**

We can also use the Beta distribution for *pi* to construct a credible interval for p(qp) that covers ≥ 95% probability as the 2.5th percentile of *pi* to the 97.5th percentile of *pi+1*.

We have calculated the lower-bound probabilities that an empiric quantile falls withing 1 percentage point of 97.5% and upper-bound credible intervals for a range of n’s in Table S5. Reviewing the table, we find that 1,000 simulations guarantees close to 95% probability that the empiric quantile actually has a probability between 96.5% and 98.5% of being drawn from the posterior distribution.

**Table S4: Probability Distribution of the Probability of Drawing a Value less than or equal to the Empiric 97.5th Percentile, Depending on Number of Samples**

|  |  |  |  |
| --- | --- | --- | --- |
| **Number of Simulations** | **Minimum Probability that the probability of the empiric 97.5th percentile falls between 0.965 and 0.985** | **Credible Interval for the probability of the empiric 97.5th quantile – with ≥95% probability** | |
| **Lower Bound** | **Upper Bound** |
| 50 | 0.132 | 0.863 | 0.995 |
| 100 | 0.292 | 0.915 | 0.994 |
| 200 | 0.522 | 0.943 | 0.992 |
| 500 | 0.793 | 0.956 | 0.986 |
| 800 | 0.910 | 0.962 | 0.985 |
| ***1,000*** | ***0.944*** | ***0.963*** | ***0.984*** |
| 1,073 | 0.950 | 0.964 | 0.983 |
| 1,200 | 0.964 | 0.965 | 0.983 |
| 1,500 | 0.978 | 0.965 | 0.982 |
| 2,000 | 0.993 | 0.967 | 0.981 |