A System Dynamics-Based Evaluation of the New York State HIV Testing Law

TECHNICAL REPORT

Prepared for AIDS Institute, New York State Department of Health

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University at Albany

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1. Overview of the System Dynamics Modeling Study

   a. Project Background

   To increase HIV testing and among New York State (NYS) residents, and subsequent entry into care and treatment among diagnosed individuals, Chapter 308 of the Laws of 2010 authorized significant changes in HIV testing. Effective September 1, these changes include a requirement that all persons between the ages of 13 and 64 be offered HIV testing as part of hospital inpatient, emergency room, or any facility or community based primary care services. It also simplifies the informed consent and pre-test counseling processes and requires that providers and facilities offering HIV tests arrange an appointment for medical care for individuals testing positive.

   An impetus for the NYS legislation was updated HIV testing recommendations from the Centers for Disease Control and Prevention (CDC) in 2006, which encouraged routine HIV testing in all healthcare settings for the general population and annual testing for high-risk populations, and a more streamlined consent process (1). Prior to the law, a third of newly diagnosed cases in NYS were identified in late stage disease, and progressed to AIDS within a year of diagnosis (2). HIV-infected individuals receiving antiretroviral therapy have better survival and reduced viral load, thereby becoming less infectious and able to transmit new infections (3–8). Increased HIV testing is critical to identifying individuals earlier in their infection, thereby linking them to medical care sooner (9).

   This law includes a statutory requirement that the commissioner of health evaluate the number of individuals who are tested, and of those testing positive, the number who access care and treatment. As part of the evaluation, Health Research, Inc. in conjunction with the AIDS Institute, NYS Department of Health has contracted Erika Martin and Roderick MacDonald at University at Albany to develop a system dynamics model to supplement the evaluation studies. Martin and MacDonald worked closely with Daniel O’Connell and a steering committee with expertise in different AIDS Institute datasets and operations (Daniel Gordon, Franklin Laufer, John Leung, Kirsten Rowe, Lou Smith, and Jim Tesoriero).

   As part of its evaluation, the AIDS Institute has collected extensive empirical data to understand various features of the law’s implementation and early outcomes. These research studies are based on a broad set of data sources (such as claims for Medicaid and outpatient hospital discharges, surveillance, and surveys) and address a wide range of stakeholders and areas affected by the law (such as patients, laboratories, providers, and public programs). However, there are limitations to these studies, which are inherent to policy evaluation.

   First, traditional quantitative research methods (such as surveys and statistical analyses of medical claims and surveillance data) may not adequately address complexities in the system of HIV testing and care, involving multiple public and private payers, facilities, providers, and social services. Qualitative research (such as interviews and site visits) can provide a nuanced understanding of these complex issues, and can therefore be a useful supplement to a quantitative
analysis. However, qualitative research cannot generate quantitative predictions (such as the anticipated number of individuals who will be linked to care over the next 10 years).

Second, the law is being implemented in the context of concurrent policies that may affect outcomes. Some of these related policies (such as national guidelines on HIV testing frequency) have similar goals to the state law, thereby attenuating its observed effect in empirical data. Other actions with policy implications, such as general fiscal strain within county and state budgets, and funding cuts from the federal government for supportive services that may improve testing and entry into care, may counteract the law’s potential effects. A third class of concurrent policies (such as upcoming financial changes from health reform) has unclear effects. These concurrent policies may make it difficult to measure the marginal effect of the law in observational data.

Third, the empirical data used for the other studies described in the report are limited to a short two-year time horizon, whereas the law may take several years to fully implement and its impact on long-term outcomes such as new infections and HIV-related mortality may occur over decades. Furthermore, many of the data sources require a lag time of a year or more for data collection and processing.

Finally, empirical data are limited to outcomes that can be directly measured. For example, a policy goal may be to reduce the incidence of new HIV infections, as a result of increased awareness of HIV status (which may lead to behavior changes) and receiving antiretroviral therapy (which may reduce viral load and infectiousness). However, it is impossible to directly measure new infections, as surveillance data are limited to new diagnoses. Only individuals who are aware of their HIV status can be directly measured.

System dynamics modeling is well-suited to supplement the other policy evaluation studies conducted by the AIDS Institute. Through extensive conversations with system experts, modelers can develop a computer simulation model that mimics the important complexities in the real system (such as dynamic processes of HIV infection, and HIV-infected individuals having imperfect retention in HIV care). Variables in the model can be manipulated to estimate the potential effects of policies or combinations of policies while holding other factors constant. The model can be simulated for many years into the future, allowing modelers to describe both short-term and long-term impacts. Finally, through a system of mathematical equations, it is possible to generate synthetic data of variables that are virtually impossible to measure in the real world, such as new infections.

b. Problem Statement and Outcomes

The modelers met regularly with the steering committee to ensure that the model would be a realistic representation of the system of HIV testing and care in NYS, appropriate NYS data sources were used for model parameters and calibration, and that the scenarios considered in the analysis were appropriate for understanding the short-term and long-term implications of the law. The steering committee developed the following consensus problem statement for this study:
What are the short-term and long-term implications of the New York State HIV testing law on rates of HIV testing, the number of HIV diagnoses, linkage to care among newly diagnosed individuals, proportion of late diagnoses, and the future incidence of HIV infections among New Yorkers? What are the additional determinants of these indicators?

- **Number of new HIV tests**
- **Number of new HIV diagnoses**
- **Number of individuals linked to care (for those diagnosed)**
- **Fraction of diagnoses that are early versus late stage**
- **Number of new HIV infections**

The first and third indicators (number of HIV tests and linkage to care) are required outcomes to report to the commissioner of health. However, the steering committee thought the other outcomes – particularly the number of new HIV infections – were also critical indicators of the law’s success.

The results are presented as graphs over time of these outcomes, which will display short- and long-term projections. Results are also presented numerically as percent changes over time. Modelers ran multiple computer simulations to assess (a) baseline projections of what would happen in the absence of the law, (b) how results would change under three different levels of implementation (low, high, and perfect), (c) how results would change under alternate scenarios on the frequency of repeat testing in the general population (annual repeat testing, five-year repeat testing, and one-time testing), (d) whether findings change under different assumptions about the time it takes until the law is fully implemented in practice, and (e) how findings would change if all individuals engaged in HIV care achieved perfect viral load suppression, thereby not being able to transmit new infections. All scenarios were developed in consultation with the steering committee.

c. **New York State Policies Capable of Being Modeled**

In developing the model, the steering committee agreed that the primary purpose of the model is to evaluate the short- and long-term consequences of the HIV testing law. However, it is also important that other relevant HIV policies can be mapped onto the model’s stock and flow diagram. The model is robust enough to demonstrate how scenarios related to these concurrent policies might affect outcomes. This has two purposes. First, predicting how these concurrent policies affect outcomes may help the AIDS Institute gain a better understanding of empirical data from other evaluation studies. Second, the model can later be modified to evaluate other important state policies.

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1 As described in section 4, the final variable names are slightly different than these labels from the original problem statement. In some cases there are multiple variables to represent a concept.
The steering committee identified the following concurrent policies:

- **NY Knows:** This public health initiative seeks to increase voluntary HIV testing through a media campaign and the offer of free testing. It started on a smaller scale as Bronx Knows and was recently expanded to Brooklyn and other communities (10).

- **Program Consolidation and Service Integration (PCSI):** This CDC strategy seeks to strengthen collaborations among programs that address HIV, STDs, viral hepatitis and tuberculosis, and to integrate services (11). Specific changes within NYS include the technical language in grants (which now reference multiple diseases as appropriate) and organizational changes within the AIDS Institute. At the service level, many NYS service providers already integrate these services, so this policy change may have limited impact in practice.

- **Testing technology regulations:** There is an evolving set of HIV testing technologies and regulations, which impact the ease with which tests can be offered and how the tests can be interpreted (12, 13). For example, in the future two positive rapid tests from different manufacturers will be acceptable evidence to confirm HIV infection. This differs from current practice, which requires a confirmatory Western blot. This may increase the likelihood that clients receive results. However, it may be problematic for HIV surveillance and partner services because so many new cases are identified via laboratory reporting. In settings that are not full service labs, the AIDS Institute may not be made aware of the positive results. In these cases, surveillance and Partner Services would be dependent on getting provider report forms to document new diagnoses. Yet historically, there has been incomplete submission of provider report forms. Thus, public health officials may not be able to count cases, provide assistance through Partner Services, and confirm linkage to care. This change is likely to happen within the next year.

- **Federal rules on preventive services that must be offered without a copayment:** Health reform will require that all preventive services with an A or B recommendation from the US Preventive Services Task Force (USPSTF) will be offered by insurance companies, Medicaid, and Medicare without out-of-pocket costs to consumers. (Some insurance plans will be grandfathered in, and will not have to meet this requirement.) There are additional preventive health guidelines for women. The USPSTF recommendations include HIV screening among individuals “at increased risk for HIV infection” (14). However, there is no clear recommendation regarding testing everyone (including those not at increased risk) for HIV. The Institute of Medicine’s recommendations for women include annual HIV screening and counseling (15), and it is likely that those will be incorporated into final rules. HRSA is taking steps towards recommending HIV testing among sexually active women, and the Presidential Advisory Council on HIV/AIDS is considering a recommendation that the USPSTF adopt the CDC guidance that everyone is tested at least once. However, these policy changes will take time, and in the meantime it is not clear whether testing in routine care would be classified as a required preventive service to offer at no-cost to consumers.
• **CDC recommendations on the frequency of HIV testing:** The CDC updated its recommendations on the frequency of testing (annual for high-risk groups and once for everyone else) and consent procedures in 2006 (1). The NYS law is not entirely consistent with the CDC’s recommendations, as there is no opt-out testing. (However, depending on how providers implement consent, it can be pretty close to opt-out testing.) The new NYS law addresses the CDC’s recommendations on consent processes; however, it does not explicitly address the frequency of test offers.

• **Pre-exposure prophylaxis (PrEP) policies:** PrEP is a method of HIV prevention in which high-risk HIV-negative individuals take antiretroviral medications to lower their likelihood of becoming infected (16). Depending on how widely this is adopted, it may enhance HIV testing among at-risk populations.

• **Funding cuts for STD services:** In some parts of the state (particularly Upstate), the county health department may be the only source of STD services. As funding is reduced, STD testing may become a lower priority. This funding challenge is particularly salient for testing at free clinics via contractors. The steering committee expects that all services offered directly or through a contractor are likely to decrease. Funding cuts also threaten public health infrastructure, such as surveillance, monitoring, program activities to ensure testing and linkage to care, and evaluation.

• **Health reform financial changes:** Health reform will lead to several changes in the public finance of medical services. Major changes relevant to HIV-infected individuals are a Medicaid expansion in 2014, the availability of subsidized private insurance through new state health insurance exchanges, and revisions to the Medicare Part D prescription drug benefits donut hole (17). This may lead to several competing changes. First is a potential reduction in support for safety net programs and categorical programs. As policymakers perceive that access to care has improved, there may be less political support for categorical services and disease-specific programs such as Ryan White. This has already occurred in Massachusetts, where the state shut down most of its free STD clinics after implementing its state health reform law. Pushing in the other direction, health reform may increase access to care. It is unknown whether the base of providers willing to accept Medicaid patients will increase, particularly as enhanced rates for HIV-infected individuals are eliminated.

• **Using social media in prevention strategies:** There is a recent focus on using new social media to target public health messages on HIV and STDs (18). The steering committee cautioned that this may be a “lack of policy” because new media is not being used in proportion to the influence it has on the target population.

• **Prevention for positives:** “Prevention for positives” is prominent in the new CDC guidelines, and 75% of CDC funds for counseling and testing are earmarked for working with HIV-infected individuals to maintain their adherence to medications as well as interventions to reduce secondary infections by this group (e.g. condoms to HIV-infected individuals, counseling to HIV-infected individuals to reduce their risky behaviors). In addition, new national guidelines recommend that all HIV-infected individuals
(regardless of CD4 count) receive antiretroviral therapy (19). The prevention for positives strategy represents a fundamental shift in HIV prevention, which traditionally has used 40-50% of the resources to empower HIV-negative individuals. Currently only a tiny fraction of HIV-infected individuals are in AIRS; the prevention for positives strategy will likely increase this percentage.

- **Quality of care:** The Office of the Medical Director (OMD) issues the NYS clinical guidelines (20). There may be changes to these recommendations, such as when to start antiretroviral therapy and improvements in prevention with HIV-infected individuals (e.g. retention in care, linkage to care). Pushing in the other direction, the realities of the cost-constrained environment may impact the recommendations about immediate initiation of antiretroviral therapy. Improved retention and linkage to care is also addressed through a new Ryan White-funded Special Project of National Significance grant that uses a collaborative approach among providers to improve linkage to and quality of care.

- **Data sharing:** CDC officials are promoting more data sharing to use surveillance data for public health purposes (21), and this is statutory for NYS. For example, surveillance data could be used for public health interventions such as linkage to care, monitoring adherence to care, and locating those out of care to link them to services. Privacy and legal concerns exist. Release of surveillance information is highly restricted by NYS law, and surveillance programs receiving federal grant money must follow CDC guidelines that have many security and confidentiality protections. Surveillance resources and the accuracy of ongoing reported laboratory data for individual level interventions are also issues that affect the ability to share surveillance data.

- **Linkage to care programs among prisoners:** The AIDS Institute has requested funding for a project with the Department of Corrections and Community Supervision to increase linkage to care. Barriers to care within correctional facilities include stigma and a (false) perception that HIV care in prisons is poor quality. Consequently, it is estimated that only half of HIV-infected incarcerated prisoners are on antiretroviral therapy. The project will try to change perceptions among prisoners, corrections officers, and HIV-infected individuals. In addition, the AIDS Institute is developing a bridge to treatment for recently released offenders. (Although the model can be adjusted to accommodate this policy, there is not yet a sector in the model that address it because this policy is still being formulated.)

- **Medicaid HIV counseling testing and referral payment to ambulatory patient group (APG) basis:** As part of Medicaid redesign, payments for HIV counseling, testing, and referral (CTR) were changed from enhanced rates to an APG basis on October 1, 2011. The APG is similar to a diagnosis-related group (DRG) for an outpatient visit (22). The steering committee expressed concern that because APG-based payment has a lower reimbursement for counseling services, it may reduce HIV testing in the general population. However, some system experts predicted that although APG payments are lower, the simplified payment system may make it easier to increase HIV testing.
• *Medicaid Screening, Brief Intervention, and Referral to Treatment (SBIRT)*: A second aspect of Medicaid redesign is to expand and reimburse for SBIRT by office-based primary care practitioners, effective September 1, 2011. SBIRT is a technique to identify substance users, provide them an on-site brief intervention, and refer cases for substance use treatment (23). This service previously was covered only in hospital clinics, emergency departments, and community-based settings. Individuals identified as candidates for substance use treatment may also be offered HIV counseling and testing.
2. System Dynamics Modeling

a. Overview of Methodological Approach

System dynamics is a branch of computer simulation modeling that is useful for policy analysis and design for problems arising in complex social, managerial, economic, or ecological systems (24-26). Models are tailored to the specific problem under review. Discussions with system experts (such as the steering committee, program officials, and practitioners) are used to understand the structure of the system, and to develop a conceptual model of the important variables and their relationships. The conceptual model is then transformed into a system of mathematical relationships between variables. Experts’ knowledge and available datasets are exploited to identify parameter estimates for key variables and to ensure that the simulation model is a reasonable reflection of the real system.

System dynamics is different from other simulation modeling approaches because it takes a holistic view of all organizations and processes involved in the system, incorporates feedback loops and dynamic processes, and includes nonlinearities in the relationships between variables. (The following section provides a more complete description of these methodological details.) System dynamics modelers work extensively with key stakeholders and experts to develop the structure of the system and incorporate data from numerous sources. Although all simulation models are imperfect reflections of reality, working closely with stakeholders throughout the process can increase its accuracy and legitimacy.

The model is calibrated by comparing model output to empirical data, and if discrepancies exist, refining the model and parameter estimates. Once the model has been developed and calibrated, inputs can be modified to conduct “what if” analyses of how short- and long-term outcomes would change in response to various policy scenarios. In addition, the process of developing the model and running the base case scenario may expose new concepts and previously unknown but significant variables (27). For example, combining numerical data, written data, and the knowledge of experts in mathematical form may identify inconsistencies about how we think the system is structured and how it behaves over time (28).

System dynamics models do not generate a forecast or claim that an outcome will have a specific value at some future point in time. Rather, system dynamics models predict dynamic implications of policies to determine whether they will result in a future that will be better or worse than it would have been without the intervention. The primary output of a model is a set of graphs over time illustrating how key variables will change in the future under different scenarios. These data can also be presented numerically as percent changes. Systems modelers seek to understand how internal policies, internal decisions, and external phenomena interact to generate the problems observed over time. An explicit goal of system dynamics is to provide an explanation for why and how the outcome will change, potential unintended consequences, and areas where implementation may not lead to intended outcomes.
b. Mathematical Formulation of System Dynamics Models

System dynamics takes an integral view of calculus to capture accumulations that occur in real systems. For example, people receiving Medicaid benefits would be represented as an accumulation with people entering and leaving the Medicaid program each time period. The level can be represented as integral calculus as:

\[\text{Level}_T = \text{Level}_{T_0} + \int_{T_0}^{T} (\text{Inflow}_t - \text{Outflow}_t) dt\]

The level can be expressed with differential calculus as:

\[\frac{d\text{Level}}{dt} = \text{inflow}_t - \text{outflow}_t\]

Visually, the system dynamics model would be represented as:

![System Dynamics Diagram]

The equation as implemented in system dynamics software would be:

\[\text{Level}_t = \text{Level}_{t-\Delta t} + \Delta t * (\text{inflow}_t - \text{outflow}_t)\]

c. Linear and Nonlinear Functions

Nonlinearity in complex systems refers to the concept that changes caused in one variable by another are not proportional over a range of inputs. For example, a doctor or practice with a very good reputation will have a delay between the time someone calls for an appointment and the time she is given an appointment. As the reputation of the practice grows the delay will become longer as more people wish to be seen by the doctor or practice and they are willing to wait a longer period of time to be seen. However, after a certain point people will be unwilling to wait any longer and will go elsewhere for treatment. Initially, incremental changes in waiting time have very little effect upon the willingness of people to come to the practice, but once a limit is reached the majority of people will be unwilling to wait. Small changes in waiting time will then have large effects.

d. Feedback Loops

A feedback loop refers to the concept of circular causality. Figure 2.1 illustrates how a simple susceptible and infection (SI) infectious disease model can be represented with feedback loops.
(This example is adapted from (26)). The infection rate ($IR$), the number of new infections in a set time period, is a function of the frequency of contacts with infected individuals ($C$), the infectivity ($i$) of the disease, and the size of the susceptible population ($S$). The size of the infectious population ($I$) has a causal relationship with the infection rate ($IR$) and forms a feedback loop labeled Contagion Loop. The Contagion Loop captures the idea that as the size of the infectious population grows, the number of new people infected will increase, resulting in a further increase in the number of infected individuals. This model also contains a Depletion Loop, which reflects the idea that as individuals from $S$ become infected, they will no longer be in that pool of individuals.

Figure 2.1: Feedback Loop Example

- Computer Modeling with Vensim® Software

All of the modeling was performed using Vensim® DSS software. Vensim is a commercial simulation software package that allows for the conceptualization, documentation, simulation and analysis of system dynamics models. A personal learning edition (Vensim PLE) is available free of charge for educational purposes and a low cost version is available for commercial purposes. Both versions are capable of replicating the model in this report. Models can be developed visually using an interface that allows a modeler to link icons that capture the structure of the system. A text editor allows modelers to directly code relationships. An equation editor formalizes the mathematical relationships in the structure, thereby allowing the model to be simulated and generate output of key variables over time.

The structure (model views) and equations used in the model are shown in appendices 3 and 4. These diagrams and equations can be used to replicate the model and reproduce the results in this report. Data sources for fixed parameters and initial conditions used in the model are explained in sections 3c, i-vi, and summarized in appendix 4. The formal model is also available from the authors.
3. Description of the New York State HIV Policy Model (HIVSIM)

a. HIVSIM Model Structure

The problem statement (described in section 1b) established the model boundary for HIVSIM. HIVSIM is designed to evaluate the NYS HIV testing law through modifying key inputs such as frequency of testing and linkage to care. In addition, the fifteen concurrent policies identified by the steering committee can be mapped onto the model. The model is able to generate graphs over time of the five outcomes specified by the steering committee (number of new HIV tests, number of new HIV diagnoses, number of individuals linked to care, fraction of diagnoses that are early versus late stage, and number of new HIV infections).

i. Stock and Flow Diagram

The basic structural diagram (Figure 3.1) illustrates the primary stock and flow structure of how individuals move through the system of HIV testing and care. There are 16 categories of HIV-infected individuals, which vary according to: whether they have been diagnosed and are aware of their infection, their linkage to and engagement in care, and disease progression (four stages, from acute to late stage disease). From left to right, there are four “columns” of stocks that represent stages 0, 1, 2, and 3. These stages mirror the staging used by the CDC (29). The four “rows” of stocks represent different levels of engagement in care. Individuals are initially unaware of their infection (row 1), and become aware of their infection but not in care (row 2) upon diagnosis. They are engaged in HIV care (row 3) after being linked to care. A certain fraction of individuals who have been linked to care may transition in and out of care, described here as entered care but care is now sporadic (row 4). In this framework, individuals who fall out of care (row 4) can later go back into care (row 3).

Figure 3.2 is an identical stock and flow diagram with alternate labels to simplify the stock names. $R_1$, $R_2$, $R_3$, and $R_4$ refer to the four “rows” that represent different levels of awareness and engagement in care (row 1, row 2, row 3, and row 4). $S_0$, $S_1$, $S_2$, and $S_3$ refer to the four disease stages (stage 0, stage 1, stage 2, stage 3).

Each stock (represented by a box on the diagram) keeps track of the number of people moving into and leaving the category as time passes. The flows (represented by pipes with valves) determine the rate at which individuals move across the categories. During the simulation, the software saves the value for each variable at each point in time. After the simulation is complete, the simulated data for each variable can be viewed, graphed and analyzed.

The number of individuals in each stock at the start of the simulation and the initial rate of movement across stocks (flows) were calculated using multiple data sources, in consultation with the steering committee. These data are described in sections 3b and 3c. After the initial start date for the model, all data in the model are generated endogenously.

Additional model views are provided in appendix 2.
Figure 3.1: HIVSIM Stock and Flow Diagram
Figure 3.2: HIVSIM Stock and Flow Diagram, with S0-S1 and R1-R4 Labels
ii. Level of Aggregation

HIVSIM takes an aggregate perspective to examine population averages for different categories of people in the system. This is different from a micro-simulation model which tracks individuals’ progress through the system, and averages results from a large number of simulated individuals. Rather than examining specific simulated individuals in the system, HIVSIM assigns each category an average time delay for flows such as disease progression, as well as average probabilities of being initially linked to care and remaining engaged in care.

In HIVSIM, the levels of aggregation are the 16 categories of HIV-infected individuals, the uninfected population, and HIV-related deaths displayed in Figure 3.1 and Figure 3.2. The current version of HIVSIM does not disaggregate (stratify) the HIV-infected population further by age, race, or sex, although this could be done in a future version of the model. Ultimately the level of aggregation in a system dynamics model is determined by the problem being addressed. Discussions with the steering committee and other system experts elicited the importance of distinguishing categories of disease progression, awareness of HIV status, and level of engagement in care. These are necessary to capture the dynamic complexity (feedback loops) involved in HIV infection, as these characteristics affect infection rates (discussed in section 3c,vii). This level of aggregation was also critical to generate output for the outcomes of interest listed in the problem statement, and calibrate HIVSIM against NYS and other data sources (described in section 3d,vii).

iii. Generation of New Infections through Feedback Loops

HIVSIM includes feedback loops to generate new infections, thereby perpetuating the epidemic. HIV-infected individuals interact with HIV-negative individuals (via a set of mathematical formulas) to influence the flow from the Uninfected stock to the S0R1 stock. This is important for the model’s face validity, as HIV is an infectious disease and the model should reflect the disease process. In addition, it is critical to include this feedback loop in order to graph future HIV infections over time (one of the outcomes identified by the steering committee) under a range of scenarios.

HIVSIM calculates new infections as the sum of infections generated by the 16 categories of those already infected (S0-S3; R1-R4). The 16 categories are assigned unique infection rates due to variation in viral load (based on disease progression and suppression with antiretroviral therapy), contact rate and frequency of encounters (sexual, injection drug, or other encounters), behavioral aspects related to encounters (harm reduction strategies such as barrier methods that would reduce the likelihood of transmitting an infection during a given encounter), and the size of the sub-population in that particular category.\(^2\) Section 3c, vii provides additional information on why infection rates differ across categories, and how they were calculated based on results from published literature and comparison to NYS surveillance data.

\(^2\) As described in section 3c, vii, several categories are assigned the same infection rate, so there are effectively five unique rates. In addition, the specific components of the infection rates (such as infectivity and contact rate) are combined into one infection rate parameter.
During the simulation, the number of individuals in the 16 stocks may change over time reflecting differences in case identification, linkage to care, and retention in care. However, the infection rate for individuals within each category is constant. As the relative distribution of individuals across the 16 categories changes, the total infection rate in NYS (all new infections per month, summed across the 16 categories) may change. For example, if the HIV testing law is successful, leading to an increase in diagnosis and linkage to care, then the aggregated total infection rate should decline.

iv. Testing Structure

HIVSIM contains model structure that mimics both the background rate of testing and also the incremental testing that would occur in routine care settings as part of the law. The background testing rate represents all testing that occurred before the law’s implementation, such as risk-based testing, offering tests to patients who requested them, and campaigns to encourage testing. The incremental testing is the new testing that will occur in routine care settings (in addition to background testing) as a result of the law. The background testing rate is operationalized as a transition probability from $R_1$ to $R_2$, and is based on historical diagnosis data (described in more detail in section 3c). This transition probability is assumed to continue after the law’s enactment at a constant level. The amount of incremental testing is based on the scenarios.

Figure 3.3 shows the structure for the testing module. This module is an additional layer of the main stock and flow diagram. The Not Recently Tested and Recently Tested stocks correspond to whether individuals have been tested as part of the law (incremental testing). Individuals who have not been recently tested in routine medical care settings can become diagnosed either as part of background testing, or else by receiving a test in a setting covered by the law. Individuals who receive a test in a routine medical care setting with a negative result are moved to the Recently Tested stock. Individuals in this category may become infected over time, based on the infection rate. If they become infected, they can only become diagnosed as part of background testing. After a period of time, individuals with a prior negative test result move back into the Not Recently Tested pool, where they can be diagnosed through background testing or else by receiving a test as part of routine medical care. This period of time ($X$ Months Until Appropriate to Offer Repeat Testing) is defined by the modelers in order to test different scenarios on the frequency of testing in routine medical care. Newly diagnosed cases from both types of testing (background testing and incremental testing) are then moved into the Diagnosed HIV Cases ($R_2, R_3, R_4$) stock.

The testing structure maps onto the main stock and flow diagram. The Not Recently Tested and Recently Tested are comprised of individuals who are in the Uninfected stock or unaware ($R_1$). The Diagnosed HIV Cases ($R_2, R_3, R_4$) stock is the sum of all diagnosed individuals in $R_2$-$R_4$.

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3 As described in section 3c, vii, the category-specific infection rates are constant starting in 2010 when the testing law was implemented. The historical estimates for the number of new infections in NYS indicate a decline over time. The infection rates decline from 2006 to 2010 to match historical estimates, and are subsequently set to a constant value in 2010.

4 This rate is a probability that an individual who is unaware will become diagnosed in a given time period. If the number of individuals who are unaware decrease over time, then the absolute number of new diagnoses in a unit of time will also decline, even though the transition probability is constant.
and is analogous to the outcome variable of people living with diagnosed HIV infection (see section 4d). The testing module additionally contains pipes that remove individuals from the model due to deaths. These flows are analogous to the flows from the main stock and flow diagram.

In order to model the alternative scenarios on the frequency of testing in routine care settings, it is necessary to have a mechanism to turn off incremental testing for individuals who are in the Recently Tested category. Conceptually, a patient who recently had an HIV test as part of routine medical care might have a flag in his or her medical record indicating the recent test, and the provider may skip the offer during that visit. As described in section 3a,ii, HIVSIM takes an aggregate perspective and is not a micro-simulation that keeps track of specific individuals’ transitions across states over time. The mechanism to turn off incremental testing for recent testers has been operationalized by calculating the fraction of the population in the Not Recently Tested category, who would be eligible to receive a test in a routine medical care setting. (The denominator is the sum of Not Recently Tested and Recently Tested). As the fraction of people who are Not Recently Tested decreases, fewer individuals are available to be tested as part of routine medical care. Conceptually, as this fraction declines, the likelihood that a physician treats a patient who is in this pool is lower, and thus there is less incremental testing.
b. Data Sources for Model Parameters and Calibration

The model considered information from the following data sources to estimate model parameters, calibrate the model, and develop scenarios. Although not all data sources were ultimately used, the modelers consulted with all relevant experts to learn about the data systems and gain a better understanding of the NYS HIV testing and care system.

- **Bureau of HIV/AIDS Epidemiology Surveillance**: These data are a census of all detected cases from NYC and rest-of-state, and are used to generate the annual NYS surveillance reports. All cases have the following information: names, personal information from case report (e.g. risk factors, demographic information, date of diagnosis), lab data (such as CD4, VL), and CDC and provider report forms. BHAE staff has the technical expertise to array and compile the data to conduct analyses as needed. There are ongoing efforts to clean the data (such as de-duplicating records, merging NYC and rest-of-state datasets, and updating person-level data as new cases are identified).
• **HIV Testing Laboratory Survey**: The BHAE surveillance data only include laboratory results that are reportable to the health department (VL, CD4, confirmatory Western blots), and consequently do not include negative HIV tests. As part of the broader HIV testing law evaluation, all NYS labs conducting HIV diagnostic testing were surveyed. Labs were asked to report the number of screening tests, and whether conventional or rapid, that they performed each month during 1/2009 to 10/2011. A limitation of this dataset is that all data are aggregated to the lab-month, and are not at the individual level with demographic information.

• **Statewide Planning and Research Cooperative System (SPARCS) Dataset**: SPARCS data contain inpatient discharges and outpatients visits for non-Federal hospitals in NYS. As part of the broader HIV testing law evaluation, outpatient files from the SPARCS data were used to examine rates of HIV testing in emergency departments. Identification of HIV testing is based on a list of vetted procedure codes. The data include all payers and analysts can differentiate by payer type.

• **Medicaid Claims**: This data source includes all claims for fee-for-service clients, and encounter data for managed care clients. Variables include demographics, Medicare/Medicaid dual eligibility status, Medicaid eligibility information (some clients have discontinuous eligibility), and some encounter data for Family Care Plus (managed care). There is an existing algorithm (based on CPT codes, rate codes, and a diagnosis code) to identify HIV-infected individuals. Approximately 60-70% of HIV-infected individuals in NYS are on Medicaid, and consequently this is a potentially rich data source. Limitations include the exclusion of other payers and the difficulty of working with the data (such as distinguishing between fee-for-service and managed care, identifying an appropriate sample).

• **Medical Providers Survey**: As part of the broader HIV testing law evaluation, the AIDS Institute conducted a survey of NYS physicians with a primary specialty in family medicine, internal medicine, general pediatrics, obstetrics/gynecology, or emergency medicine. The survey includes questions on current testing practices, barriers to testing, knowledge of the law, and characteristics of practices and patients.

• **Behavioral Risk Factor Surveillance System (BRFSS)**: The AIDS Institute included a special NYS testing module to the CDC’s 2011 survey. It contains questions about whether respondents were offered HIV tests by various providers, and whether they received a test. Data are limited to adults and do not include youth.

• **School Based Health Clinics Survey**: As part of the testing law evaluation, AIDS Institute distributed a survey to all School-Based Health Clinics, with questions to assess the routine offer of testing to the target population (low-income youth, particularly in rural communities).

• **HIV/STD/HCV Integrated Testing Module**: The survey is designed to assess the capacity of counseling and testing providers to additionally test for STD and HCV, in response to
national guidelines about integrating these services. The target population is agencies funded to do counseling and testing. The survey includes a question about awareness of the new law and barriers.

- **Medical Society Survey:** This survey targets the medical associations in NYS, in order to learn about the societies’ role in informing providers about the law, and to provide a context for interpreting quantitative results from other surveys.

- **Partner Services:** Almost all newly diagnosed cases are referred by BHAEE for follow-up. Program data include the number of partners that were tested (of those not previously identified as HIV-positive) and testing outcomes among those tested partners. The interview record has new data elements to monitor linkage to care, which are: whether a medical appointment was made, the appointment date (if applicable), and whether the scheduled appointment was attended. These data are rest-of-state and do not include NYC. NYC has different forms and may not have parallel questions on linkage to care.

- **National HIV/AIDS Behavioral Surveillance (NHBS) Survey:** The CDC conducts an ongoing survey that targets special high-risk populations. The survey is limited to high-prevalence areas. State data is limited to Long Island and NYC. In the most recent iteration, the survey included a special MSM module that was conducted in Long Island. It includes questions on recent HIV testing, although data are not representative of NYS.

- **AIDS Institute Reporting System (AIRS) and Counseling, Testing, and Referral Data:** AIRS is a client-level data management system, and includes individuals who receive: clinical services though Ryan White-funded providers; wrap-around services (such as nutrition or case management) through Ryan-White funded providers; counseling, testing, and referral services from providers funded under contract with the AIDS Institute; HIV tests that are otherwise funded by the AIDS Institute (such as clinics that are not under contract with the AIDS Institute but which receive free test kits); and anonymous HIV testing. The dataset includes detailed information on counseling, testing, and referral services. The dataset is clean and very comprehensive, but excludes individuals who do not receive AIDS Institute-funded services. Although AIRS does not have direct information on the frequency of testing in general routine care, this can be assessed indirectly using a question on the intake form about how the client was referred (one of the response choices is provider referral).

- **Blood Donations:** The AIDS Institute is exploring the feasibility of assessing HIV prevalence among first-time blood donors in NYS.

- **Youth Behavioral Risk Survey (YRBS):** This biannual survey conducted by the CDC contains a question about HIV testing among youth, although it is not clear whether this question was asked in NYS. The AIDS Institute is exploring whether these data are available for NYS.
• Published Literature: To the extent possible, HIVSIM uses NYS data. Some parameters (such as length of time for disease progression) could not be estimated from the sources above, and were generated from a literature review.

c. Derivation of HIVSIM Inputs for Parameters and Calibration

NYS data, published literature, and discussions with system experts were used to derive inputs for model parameters and calibration. This section describes the derivation of the numbers for the stocks and flows. Appendix 4 summarizes the values used for fixed parameters, initial values for variables that change over time, and historical data that were used to calibrate the model. Section 3d,vii demonstrates how HIVSIM’s simulated data match the historical NYS data.

i. Number of New Infections

It is impossible to directly measure the number of new infections (represented in HIVSIM as the flow from Uninfected to S0R1) because they are not known to the system until they are diagnosed (thereby becoming a case). The CDC estimates new infections using a mathematical algorithm that considers whether the infection is in early stage (based on lab tests of remnant serum specimens of individuals who have tested positive), with adjustments for HIV testing frequency and missing data imputations (30). Although the estimates are intended to assess HIV incidence at the national level, the large case load in NYS allows for calculation of NYS-specific estimates.

The estimated numbers of new infections in NYS in the past four years are listed below, with 95% confidence intervals in parentheses. Data were provided by BHAE.

- 2006: 5,126 new infections (95% CI: 4,290-5,962)
- 2007: 5,025 new infections (95% CI: 4,292-5,757)
- 2008: 4,439 new infections (95% CI: 3,725-5,152)
- 2009: 4,040 new infections (95% CI 3,351-4,728)

ii. Newly Diagnosed and Living HIV Cases

The March 2012 BHAE surveillance database was used to generate historical estimates of newly diagnosed HIV cases and people living with diagnosed HIV infection. Although these data are reported in published in annual reports, BHAE staff stressed the importance of using a single database for all analyses, rather than compiling estimates that were generated from different versions of the dataset.
Table 3.1 displays historical data for newly diagnosed HIV cases, adjusted newly diagnosed HIV cases, people living with diagnosed HIV infection, living HIV cases, living non-AIDS cases, and living AIDS cases. To be considered a “newly diagnosed HIV case,” the record must contain a diagnosis date. A small fraction of cases that are new to the BHAЕ database have no diagnosis date, and it is difficult for BHAЕ staff to determined their year of diagnosis. For example, a case may first appear in the data in 2008 when a positive Western blot test is recorded in the laboratory data. However, BHAЕ staff reviewing the individual’s record might find a viral load test from 2006. In this circumstance, BHAЕ does not know the true diagnosis date, but can assume that it was before 2008. These individuals are not included in published estimates. However, they are conceptually important because they are in the NYS system of testing and care. The “adjusted” column includes individuals without a diagnosis date who first appeared in the dataset in that year. Modelers were advised to use these numbers in the historical comparison.

Table 3.1: Unpublished BHAЕ Data on Newly Diagnosed and Living HIV Cases

<table>
<thead>
<tr>
<th>Year</th>
<th>Newly Diagnosed HIV Cases</th>
<th>Adjusted Newly Diagnosed HIV Cases</th>
<th>Living HIV Cases</th>
<th>Living non-AIDS Cases</th>
<th>Living AIDS Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>4,884</td>
<td>5,505</td>
<td>119,379</td>
<td>47,383</td>
<td>71,996</td>
</tr>
<tr>
<td>2007</td>
<td>4,784</td>
<td>5,294</td>
<td>121,972</td>
<td>47,896</td>
<td>74,076</td>
</tr>
<tr>
<td>2008</td>
<td>4,643</td>
<td>5,102</td>
<td>124,420</td>
<td>48,634</td>
<td>75,786</td>
</tr>
<tr>
<td>2009</td>
<td>4,188</td>
<td>4,600</td>
<td>126,485</td>
<td>49,337</td>
<td>77,148</td>
</tr>
</tbody>
</table>

iii. Number of Individuals Diagnosed and Linked to Care, by Stage

It is difficult to combine clinical and surveillance data to provide a point-in-time snapshot of the number of diagnosed individuals that are currently in each category of level of engagement in care and disease stage. The initial values in HIVSIM were generated through optimization to match the allocation of individuals with various facts provided by system experts. These pieces of information are described below.

Conversations with system experts and the literature indicate that individuals in late stage disease are more likely to be diagnosed and linked to care (31). HIVSIM is calibrated to NYS data so that the flows from $R1 \rightarrow R2$ and $R2 \rightarrow R3$ are the highest in stage 3.

A special run of BHAЕ surveillance data (unpublished data from 2006-2008, prepared on 3/12/12) was used to estimate the number of individuals who are diagnosed and linked to care, by disease stage. BHAЕ provided data on the characteristics of cases (demographics, risk group, and disease stage) that enter case within 3 months, between 4-6 months, between 7-12 months, between 13-18 months, and not within 18 months.

Disease stage was based on the first recorded CD4 test, with $S1$, $S2$, and $S3$ defined as CD4 $\geq$ 500, CD4 200-499, and CD4 < 200, respectively, following CDC staging criteria (29). The historical data used for this report do not include information on cases in $S0$ because the data
were not available in the surveillance data during those years. Data on acute stage cases may change in the future as testing technologies are updated and providers become more experienced in detecting and recording acute infection.

Using the first reported CD4 test to assign a disease stage is reasonable for individuals linked to care early, as the CD4 count is measured shortly after diagnosis. However, individuals linked to care later have a longer time elapsed between diagnosis and the CD4 test. If these individuals have progressed to a later disease stage since their initial diagnosis, using their first reported CD4 test to assign a disease stage at diagnosis may overestimate the number of cases diagnosed in late stage. Modelers considered this issue. However, because the natural history of disease is so long (see section 3c,v), using a back calculation to estimate disease stage at diagnosis would not meaningfully change estimates.

The data provided the following information:

- The overall probability of linkage to care (population average, including all stages) within 18 months ($R_2 \rightarrow R_3$) is 87.4%.
- Of those linked to care within 3 months (early linkage to care), 25.8% are $S_1$, 40.5% are $S_2$, 33.7% are $S_3$.
- There is a dose-response relationship between disease stage and the likelihood of being linked to care early (within 3 months, compared to within 4-18 months). Compared to individuals in stage 1 ($S_1R_2$), individuals diagnosed in stage 3 ($S_3R_2$) have 1.56 times the odds of getting linked to care early ($S_3R_2 \rightarrow S_3R_3$), and individuals in stage 2 ($S_2R_2$) have 1.19 times the odds of getting linked to care early ($S_2R_2 \rightarrow S_2R_3$).

iv. Number of Individuals Unaware of Their Infection, by Stage

There is no direct measure of the number of HIV-infected individuals who are unaware of their status ($R_1$) because they have not yet been diagnosed and recorded in the surveillance data. Only individuals who are aware of their status can be counted as a case. The CDC estimates that 21% of HIV-infected individuals are unaware of their status, based on its mathematical algorithm discussed in section 3c,i (30). However, local experts in NYC and Albany estimated that this fraction may be as low as 12-13% in NYS. During the calibration, HIVSIM considered a range from 12-21%, and after model calibration to historical data, this fraction is set to 12%.

The distribution of disease stage for individuals in $R_1$ (undiagnosed) is based on the natural history of disease, with 2 months in $S_0$, 47 months in $S_1$, 47 months in $S_2$, and 24 months in $S_3$. (Disease progression parameters are described in section 3c,v.)

v. Engagement in Care

As described in sections 3c, i-ii, laboratory data reported to BHAЕ can be used to estimate new diagnoses and linkage to care among all diagnosed cases. However, the health care system is
complex and fragmented, with many HIV-infected individuals having no regular source of coverage or else transitioning across payers throughout the course of their illness. Consequently there is no single database that can generate the fraction of individuals who remain engaged in care, versus having sporadic care \((R3 \text{ versus } R4)\) (32).

Researchers at New York City Department of Health and Mental Hygiene (NYCDHMH) recently used their laboratory data to assess retention in care, with visits indicated by presence of laboratory results (31). They found that 76.0% of diagnosed individuals (aged 13 and older) remained in care, but that 45.5% had regular care (at least one visit every 6 months). The advantage of this database is that it includes all HIV-infected individuals in NYC. However, a limitation is that analyses are limited to reported laboratory tests, and therefore do not include office visits for routine HIV follow-up care. This may overestimate the fraction of individuals who receive sporadic care \((R4)\).

Members of the steering committee estimate that 60 to 70% of HIV-infected individuals in NYS are enrolled in Medicaid. AIDS Institute maintains a dataset that contains claims for all NYS Medicaid recipients with known HIV infection, which can be used for analysis. Although the Medicaid dataset does not include all HIV cases in NYS, it contains information on whether individuals attended HIV-related primary care visits, which are not captured in surveillance data. The Medicaid division ran a special analysis of the fraction of HIV-infected Medicaid recipients receiving primary care services during 2009 and 2010. The primary outcome of interest was having at least two HIV primary care visits at least 6 months apart. This was 80% for both managed care and fee-for-service Medicaid clients.

Other measures of engagement in care measures were considered, including receiving at least two primary care visits at least three months apart, at least two CD4 tests (in the year, and also at least six months apart), and at least two viral load tests (in the year, and also 60 days apart in each half of the year). These measures were selected to match outcomes currently used by the NYS Office of the Medical Director quality of care report (33), and suggested by the Institute of Medicine (32). The results of the lab-based measures were similar between the Medicaid analysis and the NYCDHMH analysis of NYC surveillance data, suggesting that it would be reasonable to extrapolate the Medicaid findings to the entire NYS HIV-infected population.

The measure of “at least two HIV primary care visits at least 6 months apart” was selected as the marker to distinguish \(R3\) and \(R4\), because it corresponds with the sample design from the NYS quality of care report (33). For this report, the AIDS Institute conducted a medical chart review of a sample of patients that received at least one primary care visit in the first and second half of the year. One of the reported variables is viral load suppression, which is used in the incidence rate calculations described in section 3c,vii.

vi. Non-HIV Background Mortality and Gross AIDS Mortality

In the HIVSIM stock and flow diagram, HIV-infected individuals move out of the system from the four Stage 3 categories \((S3R1, S3R2, S3R3, S3R4)\) as a result of HIV-related deaths. However, HIV-infected individuals in all categories may also die of non-HIV deaths (such as heart attacks and traffic accidents). To address this issue, HIVSIM incorporates background
mortality rate of non-HIV deaths for all stocks ($S0-S4, R1-R4$). This allows HIV-infected individuals in each stock to exit the system according to the average non-HIV mortality rate.

The background mortality rate is based on NYS surveillance data from BHAEL. The NYS surveillance data is linked to the vital statistics registry, allowing data analysts to determine the date of death. The cause of death is not included in the surveillance database. However, it is reasonable to assume that deaths among HIV cases (excluding AIDS cases) are attributable to causes other than HIV. In contrast, deaths among AIDS cases could be due to non-HIV or else HIV-related causes.

An unpublished run of the surveillance data (prepared on 4/2/12) provided the following information.

Table 3.2: Unpublished BHAEL Data on All-Cause Mortality among Diagnosed HIV Cases in New York State, from 2006 to 2009.

<table>
<thead>
<tr>
<th>Year</th>
<th>Deaths among AIDS Cases</th>
<th>Deaths Among HIV non-AIDS Cases</th>
<th>Total Deaths among Diagnosed HIV Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>2,448</td>
<td>363</td>
<td>2,811</td>
</tr>
<tr>
<td>2007</td>
<td>2,338</td>
<td>354</td>
<td>2,692</td>
</tr>
<tr>
<td>2008</td>
<td>2,279</td>
<td>372</td>
<td>2,651</td>
</tr>
<tr>
<td>2009</td>
<td>2,150</td>
<td>373</td>
<td>2,523</td>
</tr>
</tbody>
</table>

The number of deaths among HIV non-AIDS cases was used to calibrate the model’s background mortality rate. In reality, individuals in later stages should have a higher background mortality rate (not HIV-related) because they are older, on average. HIVSIM makes a simplifying assumption that the background mortality rate is the same for all categories ($S0-S3, R1-R4$). Sensitivity analyses confirmed that because this rate is so small, varying this rate by 50% does not significantly change the model outcomes.

The number of deaths among diagnosed HIV cases was used to estimate disease progression for individuals who have been diagnosed and linked to care (see section 3,vii).

vii. Disease Progression for Individuals in Different Levels of Engagement in Care

HIVSIM individuals flow from left to right ($S0, S1, S2$, and $S3$) based on a time delay that mimics the progression of disease. Individuals in $R1$ and $R2$ (unaware of HIV infection; aware of HIV infection but not yet in care) have transition rates that are governed by the natural history of disease – that is, the length of time spent in each disease stage without therapy. Individuals in the third row (engaged in HIV care) have a slower disease progression, due to antiretroviral therapy. Individuals in the fourth row (have entered HIV care, but care is sporadic) should have a disease progression that is slower than individuals who are treatment-naïve, but faster than individuals who are engaged in HIV care. The length of time spent in each disease stage without treatment was estimated from published literature while the length of time for those in treatment at any time was calculated from NYS data.
Without treatment, the natural history of HIV disease (from infection to AIDS-related mortality) is approximately ten years, of which two months are spent in the acute state, followed by a long asymptomatic period, and symptomatic disease (AIDS) in the last two years. This can be modeled as two months in $S_0$, 94 months in $S_1$ and $S_2$ (combined), and 24 months in $S_3$ (34-37). HIVSIM distributes the time spent in the asymptomatic stage equally across $S_1$ and $S_2$, so that 47 months is spent in each stage.

NYS surveillance data were used to estimate the mean length of time spent in each stage among individuals linked to care.

In a steady state system, the average number of individuals in a stock should be the rate at which people flow into the stock, multiplied by the average time people spend in the stock. As described in sections 3c,i-v, BHAE provided NYS data on the annual number of individuals diagnosed with HIV, living with HIV, and dying with HIV. This information was used to calculate the average length of time for individuals in care. In other words, the number of individuals living with diagnosed HIV infection divided by the number of HIV-infected individuals dying each year can approximate the amount of time spent with diagnosed HIV infection.

Modelers assumed that acute stage would last for 2 months. All of the survival benefit from treatment was distributed across $S_1$, $S_2$, and $S_3$. In addition, modelers assumed that the amount of time spent in each stage among individuals in sporadic care (R4) was approximately 75% of amount of corresponding time among individuals engaged in care (R3). This allows individuals in regular care to live longer than those in sporadic care. After the initial calculations, an optimization program was used to improve the final model calibration. The 75% assumption was tested in a sensitivity analysis and did not change results meaningfully.

The table below summarizes the average length of time assigned to each category.

**Table 3.3: Model Inputs for Average Length of Time (in Months) Spent in Each Disease Stage, by Level of Engagement in Care.**

<table>
<thead>
<tr>
<th>Level of Engagement in Care</th>
<th>Stage 0</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unaware (R1)</td>
<td>2</td>
<td>47</td>
<td>47</td>
<td>24</td>
</tr>
<tr>
<td>Diagnosed but not in care (R2)</td>
<td>2</td>
<td>47</td>
<td>47</td>
<td>24</td>
</tr>
<tr>
<td>Engaged in care (R3)</td>
<td>2</td>
<td>90</td>
<td>175</td>
<td>400</td>
</tr>
<tr>
<td>In sporadic care (R4)</td>
<td>2</td>
<td>68</td>
<td>100</td>
<td>310</td>
</tr>
</tbody>
</table>

**viii. Stock-Specific Incidence Rate Calculations**

The HIVSIM model structure includes feedback loops (see section 2d) to generate new infections, thereby perpetuating the epidemic. This is important for model validity, as HIV is an

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5 Little’s theorem (used in operations management) shows that in a steady state, the average number of customers in a store ($L$) is the arrival rate ($\lambda$) times the average length of time that customers spend in the store ($W$), or $L = \lambda W$. This principle is applied here.
infectious disease and the model needs to reflect the disease process. In addition, the steering committee requested that new infections be analyzed and reported as an outcome.

In HIVSIM, new infections (the flow from Uninfected to S0R1) are calculated as the sum of new infections generated by those already infected. The 16 categories of HIV-infected individuals (S0-S3; R1-R4) have unique infection rates due to variation in viral load (based on disease progression and suppression with antiretroviral therapy), contact rate (sexual, injection drug, or other encounters), behavioral aspects related to encounters (harm reduction strategies such as barrier methods that would reduce the likelihood of transmitting an infection during a given encounter), and the size of the sub-population in that particular category. The infection rate also depends on the size of the uninfected population (which is the same for all 16 categories). HIVSIM assumes there is no net effect of in- or ex-migration to and from NYS.

Typically an incidence rate calculation requires an estimate for the contact rate, infectivity (likelihood of infection per encounter), and fraction of contacts in which individuals use a barrier method (thereby reducing new infections). The HIV epidemiology literature contains information that can be adapted as parameter estimates. Various cohort studies have yielded estimates for the infectivity in heterosexual contacts, although per-act infection probabilities are difficult to measure (38-42). In addition, there is evidence that awareness of HIV status may lead to less risky sexual behaviors (43).

Although many parameter estimates are available from the literature, adapting them to HIVSIM’s structure to generate new infections is not straightforward. NYS has a mixed epidemic comprised of MSM, heterosexual, and IDU activity (2). Each behavior has a different infectivity (as well as gender-specific differences (42, 44, 45)) and contact rate, requiring that these populations be modeled separately. (See (46) for a more comprehensive review of this issue.) Some estimates are virtually impossible to obtain from empirical data; for example, it is particularly difficult to conduct cohort studies of IDUs because they are such a marginalized and hard-to-reach population. Other HIV modelers address this uncertainty by using reasonable “best guess” assumptions or else considering IDU populations in sensitivity analyses only (47-49). Additional computational challenges to modeling new infections are that individuals’ risk behaviors may change over time, they may be engaged in multiple high risk behaviors, and the presence of biological factors such as sex during menses or the presence of another STD can increase infectivity (40, 46).

To simplify the mathematical calculations and make the estimates more representative of NYS, general findings from the published literature (such as the extent to which infection rates are higher among unaware individuals) were used to estimate the relative contribution of infections from individuals in the 16 categories. Next, NYS surveillance and Medicaid data were used to allocate the number of individuals across the 16 stocks (S0-S3; R1-R4) in 2006. (For further details on how individuals were allocated in each category, see sections 3c,i-iv.) This year was chosen as the first year of the simulation because ongoing advances in HIV treatments have improved patient survival over time, which must be considered in the simulation model (8).\textsuperscript{6}

\textsuperscript{6} Patient survival in HIVSIM could have been adjusted over time to reflect improvements in therapy, allowing the model to replicate all historical data. However, the goal of HIVSIM is to model current and future changes.
Furthermore, secondary HIV infections (new infections generated by living HIV-infected individuals) have declined considerably since the start of the epidemic (50), making it challenging to match historical estimates of new infections without adding considerable complexity to the model. These two pieces of information (relative contribution of infections from each category, and number of individuals in each stock in 2006) were combined to calculate the infection rate (number of infections per person-month) in each of the 16 categories through an optimization program in Vensim.

As HIVSIM runs, the number of individuals in the 16 categories may change over time reflecting differences in case identification, linkage to care, and retention in care (movement across R1-R4). However, the infection rate for individuals within each category is constant. As the relative distribution of individuals across the 16 categories changes, the total infection rate in NYS (all new infections per person-month, summed across the 16 categories) may change. For example, if the HIV testing law increased diagnoses and linkage to care, then HIVSIM should generate a reduction in the NYS population-level infection rate.

The following literature-based findings were applied to HIVSIM in the optimization exercise:

- *The infection rate for R1 is 3.5 times higher than the infection rate for R2, R3, and R4 combined.* This reflects different risk behaviors, as well as viral load suppression among those in care (43, 51, 52).

- *Three-quarters of individuals in R3 have an infection rate of zero. The other quarter has a similar infection rate as R2 and R4.* Several studies indicate that individuals with suppressed viral load (from treatment) generate minimal new infections (5-7, 46, 53-55). The NYS Quality of Care report, based on a chart review of HIV-infected individuals who are engaged in HIV care, indicates that 72.4% of HIV-infected NYS residents receiving regular care have a suppressed viral load (33). In a sensitivity analysis, all individuals in R3 are assigned an infection rate of zero.

- *One-quarter of new infections are attributable to individuals in S0, compared to S1-S3.* This reflects different risk behaviors and high viral load. Numerous studies provide evidence that infection rates are highest from this group (5, 38, 55-63). However, the estimated fraction of infections attributable to individuals in acute stage disease is difficult to compare across studies due to variation in the definition of “acute” stage, which can range from two months up to one year. Some studies estimate this number to attributable to the law, and not to model the HIV epidemic in NYS since 1981. Starting HIVSIM in 2006 simplified the incidence rate calculations considerably.

7 The infection rate per category is constant starting in 2010 when the law was put into effect. The historical estimates provided by BHAЕ show a declining number of new infections over time (see section 3c,i). HIVSIM includes a “ramp” function that allows the category-specific infection rate to decline linearly from 2006 to 2010 in order to match historical data. In consultation with the steering committee, the modelers made the category-specific infection rates constant starting in 2010. Although infection rates are likely to continue to decline, experts do not have clear predictions about when the slope will change. Using a constant category-specific incidence rate may overestimate the number of new infections over time. This simplifying assumption will not change major findings because the output of the analysis is comparison of changes over time across scenarios, rather than generating point estimates.
be as high as 50%, although in practice it may not be reasonable to assume that half of new infections are generated from individuals who remain in $S_0$ for only two months.

- **$S_1$, $S_2$, and $S_3$ have the same infection rate.** In reality, individuals in $S_3$ have a higher infectivity per contact than individuals in $S_1$ and $S_2$ due to increased viral load in late stage disease. Yet pulling in the other direction, some literature suggests behavior changes among those in late stage disease, which would decrease the number of unprotected encounters (64). Because there is limited empirical data on the extent to which increased infectivity in $S_3$ is offset by behavior changes, the steering committee agreed that this simplifying assumption is reasonable.

In summary the literature suggested that the following HIVSIM categories should have unique infection rates: (a) $S_0R_1$; (b) $S(1,2,3)R_1$; (c) $S_0(R_2,R_3,R_4)$, and (d) $S(1,2,3)R(2,4)$. In addition, 72.4% of individuals in $S(1,2,3)R_3$ have an infection rate of zero (reflecting viral load suppression) and the other 27.6% have the same infection rate as (d).

Table 3.4 displays the workbook used to calculate the infection rates for each category. The numbers used in the simulation are summarized in the “Infection Rate” column.
Table 3.4: Workbook to Calculate Stock-Specific Incidence Rates

<table>
<thead>
<tr>
<th>Stage 0</th>
<th>Stock</th>
<th>Infection Rate</th>
<th>New Infections/Month</th>
<th>New Infections/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Unaware</td>
<td>861</td>
<td>0.12399</td>
<td>106.8</td>
<td>1,281</td>
</tr>
<tr>
<td>Acute Aware</td>
<td>15</td>
<td>0.02000</td>
<td>0.3</td>
<td>4</td>
</tr>
<tr>
<td>Acute In treatment</td>
<td>5</td>
<td>0.00500</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>Acute Sporadic Care</td>
<td>0</td>
<td>0.00000</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>881</td>
<td></td>
<td>107.1</td>
<td>1,285</td>
</tr>
<tr>
<td><strong>Total Aware</strong></td>
<td>20</td>
<td></td>
<td>0.3</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stock</th>
<th>Infection Rate</th>
<th>New Infections/Month</th>
<th>New Infections/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 Unaware</td>
<td>10,500</td>
<td>0.00759</td>
<td>79.7</td>
<td>957</td>
</tr>
<tr>
<td>Stage 1 Diagnosed</td>
<td>4,688</td>
<td>0.00500</td>
<td>21.6</td>
<td>259</td>
</tr>
<tr>
<td>Stage 1 in Care</td>
<td>15,929</td>
<td>0.00125</td>
<td>18.3</td>
<td>220</td>
</tr>
<tr>
<td>Stage 1 Sporadic Care</td>
<td>6,163</td>
<td>0.00500</td>
<td>28.3</td>
<td>340</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>37,280</td>
<td></td>
<td>147.9</td>
<td>1,775</td>
</tr>
<tr>
<td><strong>Total Aware</strong></td>
<td>26,780</td>
<td></td>
<td>68.2</td>
<td>818</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 2</th>
<th>Stock</th>
<th>Infection Rate</th>
<th>New Infections/Month</th>
<th>New Infections/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 2 Unaware</td>
<td>4,400</td>
<td>0.00760</td>
<td>33.4</td>
<td>401</td>
</tr>
<tr>
<td>Stage 2 Diagnosed</td>
<td>4,188</td>
<td>0.00500</td>
<td>20.9</td>
<td>251</td>
</tr>
<tr>
<td>Stage 2 in Care</td>
<td>12,158</td>
<td>0.00125</td>
<td>15.2</td>
<td>182</td>
</tr>
<tr>
<td>Stage 2 Sporadic Care</td>
<td>4,237</td>
<td>0.00500</td>
<td>21.2</td>
<td>254</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>24,983</td>
<td></td>
<td>90.7</td>
<td>1,089</td>
</tr>
<tr>
<td><strong>Total Aware</strong></td>
<td>20,583</td>
<td></td>
<td>57.3</td>
<td>688</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 3</th>
<th>Stock</th>
<th>Infection Rate</th>
<th>New Infections/Month</th>
<th>New Infections/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 3 Unaware</td>
<td>110</td>
<td>0.00760</td>
<td>0.8</td>
<td>10</td>
</tr>
<tr>
<td>Stage 3 Diagnosed</td>
<td>376</td>
<td>0.00500</td>
<td>1.9</td>
<td>23</td>
</tr>
<tr>
<td>Stage 3 in Care</td>
<td>63,913</td>
<td>0.00124</td>
<td>79.5</td>
<td>954</td>
</tr>
<tr>
<td>Stage 3 Sporadic Care</td>
<td>7,981</td>
<td>0.00500</td>
<td>39.9</td>
<td>479</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>72,380</td>
<td></td>
<td>122.2</td>
<td>1,466</td>
</tr>
<tr>
<td><strong>Total Aware</strong></td>
<td>72,270</td>
<td></td>
<td>121.3</td>
<td>14,55</td>
</tr>
</tbody>
</table>

| Total Initial People | 135,524 |
| Aware or Known      | 119,653 |
| Number Unaware      | 15,871  |
| Fraction Unaware    | 0.117   |
d. Model Verification and Validation

All models are wrong because they are simplified representations of reality (26). Although a model can never be proved to be “valid,” there are multiple checks that can be done during model development to assess suitability (whether the model is appropriate for its intended purpose) and consistency (whether the model is consistent with reality, even with its simplifications) (65). These should improve confidence that the model is appropriate for the analysis, despite its shortcomings.

Sterman (26) outlines twelve tests to perform during model development: boundary adequacy, structure assessment, dimensional consistency, parameter assessment, extreme conditions, integration error, behavior reproduction, behavior anomaly, family member, surprise behavior, sensitivity analysis, and system improvement. Many of these tests are also described by Richardson and Pugh (65). HIVSIM has been assessed using all of these criteria.

i. Boundary Adequacy

Boundary adequacy includes whether the model contains all variables and feedback loops necessary to model the scenarios of interest and generate the desired outcome variables. This relates to the endogenous point of view, in which all of the components required to generate the behavior of interest are contained within the model boundary. Although the model cannot exclude key variables, the boundary also should not be so large that it becomes difficult to apply appropriate empirical data for model parameters and calibration, and fully explain model behavior.

To address this issue, the modelers worked extensively with the steering committee to develop and refine the HIVSIM stock and flow diagram and other model structure, such as the generation of new infections. In addition, the modelers showed the HIVSIM stock and flow diagram to experts in the field, and compared the stock and flow diagram and list of key variables to other HIV models from the published literature.

ii. Structure Assessment

The model structure should be consistent with experts’ descriptions of the system. The level of aggregation should be appropriate, meaning that the model does not incorrectly combine subpopulations that should be modeled separately. The model should not violate physical laws such as conservation of energy, meaning that variables such as number of HIV-infected individuals should never become negative even when the model is subject to extreme conditions. The decision rules should adequately capture behavior in the system.

All of the diagrams in the model views (see appendix 2) can be explained conceptually. During meetings with the steering committee and experts in the field, the modelers posed questions about whether the HIV stock and flow diagram adequately represented reality, and discussed the benefits and limitations to modeling subpopulations (such as MSM, IDU, or racial/ethnic groups).
separately. The HIVSIM stock and flow diagram and other model views were adjusted in response to feedback from the steering committee.

Dimensional consistency and extreme condition tests (see sections 3d,iii and 3d,v) were used to identify possible formulation mistakes. Throughout the model development, disaggregated sub-models (“mini models”) were developed to understand behaviors in that section of the system before being integrated into HIVSIM.

iii. Dimensional Consistency

All of the variables’ units and dimensions need to be compatible and have real-world meaning. Where different variables are added, subtracted, multiplied, or divided, the units must be consistent (such as people per month). For example, the proportion of new HIV diagnoses in late stage is calculated by dividing newly diagnosed AIDS cases by newly diagnosed HIV cases. The first variable is dimensionless (as it is a fraction), and the latter two variables both have units of people per month.

When writing equations in Vensim the software allows modelers to specify units for each variable. The software checks for dimensional consistency and shows a warning when the dimensional consistency is incorrect.

iv. Parameter Assessment

The fixed parameters should have real-world meaning. To the extent possible, their values should be consistent with experts’ descriptions of the system and the best available numerical data.

As documented in sections 3b-c and appendix 4, all parameter values and ranges for sensitivity analysis can be documented from NYS data, expert opinion, and published literature, and were developed in consultation with the steering committee and other system experts. In several cases the parameters were derived from special statistical analyses of NYS databases, such as surveillance and Medicaid claims.

v. Extreme Conditions

The model should behave realistically, even when its variables are set to extreme values. For example, even if all HIV-infected individuals were identified and immediately linked to care, and all individuals remained fully engaged in care (thereby generating minimal future new infections), the number of individuals living with HIV should be greater than zero for many years into the future until these individuals move out of the system due to HIV-related and non-HIV mortality. If there were no more new infections (infection rate set to zero), then there should never be a negative number of individuals in each category once the epidemic is eliminated. HIVSIM was subject to extreme condition tests throughout its development.
vi. Integration Error

The system dynamics methodology takes the perspective that, like reality, variables change continuously over time. However, system dynamics models, and the HIVSIM model, have been built to run on a digital computer. In order to approximate a continuous system on a digital computer a computation time must be selected that is small enough that it does not change the computed results in a meaningful way. The rule of thumb is that the computation time be one-sixth of the smallest time unit used in the model. This approach was used and then the model was tested for integration error by varying the computation time and comparing output with the different computation times to look for meaningful changes. Changing the computation time did not yield meaningful changes.

vii. Behavior Reproduction

The model should be able to replicate historical data from the real system. If HIVSIM is run using the base case parameter estimates corresponding to the “no law” scenario, simulated output should be similar to historical data. This section documents the correspondence between historical and simulated data for the following variables: newly diagnosed HIV cases, new infections, people living with diagnosed HIV infection, living diagnosed AIDS cases, deaths among diagnosed HIV cases, fraction of diagnosed HIV cases ever linked to care, fraction of HIV cases who are undiagnosed, fraction of new infections generated by people living with acute infection, and fraction of newly diagnosed cases with AIDS. These comparisons were vetted with the steering committee.

Figures 3.1 through 3.5 compare historical and simulated data for newly diagnosed HIV cases per year (Figure 3.1), new infections per year (Figure 3.2), people living with diagnosed HIV infection (Figure 3.3), living diagnosed AIDS cases (Figure 3.4), and deaths among diagnosed HIV cases (Figure 3.5). For each graph, the time scale is from 2006 (the start of the simulation) through 2010, when the law took effect. Each graph displays two lines. The red line represents historical data provided by AIDS Institute. The blue line displays the simulated data from HIVSIM in the “no law” scenario. If the model can reproduce the behavior, then all of the blue lines (HIVSIM simulated data) should be similar to the red lines (historical data).

In all graphs, the two lines are similar, indicating that HIVSIM is able to adequately reproduce observed behavior in the real system. The one exception is for the graph of newly diagnosed HIV cases. As described in section 3c, ii, there are some data artifacts in this measure. The two historical lines display the case counts used in reports, as well as the adjusted values. The HIVSIM trend line is higher than the empirical data, although when the X-axis is extended beyond 2010, the simulated data do trend downward as seen with the historical data.

8 The one exception to the color coding scheme is for new infections. This variable cannot be directly measured, and the data provided by BHAe are historical estimates. The new infections graph contains a red line for the point estimate and green and gray lines for the 95% confidence intervals.
Figure 3.1: Comparison of HIVSIM Simulated Data and NYS Historical Data of Newly Diagnosed HIV Cases per Year from 2006 to 2010.

Figure 3.2: Comparison of HIVSIM Simulated Data and NYS Historical Estimates of New Infections per Year from 2006 to 2010.
Figure 3.3: Comparison of HIVSIM Simulated Data and NYS Historical Data of People Living with Diagnosed HIV Infection from 2006 to 2010

Figure 3.4: Comparison of HIVSIM Simulated Data and NYS Historical Data of Living Diagnosed AIDS Cases from 2006 to 2010
Figure 3.5: Comparison of HIVSIM Simulated Data and NYS Historical Data of Deaths among Diagnosed HIV Cases from 2006 to 2010

Table 3.5 compares HIVSIM simulated data to historical data for four point-in-time fractions: diagnosed HIV cases ever linked to care, HIV cases who are undiagnosed, new infections generated by people living with acute infection, and newly diagnosed cases with AIDS. The first column contains the historical data, and the right columns list the HIVSIM model estimates for 2006 and 2010. For each variable, the estimate from HIVSIM is similar to the historical data, indicating that HIVSIM is able to adequately reproduce observed behavior in the real system.

Table 3.5: Comparison of HIVSIM Simulated Data and NYS Historical Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Historical Data</th>
<th>HIVSIM 2006</th>
<th>HIVSIM 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction of diagnosed HIV cases ever linked to care</td>
<td>0.874</td>
<td>0.92</td>
<td>0.91</td>
</tr>
<tr>
<td>Fraction of HIV cases who are undiagnosed</td>
<td>0.12 – 0.21</td>
<td>0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>Fraction of newly diagnosed cases with AIDS</td>
<td>0.337</td>
<td>0.24</td>
<td>0.21</td>
</tr>
<tr>
<td>Fraction of new infections generated by people living with acute infection</td>
<td>0.25</td>
<td>0.24</td>
<td>0.21</td>
</tr>
</tbody>
</table>

9 A range is provided for the fraction of HIV cases who are undiagnosed because this quantity cannot be directly measured in the real world.
viii. Behavior Anomaly

In some circumstances it may not be possible to empirically test the size and significance of a relationship among key variables in the system. However, these variables could be included in the model structure if system experts’ qualitative descriptions of the system indicate that they are important. Behavior anomaly tests assess whether removing these structures and relationships among variables that do not have supporting empirical data generates unexpected behaviors. HIVSIM has been subject to these tests throughout its development.

ix. Family Member

The family member test assesses whether the model is generalizable to other similar systems. Although HIVSIM is designed to model the system of HIV testing and care in NYS, it should also be able to model the similar system in other US states.

HIVSIM was developed to model the effect of the testing law and other policies on the system of HIV testing and care in NYS. Therefore the model’s applicability to other US states was not considered. The basic processes of disease progression and infection are generic and match published literature, giving confidence that the basic structure can be used to model the system in other states, with appropriate adjustments for parameters such as the fraction linked to care and the fraction of cases receiving sporadic care. Adapting HIVSIM to other states could be done in future work, if it is of interest to the AIDS Institute.

x. Surprise Behavior

There may be discrepancies between how the simulation model works and how the real system behaves. Often it is because the simulation model is incorrect; however at times it is due to a flaw in experts’ understanding of how the system works. There were no surprise behaviors in HIVSIM.

xi. Sensitivity Analysis

All models are an imperfect representation of reality, based on assumptions about how the system works, how variables are related, and how to categorize people in the system (level of aggregation). Sensitivity analyses examine whether the results change when assumptions are modified. Items to modify include fixed parameters, the type of diffusion of innovation pattern (for the implementation of the HIV testing law over time), and the level of aggregation.

Sensitivity analyses on various assumptions have been done throughout the model development. For example, when calculating the length of time for disease progression for individuals engaged in care (R3) and in sporadic care (R4), modelers examined output under alternative assumptions about the relative difference in survival benefits between the two levels of engagement in care. In addition, several of the scenarios presented in sections 4 and 5 contain sensitivity analyses around key parameters (such as how long it takes to fully implement the law).
xii. System Improvement

The ultimate goal of the modeling process is to improve the system, including increasing experts’ understanding and communication about it. Although it is difficult to document whether HIVSIM accomplished this goal, the modelers used regular face-to-face meetings with the steering committee and other system experts to ensure that the model met the AIDS Institute’s goals and results were presented in a way that would facilitate communication with other NYS government actors.
4. Description of Scenarios

a. Model-Based Policy Analysis

After HIVSIM has been calibrated so that it can replicate NYS historical data, it can be manipulated to assess the anticipated effects of different policies. By manipulating model parameters and structure, HIVSIM can perform “what if” analyses of how the system would change under different conditions. Modelers can examine the output and behavior of key variables to understand what policies work, and why (65).

In order to accomplish this, the scenarios must first be conceptualized. These represent different conditions of what might happen, such as a base case (no law scenario – nothing changes, and the future continues under current conditions), and a perfect implementation scenario (where all providers eventually offer testing and all patients accept the offer). It is also possible to design scenarios that reflect different permutations of what could happen as the law is implemented, such as sudden resource constraints or testing rates falling back to pre-law levels after an initial push for expanded testing. The scenarios described in section 4b were generated from discussions with the steering committee.

After the scenarios are conceptualized, they need to be operationalized into different values of fixed parameters and alterations of the model structure. Ideally the values should be specified by the steering committee and other system experts. Where empirical data is not available, modelers can vary variables by a fixed amount. All scenarios must fit within the model boundary, or else they cannot be operationalized.

b. Scenarios Modeled in HIVSIM

In addition to the no law scenario (also referred to as the baseline projection), there are nine scenarios that vary according to the level of implementation (perfect, high, and low) and whether individuals are eligible for repeat offers of testing as part of routine care (annual eligibility for repeat testing, five year eligibility for repeat testing, and one-time testing). Each permutation of level of implementation and frequency of repeat testing is considered, yielding nine scenarios altogether.

Table 4.1 below summarizes the parameters adjusted in each scenario and the sources used to generate the parameters. In all of the scenarios, it is assumed that the law is implemented gradually over three years, at which point it is fully implemented. This assumption is based on conversations with NYCDPHMH officials who implemented the Bronx Knows initiative, which occurred over three years, and was vetted with the steering committee. Each scenario assumes that the population to be tested is all New Yorkers aged 13 to 64, consistent with the law’s text. This value was 13.7 million and based on the Census data. Information on provider supply was from the Henry J. Kaiser Family Foundation State Health Facts website.
Table 4.1: Summary of Scenarios Modeled in HIVSIM

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Data Sources for Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perfect implementation</td>
<td>100% of patients who seek care are offered a test by a provider, and 100% accept a test if they are offered.</td>
<td>These conditions will not be observed in the real world. However, this scenario can provide insights into the maximum benefit that could be accrued from the law.</td>
</tr>
</tbody>
</table>
| High implementation  | 75% of patients who seek care are offered a test, and 60% of patients accept the test if it offered. | The NYS module of BRFSS asks respondents if they sought care at medical settings covered by the law since September 2010, were offered a test, and accepted the test if it were offered.  
  
  The 75% offer assumption is much higher than the data indicate. However, this is a key feature of the law and the steering committee agreed that it would be a useful upper bound to model high implementation. |
| Low implementation  | 25% of patients who seek care are offered a test, and 60% of patients accept the test if it offered. | The NYS module of BRFSS asks respondents if they sought care at medical settings covered by the law since September 2010, were offered a test, and accepted the test if it were offered.  
  
  The 25% offer assumption is higher than the data indicate. However, this could have been because the law was not fully implemented when the survey was fielded. The steering committee agreed that it would be a useful lower bound to model low implementation. |

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10 The BRFSS survey includes questions on whether respondents saw different types of providers since September 2010. Initial numbers for seeking care at facilities are: hospital inpatient 17.4%, emergency department 20.5%, primary care provider 61.1%, and other medical care provider 29.2%. These variables are not mutually exclusive, as some individuals may have received care at multiple providers. Consequently these figures cannot be summed to generate one estimate on the fraction of New Yorkers who sought care at one or more providers covered by the law. The modelers requested that OPER develop a summary variable for “any provider.” That data request is still pending and until the number is finalized, modelers assumed a value of 75%. This assumption was vetted with the steering committee. BRFSS also contained questions on whether respondents were offered a test in these settings. Initial numbers for being offered a test are: hospital inpatient 17.7%, emergency department 11.7%, primary care 15.4%, and other medical provider 13.7%. Because this item is targeted by the law, it was varied in the three scenarios for level of implementation. Finally, BRFSS asked whether patients who were offered the test accepted it. This value was 60.7%, and used in all scenarios.
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual eligibility for repeat testing</td>
<td>During the implementation time, everyone is eligible to receive an initial test, within the conditions of the level of implementation. One year after receiving a test, individuals are eligible to receive a subsequent test.</td>
<td>The law does not specify how often New Yorkers should be offered HIV tests as part of routine medical care, and the steering committee was interested in examining output under alternative assumptions about the frequency of test offers.</td>
</tr>
<tr>
<td>Five year eligibility for repeat testing</td>
<td>During the implementation time, everyone is eligible to receive an initial test, within the conditions of the level of implementation. Five years after receiving a test, individuals are eligible to receive a subsequent test.</td>
<td>The law does not specify how often New Yorkers should be offered HIV tests as part of routine medical care, and the steering committee was interested in examining output under alternative assumptions about the frequency of test offers.</td>
</tr>
<tr>
<td>One-time testing</td>
<td>During the implementation time, everyone is eligible to receive an initial test, within the conditions of the level of implementation. Once individuals have received a test, they are no longer eligible for subsequent tests.</td>
<td>The law does not specify how often New Yorkers should be offered HIV tests as part of routine medical care, and the steering committee was interested in examining output under alternative assumptions about the frequency of test offers.</td>
</tr>
</tbody>
</table>
c. Sensitivity Analyses

In addition to the scenarios described above, two sensitivity analyses are reported.

First, modelers varied the implementation time. The primary scenarios assumed that it would take three years for full implementation to occur, with implementation increasing gradually throughout the period. This was varied from 1.5 years to 5 years. In the model this was operationalized by varying the time for providers to become aware of the new policy. HIVSIM was simulated 200 times, with each run taking on a random number within this range.

Second, modelers ran two additional scenarios that changed the fraction of individuals engaged in care (R3) who are infectious. In the primary scenarios, 72.4% of these individuals were assumed to have an infection rate of zero. (See section 3,vii.) In the sensitivity analysis, 100% of individuals in R3 were assigned an infection rate of zero starting in 2010, the year that the law was implemented. This would reflect perfect viral load suppression and/or behavioral interventions to eliminate risky behaviors among individuals in care. The perfect viral load suppression scenario considers what would happen if there were no law in place (baseline projection) but viral load was perfectly suppressed among individuals engaged in care. The perfect viral load suppression, annual testing, and perfect implementation scenario considers what would happen if the law were implemented perfectly as designed, individuals received repeat tests annually, and all cases engaged in care had perfect viral load suppression. This would represent the maximum benefit that could be achieved if both policies were implemented perfectly.

d. Outcome Variables

Results are presented for the following variables: increase in HIV tests, new infections, newly diagnosed HIV cases, newly diagnosed AIDS cases, fraction of newly diagnosed cases with AIDS, diagnosed HIV cases newly linked to care, diagnosed HIV cases ever linked to care, diagnosed HIV cases currently engaged in care, people living with diagnosed HIV infection, people living with HIV infection (diagnosed and undiagnosed), and fraction of HIV cases who are undiagnosed. These variables are summarized in Table 4.2.

There are more outcome variables than the original five items from the problem statement (number of new HIV tests, number of new HIV diagnoses, number of individuals linked to care, fraction of diagnoses that are early versus late stage, and number of new HIV infections). In some cases there is more than one variable per item from the problem statement. In addition, there are several outcome variables that do not directly correspond with the items from the problem statement but which the steering committee thought would be important to consider.
Table 4.2: Outcome Variables Considered in the Scenario Analysis.

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>Description</th>
<th>Item from Problem Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in HIV tests</td>
<td>Number of additional HIV tests given to New Yorkers as part of routine medical care, compared to the baseline level of testing before the law.</td>
<td>Number of new HIV tests</td>
</tr>
<tr>
<td>New infections</td>
<td>Individuals who were previously uninfected and become newly infected. Impossible to measure directly in the real world.</td>
<td>Number of new HIV infections</td>
</tr>
<tr>
<td>Newly diagnosed HIV cases</td>
<td>Individuals who are newly diagnosed with HIV at any disease stage.</td>
<td>Number of new HIV diagnoses</td>
</tr>
<tr>
<td>Newly diagnosed AIDS cases</td>
<td>Individuals who are newly diagnosed with HIV at disease stage 3 (also known as “concurrent HIV/AIDS diagnoses”), plus individuals previously diagnosed with HIV whose HIV disease has reached stage 3.</td>
<td>Fraction of diagnoses that are early versus late stage</td>
</tr>
<tr>
<td>Fraction of newly diagnosed cases with concurrent AIDS</td>
<td>Among all individuals who are newly diagnosed with HIV, the fraction who are diagnosed in stage 3 (also known as “concurrent HIV/AIDS”).</td>
<td>Fraction of diagnoses that are early versus late stage</td>
</tr>
<tr>
<td>Diagnosed HIV cases newly linked to care</td>
<td>Individuals who have been previously diagnosed and are linked to care for the first time.</td>
<td>Number of individuals linked to care</td>
</tr>
<tr>
<td>Diagnosed HIV cases ever linked to care</td>
<td>Individuals who have been diagnosed and initially linked to care. Includes individuals currently engaged in care and in sporadic care. Includes all disease stages.</td>
<td>Number of individuals linked to care</td>
</tr>
<tr>
<td>Diagnosed HIV cases currently engaged in care</td>
<td>Individuals who have been diagnosed and initially linked to care, and are currently engaged in care. Includes all disease stages.</td>
<td>Number of individuals linked to care</td>
</tr>
<tr>
<td>People living with diagnosed HIV infection</td>
<td>Individuals who are currently living with HIV at any disease stage, and have been diagnosed.</td>
<td>n/a</td>
</tr>
<tr>
<td>People living with HIV infection (diagnosed and undiagnosed)</td>
<td>Individuals who are currently living with HIV at any disease stage, including both those who have been diagnosed and those who are undiagnosed. Impossible to measure directly in the real world.</td>
<td>n/a</td>
</tr>
<tr>
<td>Fraction of HIV cases who are undiagnosed</td>
<td>Among all individuals currently living with HIV, the fraction that has been diagnosed. Impossible to measure directly in the real world.</td>
<td>n/a</td>
</tr>
</tbody>
</table>
5. Results of Scenario Analysis

Results are presented in two ways. First, there is a set of graphs over time for all of the outcome variables. These graphs contain four lines. The blue line projects what would happen if the law had not been implemented. Each graph contains three additional lines that correspond to the three levels of implementation (perfect, high, and low). Second, results are displayed in a set of tables that display percent differences.

Although the modelers ran the three sets of scenarios on repeat testing frequency described in section 4 (annual eligibility for repeat testing, five-year eligibility for repeat testing, and one-time testing), only the results of the first and third sets of scenarios are presented. The results of the second set of scenarios are not meaningfully different, and are available upon request.

a. Baseline Projections of Outcomes without the Law

Table 5.1 summarizes baseline projections of how outcomes will change over time in the absence of the new law. For each variable, the value from 2010 is compared to the projected values in 2015 and 2020. These differences are represented as percent changes. As an example, the percent change in new infections in 2015 is calculated as \[
\frac{(\text{new infections})_{2015} - (\text{new infections})_{2010}}{(\text{new infections})_{2010}} \times 100.
\]

This information can be seen visually in the graphs presented in section 5b (Figures 5.1-5.22). The relevant information would be the blue lines. (An identical no law projection is displayed in the graphs for the annual eligibility for repeat testing and one-time testing scenarios.)

Key findings are summarized below.

- **There will be a continuing decline in the number of new infections per year.** Even though HIVSIM assumed a category-specific incidence rate starting in 2010, the model projects a decline in new infections per year. This reflects individuals being linked to care and becoming less infectious through viral load suppression. In the real world, infection rates are declining. The true number of new infections may be even lower than what is generated by HIVSIM.

- **There will be a continuing decline in the number of newly diagnosed HIV and AIDS cases annually.** By 2020 there will be a 59.7% reduction in the number of newly diagnosed HIV cases per year, and a 60.3% reduction in newly diagnosed AIDS cases. This corresponds with the anticipated decline in new infections.

- **The fraction of newly diagnosed cases with AIDS will remain constant.** Although the absolute number of cases with HIV and AIDS will decline, the relative fraction that will be diagnosed with AIDS is expected to remain the same.

- **The fraction of undiagnosed HIV cases will continue to decline.** By 2020, this fraction will be under 10%, although some cases will continue to remain undiagnosed.
The number of people living with diagnosed HIV infection will continue to increase slightly. Although the number of new infections will decline, receiving antiretroviral therapy provides substantial survival benefits. Consequently, individuals in care remain in the HIV testing and treatment system for a long time. Although the number of individuals living with diagnosed HIV infection will eventually decline, this will not occur in the short term. By 2020 there will be a 2.2% increase in the number of people living with diagnosed HIV infection. HIVSIM projections indicate a leveling off and then slight decline in the total number of (diagnosed and undiagnosed) people living with HIV. This slight discrepancy is due to the decline in the fraction of cases who remain undiagnosed. Although there may be slightly fewer individuals in the system overall, more cases will be diagnosed.

The number of newly diagnosed cases being initially linked to care per year will decline. This reflects reductions in the anticipated number of new diagnoses per year.

The number of individuals in care will increase. Although the number of individuals newly linked to care each year will decline, the total number in care will increase slightly. This is consistent with the prediction that the number of people living with diagnosed HIV infection will increase.

Table 5.1: Baseline Projections of Outcome Variables in the Absence of the Law

<table>
<thead>
<tr>
<th>Outcome</th>
<th>% Change 2010 to 2015</th>
<th>% Change 2010 to 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual New Infections</td>
<td>-38.0</td>
<td>-62.8</td>
</tr>
<tr>
<td>Annual Newly Diagnosed HIV Cases</td>
<td>-43.2</td>
<td>-59.7</td>
</tr>
<tr>
<td>Annual Newly Diagnosed AIDS Cases</td>
<td>-34.2</td>
<td>-60.3</td>
</tr>
<tr>
<td>Fraction of Newly Diagnosed Cases with Concurrent AIDS</td>
<td>4.0</td>
<td>-1.5</td>
</tr>
<tr>
<td>Annual Diagnosed HIV Cases Newly Linked to Care</td>
<td>-29.7</td>
<td>-54.1</td>
</tr>
<tr>
<td>Diagnosed HIV Cases Ever Linked to Care</td>
<td>7.1</td>
<td>7.4</td>
</tr>
<tr>
<td>Diagnosed HIV Cases Currently Engaged in Care</td>
<td>5.9</td>
<td>6.1</td>
</tr>
<tr>
<td>People Living with Diagnosed HIV Infection</td>
<td>3.9</td>
<td>2.2</td>
</tr>
<tr>
<td>People Living with HIV Infection Diagnosed and Undiagnosed</td>
<td>-0.7</td>
<td>-3.7</td>
</tr>
<tr>
<td>Fraction of HIV Cases Who Are Undiagnosed</td>
<td>-44.4</td>
<td>-57.8</td>
</tr>
</tbody>
</table>

b. Anticipated Changes to Outcomes as a Result of the Law

Tables 5.2 and 5.3 summarize differential changes in outcomes comparing the law and no law scenarios, for the annual repeat testing scenarios (Table 5.2) and one-time testing scenarios (Table 5.3). For each variable, the projected value for the law scenario in 2015 or 2020 is compared to the projected value for the no law scenario. (The no law scenario is identical to the
baseline projections described in section 5a.) The three sets of columns (Low Impl, High Impl, and Perfect Impl) correspond to the three levels of implementation (low, high, and perfect).

For example, the percent change in new infections in 2015 comparing the low implementation scenario to the no law scenario is calculated as \[ \frac{(\text{new infections})_{2015 \text{ Low Impl}} - (\text{new infections})_{2015 \text{ No Law}}}{(\text{new infections})_{2015 \text{ No Law}}} \times 100. \]

The annual increase in new tests is not included in the tables because the value is zero in the no law scenario, and the percent change is meaningless.

Figures 5.1-5.22 display graphs over time of the outcome variables. There are two sets of graphs for each variable, which correspond to the annual repeat testing (top) and one-time testing (bottom) scenarios.

Key findings are summarized below.

- **Compared to the no law scenario, there will be a large increase in the number of tests performed in as part of routine medical care.** Under one-time testing there will be an initial surge and then decline, whereas under annual testing there will be an immediate surge followed by a steady high rate of testing.

- **Compared to the no law scenario, there will be a relative decrease in new infections.** This will occur as a result of more individuals being identified and linked to care. Although the number of new infections will be lower than expected in the baseline projection, the value will not go to zero and new infections will continue to occur.

- **Compared to the no law scenario, there will be an initial surge in the number of newly diagnosed HIV cases.** Rather than the steady decline in newly diagnosed HIV cases projected under no law, NYS can expect a sharp increase then a sharp decline in all implementation scenarios. These curves are steeper and more pronounced under high or perfect implementation.

- **Compared to the no law scenario, the number of newly diagnosed AIDS cases will decline.** Although there will be an initial surge in newly diagnosed HIV cases (described above), there will be fewer diagnosed AIDS cases. This reflects individuals being diagnosed earlier in their infection, before reaching late stage disease.

- **Compared to the no law scenario, the fraction of newly diagnosed cases with concurrent AIDS will decline in the short term and possibly increase in the long term.** In the annual testing scenarios, the fraction of newly diagnosed cases with concurrent AIDS steadily declined under the three levels of implementation. In the one-time testing scenario, this fraction initially declined but then increased in later years. In all one-time testing scenarios this fraction was always lower than the baseline projection. The differences across scenarios have a different pattern than all other outcomes. This finding is likely the result of a data artifact, as the outcome contains a changing denominator of all newly diagnosed cases.
• **There will be minimal increases in the annual number of cases newly linked to care.** Compared to the no law scenario, there will be an initial *relative* increase in the number of diagnosed cases newly linked to care. More cases would be linked to care annually, compared to what is expected under the baseline projection. However, even with an initial surge in newly diagnosed cases, there will never be a large increase in the *absolute* number of cases newly linked to care each year except in the extreme scenario of perfect implementation. All of these increases occur in the short-term. This is due to the continual decline in new infections and fraction of undiagnosed HIV cases, described above.

• **Compared to the no law scenario, there will be minimal difference in the number of people living with HIV infection.** This is consistent with the finding from the baseline projection that the number of individuals living with HIV infection will remain high even as new infections decline.

• **Compared to the no law scenario, there will be minimal difference in the number of cases ever linked to care or currently linked to care.** This is consistent with the finding from the baseline projection that the number of individuals living with HIV infection will remain high even as new infections decline.

• **Compared to the no law scenario, the fraction of undiagnosed HIV cases will decrease.** In the most extreme scenario of annual testing and perfect implementation this value will be close to – but never equal to – zero.
Table 5.2: Projected Changes to Outcome Variables under Annual Repeat Testing Scenario

<table>
<thead>
<tr>
<th>Variable</th>
<th>% Change from No Law in 2015</th>
<th></th>
<th>% Change from No Law in 2020</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Impl</td>
<td>High Impl</td>
<td>Perfect Impl</td>
<td>Low Impl</td>
</tr>
<tr>
<td>Annual New Infections</td>
<td>-17.2</td>
<td>-27.5</td>
<td>-33.2</td>
<td>-19.0</td>
</tr>
<tr>
<td>Annual Newly Diagnosed AIDS Cases</td>
<td>-46.3</td>
<td>-74.8</td>
<td>-86.7</td>
<td>-58.8</td>
</tr>
<tr>
<td>Fraction of Newly Diagnosed Cases with</td>
<td>-41.5</td>
<td>-65.5</td>
<td>-78.0</td>
<td>-47.9</td>
</tr>
<tr>
<td>Concurrent AIDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Diagnosed HIV Cases Newly Linked to</td>
<td>4.0</td>
<td>1.8</td>
<td>-2.9</td>
<td>-13.3</td>
</tr>
<tr>
<td>Care</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosed HIV Cases Ever Linked to Care</td>
<td>0.7</td>
<td>1.2</td>
<td>1.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Diagnosed HIV Cases Currently Engaged in</td>
<td>0.8</td>
<td>1.3</td>
<td>1.6</td>
<td>0.1</td>
</tr>
<tr>
<td>Care</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People Living with Diagnosed HIV Infection</td>
<td>1.4</td>
<td>2.1</td>
<td>2.2</td>
<td>0.2</td>
</tr>
<tr>
<td>People Living with HIV Infection Diagnosed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Undiagnosed</td>
<td>-0.6</td>
<td>-1.2</td>
<td>-1.6</td>
<td>-1.6</td>
</tr>
<tr>
<td>Fraction of HIV Cases Who Are</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undiagnosed</td>
<td>-40.7</td>
<td>-66.1</td>
<td>-77.2</td>
<td>-47.3</td>
</tr>
</tbody>
</table>

Notes: This table summarizes differential changes in outcomes comparing the law and no law scenarios, for the annual repeat testing scenario. The annual repeat testing occurs as part of incremental testing in routine medical care settings by the law, holding background testing constant. For each variable, the projected value for the law scenario in 2015 or 2020 is compared to the projected value for the no law scenario. (The no law scenario is identical to the baseline projections in Table 1.) The three sets of columns (Low Impl, High Impl, and Perfect Impl) correspond to the three levels of implementation (low, high, and perfect). For example, the percent change in new infections in 2015 comparing the low implementation scenario to the no law scenario is calculated as \((\text{new infections}_{2015 \text{Low Impl}} - \text{new infections}_{2015 \text{No Law}}) / \text{new infections}_{2015 \text{No Law}} \times 100\). The annual increase in new tests is not included in the table because the value is zero in the no law scenario, and the percent change is meaningless.
Table 5.3: Projected Changes to Outcome Variables under One-Time Testing Scenario

<table>
<thead>
<tr>
<th>Outcome</th>
<th>% Change from No Law in 2015</th>
<th>% Change from No Law in 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Implant</td>
<td>High Implant</td>
</tr>
<tr>
<td>Annual New Infections</td>
<td>-13.8</td>
<td>-17.8</td>
</tr>
<tr>
<td>Annual Newly Diagnosed HIV Cases</td>
<td>-14.8</td>
<td>-35.9</td>
</tr>
<tr>
<td>Annual Newly Diagnosed AIDS Cases</td>
<td>-38.3</td>
<td>-50.5</td>
</tr>
<tr>
<td>Fraction of Newly Diagnosed Cases with Concurrent AIDS</td>
<td>-27.6</td>
<td>-22.8</td>
</tr>
<tr>
<td>Annual Diagnosed HIV Cases Newly Linked to Care</td>
<td>1.8</td>
<td>-3.6</td>
</tr>
<tr>
<td>Diagnosed HIV Cases Ever Linked to Care</td>
<td>0.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Diagnosed HIV Cases Currently Engaged in Care</td>
<td>0.6</td>
<td>0.9</td>
</tr>
<tr>
<td>People Living with Diagnosed HIV Infection</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>People Living with HIV Infection Diagnosed and Undiagnosed</td>
<td>-0.5</td>
<td>-0.9</td>
</tr>
<tr>
<td>Fraction of HIV Cases Who Are Undiagnosed</td>
<td>-32.5</td>
<td>-41.3</td>
</tr>
</tbody>
</table>

Notes: This table summarizes differential changes in outcomes comparing the law and no law scenarios, for the one-time testing scenario. The one-time testing occurs as part of incremental testing in routine medical care settings by the law, holding background testing constant. For each variable, the projected value for the law scenario in 2015 or 2020 is compared to the projected value for the no law scenario. (The no law scenario is identical to the baseline projections in Table 1.) The three sets of columns (Low Implant, High Implant, and Perfect Implant) correspond to the three levels of implementation (low, high, and perfect). For example, the percent change in new infections in 2015 comparing the low implementation scenario to the no law scenario is calculated as \[
\frac{(\text{new infections})_{2015 \text{ Low Implant}} - (\text{new infections})_{2015 \text{ No Law}}}{(\text{new infections})_{2015 \text{ No Law}}} \times 100.\] The annual increase in new tests is not included in the table because the value is zero in the no law scenario, and the percent change is meaningless.
Figure 5.1: Projected Increase in HIV Tests per Year under Annual Testing, Comparing No Law to Three Levels of Implementation

Figure 5.2: Projected Increase in HIV Tests per Year under One-Time Testing, Comparing No Law to Three Levels of Implementation
Figure 5.3: Projected New Infections per Year under Annual Testing, Comparing No Law to Three Levels of Implementation

Figure 5.4: Projected New Infections per Year under One-Time Testing, Comparing No Law to Three Levels of Implementation
Figure 5.5: Projected Newly Diagnosed HIV Cases per Year under Annual Testing, Comparing No Law to Three Levels of Implementation

Figure 5.6: Projected Newly Diagnosed HIV Cases per Year under One-Time Testing, Comparing No Law to Three Levels of Implementation
Figure 5.7: Projected Newly Diagnosed AIDS Cases per Year under Annual Testing, Comparing No Law to Three Levels of Implementation

Figure 5.8: Projected Newly Diagnosed AIDS Cases per Year under One-Time Testing, Comparing No Law to Three Levels of Implementation
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**Figure 5.9: Projected Fraction of Newly Diagnosed Cases with Concurrent AIDS under Annual Testing, Comparing No Law to Three Levels of Implementation**

![Graph showing projected fraction of newly diagnosed cases with concurrent AIDS under annual testing.](image)

**Figure 5.10: Projected Fraction of Newly Diagnosed Cases with Concurrent AIDS under One-Time Testing, Comparing No Law to Three Levels of Implementation**

![Graph showing projected fraction of newly diagnosed cases with concurrent AIDS under one-time testing.](image)
Figure 5.11: Projected Diagnosed HIV Cases Newly Linked to Care per Year under Annual Testing, Comparing No Law to Three Levels of Implementation

Figure 5.12: Projected Diagnosed HIV Cases Newly Linked to Care per Year under One-Time Testing, Comparing No Law to Three Levels of Implementation
Figure 5.13: Projected Diagnosed HIV Cases Ever Linked to Care per Year under Annual Testing, Comparing No Law to Three Levels of Implementation

Figure 5.14: Projected Diagnosed HIV Cases Ever Linked to Care per Year under One-Time Testing, Comparing No Law to Three Levels of Implementation
**Figure 5.15: Projected Diagnosed HIV Cases Currently Engaged in Care under Annual Testing, Comparing No Law to Three Levels of Implementation**

![Graph showing projected diagnosed HIV cases currently engaged in care under annual testing, comparing no law to three levels of implementation.](image)

**Figure 5.16: Projected Diagnosed HIV Cases Currently Engaged in Care under One-Time Testing, Comparing No Law to Three Levels of Implementation**

![Graph showing projected diagnosed HIV cases currently engaged in care under one-time testing, comparing no law to three levels of implementation.](image)
Figure 5.17: Projected People Living with Diagnosed HIV Infection under Annual Testing, Comparing No Law to Three Levels of Implementation

Figure 5.18: Projected People Living with Diagnosed HIV Infection under One-Time Testing, Comparing No Law to Three Levels of Implementation
Figure 5.19: Projected People Living with HIV Infection (Diagnosed and Undiagnosed) under Annual Testing, Comparing No Law to Three Levels of Implementation

Figure 5.20: Projected People Living with HIV Infection (Diagnosed and Undiagnosed) under One-Time Testing, Comparing No Law to Three Levels of Implementation
Figure 5.21: Projected Fraction of HIV Cases Who Are Undiagnosed under Annual Testing, Comparing No Law to Three Levels of Implementation

Figure 5.22: Projected Fraction of HIV Cases Who Are Undiagnosed under One-Time Testing, Comparing No Law to Three Levels of Implementation
c. Differences across Scenarios that Vary the Frequency of Repeat Testing

The scenarios for repeat annual testing and one-time testing can be compared by examining the two sets of plots on each page.

- **The primary difference between the two sets of scenarios is the number of tests that will be performed.** In the annual testing scenario, the number of tests performed each year initially increases and then remains at a high level. In contrast the one-time testing scenario demonstrates a smaller initial surge and then declines to pre-2010 levels.

- **Overall there will be very minimal differences new infections, newly diagnosed HIV and AIDS cases, diagnosed cases newly linked to care, the number of cases in care, the number of people living with HIV infection, and the fraction of cases who are undiagnosed.** The two sets of plots for all of these variables are very similar. Where there are differences (such as a slightly lower number of new infections under repeat annual testing), most of the variation occurs in the extreme scenario of perfect implementation. General trends such as an initial surge then decline of newly diagnosed HIV cases are consistent across the two scenarios.

- **The projected trends for the fraction of newly diagnosed cases with concurrent AIDS are noticeably different between the two sets of scenarios.** Under annual repeat testing, this fraction is expected to steadily decline over time. In contrast this outcome will initially decrease but then rise again under one-time testing. As described previously, this is attributable to a data artifact because the denominator changes over time.

d. Differences across Scenarios that Vary the Level of Implementation

The scenarios for the three levels of implementation (perfect, high, and low) can be compared by examining how the trend lines differ within each plot.

- **As implementation improves, there will be a marked increase in the number of tests, newly diagnosed HIV and AIDS cases, and cases newly linked to care; and a decrease in new infections.** These outcomes are attributable to additional undiagnosed cases becoming identified and newly linked to care, thereby lowering their infection rates.

- **As implementation improves, there will be noticeable declines in the fraction of newly diagnosed cases with AIDS and fraction of cases who are undiagnosed.** This is consistent with improvements in the outcomes described above.

- **As implementation improves, there will be a slight increase in the number of people living with diagnosed HIV infection.** This improvement is most prominent in the annual repeat testing scenario, and reflects individuals transitioning from being unaware to diagnosed.
• **As implementation improves, there will be virtually no difference in the number of cases ever linked to care, cases currently engaged in care, and people living with HIV infection (diagnosed and undiagnosed).** This is consistent with the finding from the baseline projection that the number of individuals living with HIV will remain high even as new infections decline.

**e. Findings from Sensitivity Analysis on Time to Implementation**

Figure 5.23-5.34 present sensitivity analyses that vary time to implementation. The graphs are for a limited set of variables, which were selected because they had the most change across scenarios (new infections, newly diagnosed HIV cases, newly diagnosed AIDS cases, diagnosed HIV cases newly linked to care, people living with diagnosed HIV infection, and fraction of HIV cases who are undiagnosed). Each graph displays two scenarios. The red line corresponds to the baseline projection under no law. The other colored lines represent the simulated values when the specific scenario (such as annual testing and perfect implementation) was simulated with different values for the time to implementation. Each simulation run used a randomly generated value for the time to implementation, ranging from 1.5 to 5 years. The percentages in the graphs indicate that 50%, 75%, 95%, or 100% of the simulations fell within that range. Readers should interpret the graphs by examining the width of the band. A wide band would indicate that the outcome variable is sensitive to the time to implementation, whereas a narrow band would indicate the outcome variable is not sensitive to this parameter. For each variable, there are two graphs that display sensitivity analyses on two scenarios: annual testing and perfect implementation, and annual testing and low implementation. These were selected to show extreme conditions.

• **Varying the time to implementation has little overall effect on all outcomes.** In particular, there is virtually no change in the number of new infections or people living with diagnosed HIV infection.

• **In the extreme condition of perfect implementation, varying the time to implementation would have an effect on the number of newly diagnosed HIV and AIDS cases per year, with a corresponding small effect on the number newly linked to care annually and the fraction of cases who are undiagnosed.** Under a shorter implementation time, the number of newly diagnosed HIV cases would immediately increase. However, the curves eventually cross, indicating that if implementation took longer, the same number of cases would be eventually diagnosed but at a slightly later date. As the implementation time is shortened, there will be a steeper decline in the number of newly diagnosed AIDS cases, which is most dramatic in the perfect implementation scenario. These changes are not dramatic under low implementation.
Figure 5.23: Sensitivity Analysis of Time to Implementation (1.5 to 5 years) on New Infections per Year, under Annual Testing and Perfect Implementation

Annual Testing & Perfect Implementation Sensitivity

No Law

50% 75% 95% 100%

New Infections

6,000

4,500

3,000

1,500

0

2006 2009 2013 2017 2021

Year

Figure 5.24: Sensitivity Analysis of Time to Implementation (1.5 to 5 years) on New Infections per Year, under Annual Testing and Low Implementation

Annual Testing & Low Implementation Sensitivity

No Law

50% 75% 95% 100%

New Infections

6,000

4,500

3,000

1,500

0

2006 2009 2013 2017 2021

Year
Figure 5.25: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on Newly Diagnosed HIV Cases per Year, under Annual Testing and Perfect Implementation

Annual Testing & Perfect Implementation Sensitivity

No Law

50% 75% 95% 100% 100%

Annual Newly Diagnosed HIV Cases

![Diagram showing sensitivity analysis of time to implementation on newly diagnosed HIV cases per year, under annual testing and perfect implementation.]

Figure 5.26: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on Newly Diagnosed HIV Cases per Year, under Annual Testing and Low Implementation

Annual Testing & Low Implementation Sensitivity

No Law

50% 75% 95% 100% 100%

Annual Newly Diagnosed HIV Cases

![Diagram showing sensitivity analysis of time to implementation on newly diagnosed HIV cases per year, under annual testing and low implementation.]

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Figure 5.27: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on Newly Diagnosed AIDS Cases per Year, under Annual Testing and Perfect Implementation

Annual Testing & Perfect Implementation Sensitivity

No Law

50% 75% 95% 100% 100%

Annual Newly Diagnosed AIDS Cases

2,000

1,500

1,000

500

0

2006 2009 2013 2017 2021

Year

Figure 5.28: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on Newly Diagnosed AIDS Cases per Year, under Annual Testing and Low Implementation

Annual Testing & Low Implementation Sensitivity

No Law

50% 75% 95% 100% 100%

Annual Newly Diagnosed AIDS Cases

2,000

1,500

1,000

500

0

2006 2009 2013 2017 2021

Year
Figure 5.29: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on Diagnosed HIV Cases Newly Linked to Care per Year, under Annual Testing and Perfect Implementation Sensitivity

No Law

50% 75% 95% 100% 100%

Diagnosed HIV Cases Newly Linked to Care Annually

6,000

4,500

3,000

1,500

0

2006 2009 2013 2017 2021

Year

Figure 5.30: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on Diagnosed HIV Cases Newly Linked to Care per Year, under Annual Testing and Low Implementation Sensitivity

No Law

50% 75% 95% 100% 100%

Diagnosed HIV Cases Newly Linked to Care Annually

6,000

4,500

3,000

1,500

0

2006 2009 2013 2017 2021

Year
Figure 5.31: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on People Living with Diagnosed HIV Infection, under Annual Testing and Perfect Implementation

Annual Testing & Perfect Implementation Sensitivity

No Law

50%  75%  95%  100%  %

People Living with Diagnosed HIV Infection

200,000

175,000

150,000

125,000

100,000

Year

2006  2009  2013  2017  2021

Figure 5.32: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on People Living with Diagnosed HIV Infection, under Annual Testing and Low Implementation

Annual Testing & Low Implementation Sensitivity

No Law

50%  75%  95%  100%  %

People Living with Diagnosed HIV Infection

200,000

175,000

150,000

125,000

100,000

Year

2006  2009  2013  2017  2021
Figure 5.33: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on Fraction of HIV Cases Who Are Undiagnosed, under Annual Testing and Perfect Implementation

Annual Testing & Perfect Implementation Sensitivity

No Law

50% 75% 95% 100%

Fraction of HIV Cases Who Are Undiagnosed

![Graph showing sensitivity analysis of time to implementation on fraction of HIV cases who are undiagnosed.]

Figure 5.34: Sensitivity Analysis of Time to Implementation (1.5 to 5 Years) on Fraction of HIV Cases Who Are Undiagnosed, under Annual Testing and Low Implementation

Annual Testing & Low Implementation Sensitivity

No Law

50% 75% 95% 100%

Fraction of HIV Cases Who Are Undiagnosed

![Graph showing sensitivity analysis of time to implementation on fraction of HIV cases who are undiagnosed.]

f. Findings from Sensitivity Analysis on Fraction of Individuals in Care with Viral Load Suppression

Figures 5.35-5.40 display sensitivity analyses that consider how outcomes would change if all cases engaged in care had an infection rate of zero, which could happen if there were perfect viral load suppression. Each graph contains four lines. The blue line is the baseline projection of how outcomes will change with no law. The red line corresponds to the scenario of annual testing and perfect implementation. The blue and red lines are identical to the projections in Figures 5.1-5.22. The gray line illustrates how outcomes would change under no law, but with perfect viral load suppression among individuals engaged in care starting in 2010. The green line represents what would happen if both the law were implemented perfectly with annual repeat testing and individuals engaged in care had perfect viral load suppression starting in 2010.

- **Compared to the no law scenario, perfect viral load suppression among individuals engaged in care will lead to small improvements in the number of people living with diagnosed HIV infection and the fraction of HIV cases who are undiagnosed.** The overall trends will be similar to the baseline projections, although values will be slightly lower. Improvements in these outcomes are due to averted infections.

- **Compared to the no law scenario, perfect viral load suppression among individuals engaged in care will lead to fewer diagnosed HIV and AIDS cases, and HIV cases newly linked to care.** This can be considered an improvement (although its change is in the opposite direction of the testing law) because it is the result of averted infections.

- **Perfect viral load suppression among individuals engaged in care will yield a decline in new infections that is similar to that expected under perfect implementation of the HIV testing law.** By 2020, the perfect viral load suppression (but no law) and perfect law implementation scenarios will result in a similar number of new infections per year.

- **The simultaneous implementation of perfect viral load suppression among individuals engaged in care and perfect implementation of the HIV testing law will yield additional improvements to new infections and newly diagnosed HIV cases.** Other outcomes did not show a large additive effect from incorporating both policies.
Figure 5.35: Sensitivity Analysis of Viral Load Suppression among Cases Engaged in Care on New Infections per Year, under Annual Testing and Perfect Implementation

Figure 5.36: Sensitivity Analysis of Viral Load Suppression among Cases Engaged in Care on Newly Diagnosed HIV Cases per Year, under Annual Testing and Perfect Implementation
Figure 5.37: Sensitivity Analysis of Viral Load Suppression among Cases Engaged in Care on Newly Diagnosed AIDS Cases per Year, under Annual Testing and Perfect Implementation

Figure 5.38: Sensitivity Analysis of Viral Load Suppression among Cases Engaged in Care on Diagnosed HIV Cases Newly Linked to Care per Year, under Annual Testing and Perfect Implementation
Figure 5.39: Sensitivity Analysis of Viral Load Suppression among Cases Engaged in Care on People Living with Diagnosed HIV Infection, under Annual Testing and Perfect Implementation

Figure 5.40: Sensitivity Analysis of Viral Load Suppression among Cases Engaged in Care on Fraction of HIV Cases Who Are Undiagnosed, under Annual Testing and Perfect Implementation
6. Conclusions and Model Insights

This section summarizes the most salient findings from section 5, and key model insights that are relevant to the AIDS Institute’s implementation and monitoring of the law.

a. Summary of Main Findings

In the absence of the law, the state can expect a continuing decline in the annual number of new infections and new diagnoses, as well as the fraction of undiagnosed cases. However, the number of individuals living with HIV infection and the number of cases currently in care will continue to increase slightly. This somewhat counterintuitive finding is because individuals remain in the system for a long time, as a result of large survival benefits from antiretroviral therapy.

If the law is implemented as designed, it has the potential to reduce the number of new infections and the fraction of undiagnosed cases. The state could expect an initial surge in the number of newly diagnosed HIV cases per year followed by a decline, and a steadily declining number of newly diagnosed AIDS cases. The initial surge in newly diagnosed HIV cases reflects the rapid identification of individuals who are unaware of their infection. The anticipated decline in the number of newly diagnosed AIDS cases is due to individuals being diagnosed earlier in their infection, before they progress to late stage disease.

If the law is implemented as designed, there will not be a large surge in the number of individuals newly linked to care per year. Although there will be an increase compared to the baseline projection without the law, the absolute number of individuals newly linked to care annually will not rise except in the extreme scenario of perfect implementation. There will be virtually no change in the number of people living with HIV infection or the number of cases in care. Although there are slight numerical differences, the relative increase in these outcomes will be small because individuals in care can remain alive (and therefore in the system) for several decades.

Even if the law is implemented perfectly, the number of new infections and the fraction of undiagnosed cases do not approach zero. By itself, the law will not eliminate the HIV epidemic.

Comparing the annual repeat testing to one-time testing scenarios, there are minimal differences in outcomes. The biggest difference is in the number of tests performed. In contrast, increasing the level of implementation can lead to improvements in outcomes such as the number of new infections, newly diagnosed cases, the fraction of newly diagnosed cases with concurrent AIDS, and the fraction of cases who are undiagnosed. Varying the time to implementation did not change results significantly.

An alternative policy of perfect viral load suppression among individuals engaged in care will yield a decline in new infections that is similar to that expected under perfect implementation of the law. The largest improvement to new infections will happen if both the law is implemented perfectly and all individuals in care have perfect viral load suppression.
The findings for the fraction of newly diagnosed cases with concurrent AIDS are inconsistent and difficult to interpret. This is because the measure relies on a denominator that changes over time. In general, the outcomes that are cross-sectional counts (such as people living with HIV and people engaged in care) do not change significantly across scenarios. Although there will be some improvements under the law (especially with perfect implementation), it would be difficult to assess these changes statistically.

b. Model Insights Relevant to the Law’s Implementation and Monitoring

*Insight #1: New York should continue to invest resources in programs that provide medical care to HIV patients, improve their retention in care, and encourage reductions in risky behaviors.*

The evidence for this recommendation is that there will be an increase in the number of HIV cases in care, even under the baseline projection without the law. This is due to the overall increase in the number of living cases, even as infection rates decline. The sensitivity analysis on viral load suppression highlights the potential gains from reducing infections among individuals who are in care, which could occur through a combination of high adherence to medications and reductions in risky behaviors. This is consistent with the CDC’s interest in prevention with positives. The model predicts that there will be a minimal surge in the number of diagnosed cases newly linked to care per year. Continued support for programs that link individuals to care will be important, but the model does not anticipate a large increase in annual demand for these services even if the testing law is implemented perfectly.

*Insight #2: The most useful indicators of whether the law is successful are the number of newly diagnosed HIV cases and newly diagnosed AIDS cases.*

The steering committee and experts in the field broadly agreed that the overarching policy goal is to eliminate all new infections. However, the number of new infections per year is not the most illustrative indicator of how well the law is working. The simulation runs demonstrated that under different levels of implementation, there should be an initial surge in newly diagnosed HIV cases followed by a sharp decline. In addition, the decline in newly diagnosed AIDS cases will be lower than the historical trend. In contrast, many of the other indicators – particularly those that rely on cross-sectional counts – will not change significantly. If the law is successful, there will be a decrease in the number of new infections and the fraction of cases who are undiagnosed. However, those indicators are impossible to measure directly in the real world and the historical estimates have wide confidence intervals. The fraction of newly diagnosed cases with concurrent AIDS is relatively easy to generate by BHAЕ staff using existing data, but will not be a useful indicator because the changing denominator makes it difficult to interpret trends. At the time of this report, there is national attention on how to streamline public health indicators of HIV care to monitor trends and assess the effects of different HIV policy interventions (32, 66). Although these other nationally recommended indicators are important, the model results suggest that simple plots of the number of new HIV and AIDS diagnoses over time will be the most useful indicator for the AIDS Institute to monitor the success of the testing law.
Insight #3: The AIDS Institute should work with hospitals and physicians to encourage all New Yorkers to be tested once as part of routine medical care.

The evidence for this recommendation is that there are minimal differences in the outcomes between the annual repeat testing and one-time testing scenarios. In contrast, there are large differences in the number of new infections, new diagnoses, and the fraction of HIV cases who are undiagnosed as implementation improves (from low to perfect). The AIDS Institute may maximize its return on investment by promoting a policy to test all patients once as part of routine care, rather than devoting additional resources to working with hospitals and physicians to test patients more frequently. This finding is consistent with CDC recommendations that everyone in the general population should be tested once, with annual repeat testing among high risk populations (1).

Insight #4: New York should continue to rely on a broader policy approach that includes a wide range of HIV prevention interventions, in addition to the law.

Results demonstrate that if the law is implemented as designed, many of the outcomes considered will improve. Yet even under perfect implementation and annual repeat testing, the law alone will not curb the HIV epidemic and there will continue to be new infections.
Appendix 1. Description of Key Variables

The following table describes the key variables in HIVSIM, and how they map onto the stock and flow diagram using the R (row) and S (stage) terminology.

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Stock and Flow Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newly diagnosed HIV cases</td>
<td>Individuals who are newly diagnosed with HIV at any disease stage.</td>
<td>Change per unit time: $R_1 \rightarrow R_2$, for all stages $(S_0, S_1, S_2, S_3)$</td>
</tr>
<tr>
<td>Newly diagnosed HIV non AIDS cases</td>
<td>Individuals who are newly diagnosed with HIV in stages 0, 1, or 2.</td>
<td>Change per unit time: $R_1 \rightarrow R_2$, stages $S_0, S_1, S_2$ (excludes $S_3$)</td>
</tr>
<tr>
<td>Newly diagnosed AIDS cases</td>
<td>Individuals who are newly diagnosed with HIV at disease stage 3 (also known as “concurrent HIV/AIDS diagnoses”), plus individuals previously diagnosed with HIV whose HIV disease has reached stage 3.</td>
<td>Change per unit time: $S_3R_1 \rightarrow S_3R_2$ and $S_2(R_2, R_3, R_4) \rightarrow S_3(R_2, R_3, R_4)$</td>
</tr>
<tr>
<td>New infections</td>
<td>Individuals who were previously uninfected and become newly infected. Impossible to measure directly in the real world.</td>
<td>Change per unit time: $Uninfected \rightarrow S_0R_1$</td>
</tr>
<tr>
<td>People living with diagnosed HIV infection</td>
<td>Individuals who are currently living with HIV at any disease stage, and have previously been diagnosed.</td>
<td>Point in time count: $S_0(R_2, R_3, R_4) + S_1(R_2, R_3, R_4) + S_2(R_2, R_3, R_4) + S_3(R_2, R_3, R_4)$</td>
</tr>
<tr>
<td>People living with HIV infection (diagnosed and undiagnosed)</td>
<td>Individuals who are currently living with HIV at any disease stage, including both those who have been diagnosed and those who are undiagnosed. Impossible to measure directly in the real world.</td>
<td>Point in time count: $S_0(R_1, R_2, R_3, R_4) + S_1(R_1, R_2, R_3, R_4) + S_2(R_1, R_2, R_3, R_4) + S_3(R_1, R_2, R_3, R_4)$</td>
</tr>
<tr>
<td>Living diagnosed HIV non AIDS cases</td>
<td>Individuals who are currently in stages 0, 1, or 2, and have previously been diagnosed. Does not include individuals who have progressed to stage 3 (also known as “concurrent HIV/AIDS”) or individuals who have not yet been diagnosed.</td>
<td>Point in time count: $S_0(R_2, R_3, R_4) + S_1(R_2, R_3, R_4) + S_2(R_2, R_3, R_4)$</td>
</tr>
<tr>
<td>Living diagnosed HIV non AIDS cases (diagnosed and undiagnosed)</td>
<td>Individuals who are in stages 0, 1, or 2, including both those who have been diagnosed and those who are undiagnosed. Impossible to measure directly in the real world.</td>
<td>Point in time count: $S_0(R_1, R_2, R_3, R_4) + S_1(R_2, R_3, R_4) + S_2(R_2, R_3, R_4)$</td>
</tr>
<tr>
<td>Living diagnosed AIDS cases</td>
<td>Individuals who are currently in stage 3 (also known as “concurrent HIV/AIDS”), and have been previously diagnosed.</td>
<td>Point in time count: $S_3(R_2, R_3, R_4)$</td>
</tr>
<tr>
<td>Living AIDS cases (diagnosed and undiagnosed)</td>
<td>Individuals who are currently in stage 3 (also known as “concurrent HIV/AIDS”), including both those who have been diagnosed and those who are undiagnosed. Impossible to measure directly in the real world.</td>
<td>Point in time count: $S3(R1,R2,R3,R4)$</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Fraction of diagnosed HIV cases ever linked to care</td>
<td>Among individuals who have been previously diagnosed, the fraction that has been initially linked to care. Includes individuals currently engaged in care and in sporadic care.</td>
<td>Fraction: $[S0(R3,R4) + S1(R3,R4) + S2(R3,R4) + S3(R3,R4)] ÷ \left(S0(R2,R3,R4) + S1(R2,R3,R4) + S2(R2,R3,R4) + S3(R2,R3,R4)\right)$</td>
</tr>
<tr>
<td>Fraction of HIV cases who are undiagnosed</td>
<td>Among all individuals currently living with HIV, the fraction that has been diagnosed. Impossible to measure directly in the real world.</td>
<td>Fraction: $\frac{S0(R1,R2,R3,R4)}{S0(R1,R2,R3,R4) + S1(R1,R2,R3,R4) + S2(R1,R2,R3,R4) + S3(R1,R2,R3,R4)}$</td>
</tr>
<tr>
<td>Fraction of newly diagnosed cases with AIDS</td>
<td>Among all individuals who are newly diagnosed with HIV, the fraction who are diagnosed in stage 3 (also known as “concurrent HIV/AIDS”).</td>
<td>Fraction: $S3R2 ÷ \left[S0R2 + S1R2 + S2R2 + S3R2\right]$</td>
</tr>
<tr>
<td>Deaths among diagnosed HIV cases</td>
<td>Deaths (both HIV-related and non HIV-related) among individuals who are currently living with HIV at any disease stage (also known as “all-cause mortality”). Excludes individuals who remain undiagnosed.</td>
<td>Change per unit time: $S3(R2,R3,R4) \rightarrow \text{Cumulative HIV-Related Deaths} + \text{flows from all stocks} + \text{Background (Non-AIDS) Mortality (not shown on diagram)}$</td>
</tr>
<tr>
<td>Fraction of new infections generated by people living with acute HIV infection</td>
<td>Among all new infections, the fraction that occurred as a result of contact with an individual living with acute HIV infection. Impossible to measure directly in the real world.</td>
<td>Fraction: New infections generated by $S0(R1, R2, R3, R4) ÷ \left[S0(R1,R2,R3,R4) + S1(R1,R2,R3,R4) + S2(R1,R2,R3,R4) + S3(R1,R2,R3,R4)\right]$</td>
</tr>
<tr>
<td>Increase in HIV tests</td>
<td>Number of additional HIV tests given to New Yorkers as part of routine medical care, compared to the baseline level of testing before the law.</td>
<td>Not shown on diagram</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Formula</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Diagnosed HIV cases newly linked to care</td>
<td>Individuals who have been previously diagnosed and are linked to care for the first time.</td>
<td>( R_2 \rightarrow R_3 ), for all stages ((S_0, S_1, S_2, S_3))</td>
</tr>
<tr>
<td>Diagnosed HIV cases ever linked to care</td>
<td>Individuals who have been diagnosed and have been initially linked to care. Includes individuals currently engaged in care and in sporadic care. Includes all disease stages.</td>
<td>Point in time count: ( S_0(R_3, R_4) + S_1(R_3, R_4) + S_2(R_3, R_4) + S_3(R_3, R_4) )</td>
</tr>
<tr>
<td>Diagnosed HIV cases currently engaged in care</td>
<td>Individuals who have been diagnosed and initially linked to care, and are currently engaged in care. Includes all disease stages.</td>
<td>Point in time count: ( S_0R_3 + S_1R_3 + S_2R_3 + S_3R_3 )</td>
</tr>
<tr>
<td>Diagnosed HIV cases currently in sporadic care</td>
<td>Individuals who have been diagnosed and initially, but whose care is now sporadic.</td>
<td>Point in time count: ( S_0R_4 + S_1R_4 + S_2R_4 + S_3R_4 )</td>
</tr>
</tbody>
</table>
Appendix 2: Additional Model Views

The main stock and flow diagram was displayed in section 3a, i. This appendix contains additional model views that illustrate feedback loops and other relationships among variables. This page shows the diagramming notation (based on Sterman (2000) (26)), followed by all model views.

**General structure:**

```
Cloud -- Inflow -- Stock -- Outflow
```

**Key terms:**

- **Stock:** captures accumulations in the system.

```
Stock: captures accumulations in the system.
```

- **Flow:** captures the concept of movement to or from a stock.

```
Flow: captures the concept of movement to or from a stock.
```

- **Valve:** regulates the flow between stocks.

```
Valve: regulates the flow between stocks.
```

- **Cloud:** represents a source or sink outside the model boundary.

```
Cloud: represents a source or sink outside the model boundary.
```

- **Shadow Variable:** A variable name that appears between less than < and greater than > signs is calculated elsewhere in the model.

```
<Inflow> Shadow Variable: A variable name that appears between less than < and greater than > signs is calculated elsewhere in the model.
```
Acutely Infected Stage 0 Structure
Early Stage HIV (Stage 1) Structure

- **Early Stage HIV, Unaware of HIV Infection**
  - Early Stage HIV Unaware Tested and Diagnosed
  - Non AIDS Mortality for Early Stage HIV Unaware
  - Average Time in Early Stage HIV Unaware
  - Fraction of Early Stage HIV with Non AIDS Deaths Per Month
- **Early Stage HIV, Aware of HIV Infection (Not in Care)**
  - Early Stage HIV Diagnosed Progressing to Mid Stage HIV Diagnosed
  - Non AIDS Mortality for Early Stage HIV Diagnosed
  - Average Time in Early Stage HIV Diagnosed
  - Fraction of Early Stage HIV with Non AIDS Deaths Per Month
- **Early Stage HIV, Engaged in HIV Care**
  - Early Stage HIV in Care Progressing to Mid Stage HIV in Care
  - Non AIDS Mortality for Early Stage HIV in Care
  - Average Time in Early Stage HIV in Care
- **Early Stage HIV, Entered HIV Care but Care Is Now Sporadic**
  - Early Stage HIV in Sporadic Care Progressing to Mid Stage HIV in Sporadic Care
  - Non AIDS Mortality for Sporadic in Care
  - Fraction of Early Stage HIV with Non AIDS Deaths Per Month
  - Average Time Early Stage HIV in Sporadic Care

**Number of Additional Early Stage HIV Unaware of HIV Infection Accepting Tests Per Month**

**Average Time in Acutely Infected in Care**

**Fraction of Early Stage HIV with Non AIDS Deaths Per Month**

**Fraction of Early Stage HIV with Non AIDS Deaths Per Month**

**Non AIDS Mortality for Early Stage HIV Unaware**

**Non AIDS Mortality for Early Stage HIV Diagnosed**

**Non AIDS Mortality For Early Stage HIV in Care**

**Non AIDS Mortality for Sparodic in Care**

**Fraction of Early Stage HIV with Non AIDS Deaths Per Month**

**Non AIDS Mortality for Early Stage HIV in Sporadic Care**

**Fraction of Early Stage HIV with Non AIDS Deaths Per Month**

**Number of Additional Early Stage HIV Unaware of HIV Infection Accepting Tests Per Month**
Mid Stage HIV (Stage 2) Structure
Late Stage HIV (Stage 3) Structure

- Non AIDS Mortality for Late Stage HIV Unaware
  - <Mid Stage HIV Unaware Progressing to Late Stage HIV Unaware>
  - <Number of Additional Late Stage Unaware Diagnosed Per Month>
  - <Fraction of Late Stage HIV with Non-AIDS Deaths Per Month>

- Non AIDS Mortality for Late Stage HIV Diagnosed
  - <Mid Stage HIV Diagnosed Progressing to Late Stage HIV In Care>

- Non AIDS Mortality for Late Stage HIV in Care
  - <Mid Stage HIV in Care Progressing to Late Stage HIV in Care>

- Non AIDS Mortality for Late Stage HIV in Sporadic Care
  - <Fraction of Late Stage HIV with Non-AIDS Deaths Per Month>

- Late Stage HIV, Unaware of HIV Infection
  - AIDS Deaths Among Late Stage HIV Unaware
  - Average Time in Late Stage HIV Unaware
  - Late Stage HIV Unaware Tested and Diagnosed
  - Fraction of Late Stage HIV Infected Getting Tested Per Month

- Late Stage HIV, Aware of HIV Infection (Not in Care)
  - AIDS Deaths Among Late Stage HIV Diagnosed
  - Average Time in Late Stage HIV Diagnosed
  - Late Stage HIV Diagnosed Initially Linked to Care
  - Fraction of Late Stage HIV Diagnosed Initially Linked to Care Per Month

- Late Stage HIV, Engaged in HIV Care
  - AIDS Deaths Among Late Stage HIV in Care
  - Current Average Time in Late Stage HIV in Care
  - Fraction of Late Stage HIV in Care Re-Engaged in Care
  - Average Time in Late Stage HIV in Care
  - Late Stage HIV Re-Engaged in Care

- Late Stage HIV, Entered HIV Care but Care Is Now Sporadic
  - AIDS Deaths for Late Stage HIV in Sporadic Care
  - Initial Average Time in Late Stage HIV in Sporadic Care
  - Current Average Time Late Stage HIV in Sporadic Care

- Late Stage HIV, Re-Engaging in Care
  - AIDS Deaths for Late Stage HIV in Sporadic Care
  - Adjustment to Capture People Living Longer with Antiretroviral Therapy

- Fraction of Late Stage HIV with Non-AIDS Deaths Per Month

- Late Stage HIV Unaware Tested and Diagnosed
  - Fraction of Late Stage HIV Infected Getting Tested Per Month

- Cumulative HIV-related deaths

- AIDS Deaths for Late Stage HIV in Sporadic Care
  - Fraction of Late Stage HIV in Sporadic Care Re-Engaged in Care Per Month
  - Current Average Time Late Stage HIV in Sporadic Care

- Non AIDS Mortality for Late Stage HIV Unaware
  - <Number of Additional Late Stage Unaware Diagnosed Per Month>

- Non AIDS Mortality for Late Stage HIV Diagnosed
  - <Mid Stage HIV Diagnosed Progressing to Late Stage HIV In Care>

- Non AIDS Mortality for Late Stage HIV in Care
  - <Mid Stage HIV in Care Progressing to Late Stage HIV in Care>

- Non AIDS Mortality for Late Stage HIV in Sporadic Care
  - <Fraction of Late Stage HIV with Non-AIDS Deaths Per Month>

- Late Stage HIV, Entered HIV Care but Care Is Now Sporadic
  - AIDS Deaths for Late Stage HIV in Sporadic Care
  - Adjustment to Capture People Living Longer with Antiretroviral Therapy
A System Dynamics-Based Evaluation of the NYS HIV Testing Law

Annual New Infections

<New Infections Per Month>

New Infections

Months Per Year

Population Totals

<Late Stage HIV, Aware of HIV Infection (Not in Care)>

<Late Stage HIV, Unaware of HIV Infection>

<Late Stage HIV, Entered HIV Care but Care Is Now Sporadic>

<Early Stage HIV, Unaware of HIV Infection>

<Early Stage HIV, Entered HIV Care but Care Is Now Sporadic>

<Early Stage HIV, Aware of HIV Infection (Not in Care)>

<Early Stage HIV, Engaged in HIV Care>

Total Late Stage HIV

People Living with HIV Infection (Diagnosed and Undiagnosed)

Total Early Stage HIV

Total Mid Stage HIV

Total Acutely Infected

<Acutely infected, unaware of HIV infection>

<Acutely Infected, Entered HIV Care but Care Is Now Sporadic>

<Acutely Infected, Aware of HIV Infection (Not in Care)>

<Acutely Infected, Entered HIV Care but Care Is Now Sporadic>

<Acutely Infected, Aware of HIV Infection (Not in Care)>

<Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic>

<Mid Stage HIV, Aware of HIV Infection (Not in Care)>

<Mid Stage HIV, Engaged in HIV Care>

People Living with HIV Infection (Diagnosed and Undiagnosed)

Total Late Stage HIV

Total Early Stage HIV

Total Mid Stage HIV

Total Acutely Infected
Diagnosed HIV Cases Engaged in Care

Diagnosed HIV Cases Newly Linked to Care Annually
People Living with Diagnosed HIV Infection and Fraction Unaware

Infections Generated by Early Stage HIV Unaware

Erika Martin and Roderick MacDonald
Infections Generated by Early Stage HIV Diagnosed

Infections Generated by Early Stage HIV in Care
Infections Generated by Early Stage HIV in Sporadic Care

<Early Stage HIV, Entered HIV Care but Care Is Now Sporadic>
<Uninfected>
<Total Population>

New Infections Generated by Early Stage HIV in Sporadic Care

Contacts per Early Stage HIV in Sporadic Care

Infection Rate per Contact for Early Stage HIV in Sporadic Care

Infections Generated by Mid Stage HIV Unaware

<Mid Stage HIV, Unaware of HIV Infection>
<Uninfected>
<Total Population>

New Infections Generated by Mid Stage HIV Unaware

Contacts Per Mid Stage HIV Unaware

Infection Rate Per Contact for Mid Stage HIV Unaware
Infections Generated by Mid Stage HIV Diagnosed

Infections Generated by Mid Stage HIV in Care
Infections Generated by Mid Stage HIV in Sporadic Care

Infections Generated by Late Stage HIV Unaware
Infections Generated by Late Stage HIV Diagnosed

- <Late Stage HIV, Aware of HIV Infection (Not in Care)>
- <Uninfected>
- <Total Population>

New Infections Generated by Late Stage HIV Diagnosed

Infection Rate per Contact for Late Stage HIV Diagnosed

Contacts per Late Stage HIV Diagnosed

---

Infections Generated by Late Stage HIV in Care

- <Fraction of HIV Cases in Care Not Virally Suppressed>
- <Uninfected>
- <Total Population>

Late Stage HIV in Care Not Virally Suppressed

New Infections Generated by Late Stage HIV in Care

Infection Rate per Contact Late Stage HIV in Care

Contacts per Late Stage HIV in Care

---
Infections Generated by Late Stage HIV in Sporadic Care

Infections Generated by Acute Stage HIV Infection Diagnosed
Infections Generated by Acute HIV Infection Unaware

Infections Generated by Acute HIV Infection in Care
Infections Generated by Acute HIV Infection in Sporadic Care

New Infections Generated by Different Groups
Annual Deaths among Diagnosed HIV Cases

**<Estimated Annual Deaths>** → Deaths Among Diagnosed HIV Cases

**<Annual Non AIDS Mortality for Diagnosed HIV Cases>**

Historical Estimates of New Infections with Confidence Intervals

**<New Infections>** → New Infections Upper CI → New Infections Lower CI
Newly Diagnosed HIV Cases by Stage

Newly Diagnosed HIV (non-AIDS) Cases

Acutely Infected Unaware Tested and Diagnosed

Early Stage HIV Unaware Tested and Diagnosed

Mid Stage HIV Unaware Tested and Diagnosed

Late Stage HIV Unaware Tested and Diagnosed

Newly Diagnosed HIV Cases Per Month

Fraction of New Diagnoses in Early Stage

Fraction of New Diagnoses in Mid Stage

Fraction of Newly Diagnosed Cases with AIDS

Annual Newly Diagnosed HIV Cases

Months Per Year

New Diagnoses Through Background (Historical) Testing

Total HIV Positive Unaware

Acutely infected, unaware of HIV infection

Early Stage HIV, unaware of HIV infection

Mid Stage HIV, unaware of HIV infection

Late Stage HIV, unaware of HIV infection

Fraction Early Stage Unaware

Fraction Mid Stage Unaware

Fraction Late Stage Unaware

Number of Additional Acutely Infected Unaware Diagnosed Per Month

Number of Additional Early Stage Unaware Diagnosed Per Month

Number of Additional Mid Stage Unaware Diagnosed Per Month

Number of Additional Late Stage Unaware Diagnosed Per Month

Number of People HIV Positive But Unaware Tested and Diagnosed
Fraction of New Infections Generated by Different Categories

Diagnosed HIV Cases Currently Engaged in Care

<Acutely Infected, Engaged in HIV Care>  <Late Stage HIV, Engaged in HIV Care>

<Mid Stage HIV, Engaged in HIV Care>  Diagnosed HIV Cases Currently Engaged in Care

<Early Stage HIV, Engaged in HIV Care>
Fraction of Diagnosed HIV Cases Ever Linked to Care

Diagnosed HIV Cases Ever Linked to Care by Category
Living HIV and AIDS Cases (Diagnosed and Undiagnosed)

Non-AIDS Mortality for Diagnosed Cases (Background Mortality)
Non-AIDS Mortality for Undiagnosed Cases (Background Mortality)

HIV Cases Currently in Care by Stage

Annual Increase in HIV Tests from Testing Law and Annual Newly Diagnosed AIDS Cases
Diagnosed HIV Cases Newly Linked to Care Annually

Diagnosed HIV Cases Newly Linked to Care Annually

Total Linked to Care Per Month

Total Linked to Care Per Month

<Diagnosed HIV Cases Newly Linked to Care>

<Months Per Year>

<Diagnosed HIV Cases Newly Linked to Care>

<Acutely Infected Diagnosed Initially Linked to Care>

<Early Stage HIV Diagnosed Initially Linked to Care>

<Mid Stage HIV Diagnosed Initially Linked to Care>

<Late Stage HIV Diagnosed Initially Linked to Care>
Negative Slope for Infection Rate to Capture Historical Decline in New Infections

Newly Diagnosed AIDS Cases per Month
Living Diagnosed AIDS Cases

- <Late Stage HIV, Aware of HIV Infection (Not in Care)>
- <Late Stage HIV, Entered HIV Care but Care Is Now Sporadic>

Living Diagnosed AIDS Cases

Total HIV Cases in Sporadic Care

- <Early Stage HIV, Entered HIV Care but Care Is Now Sporadic>
- <Acutely Infected, Entered HIV Care but Care Is Now Sporadic>
- <Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic>
- <Late Stage HIV, Entered HIV Care but Care Is Now Sporadic>

Total Number of HIV Cases Currently in Sporadic Care
Isolating the Population Available for Testing

Isolating the Population Available for Retesting Policies
Testing Law Structure (Described as “Incremental Testing” to Distinguish from Historical Background Testing)

Testing Pools for Recently Tested and Not Recently Tested in Routine Medical Care Settings
Diagnoses Through Background Testing (Based on Historical Data)

- Early Stage HIV Unaware Tested and Diagnosed Through Background Testing
- Late Stage HIV Unaware Diagnosed Through Background Testing
- Mid Stage HIV Unaware Diagnosed Through Background Testing
- Base Case Acutely Infected Unaware Diagnosed Through Background Testing

Total New Diagnoses Through Background Testing
Appendix 3: Vensim Source Code Including Model Equations

This appendix includes the Vensim source code of the equations used in HIVSIM. This information can be used to reproduce the model.

1. Number of Known Infected Tested =
   a. Incremental Testing Capacity*Fraction of Population HIV Positive Aware
   b. ~ People/Month

2. Non AIDS Mortality for Late Stage HIV in Care =
   a. "Fraction of Late Stage HIV with Non-AIDS Deaths Per Month"*"Late Stage HIV, Engaged in HIV Care"
   b. ~ People/Month

3. Acutely Infected in Care Progressing to Early Stage HIV in Care =
   a. "Acutely Infected, Engaged in HIV Care"/Average Time in Acutely Infected in Care
   b. ~ People/Month

4. Number of People Receiving Incremental Tests =
   a. Number of People Offered First Test*Fraction of People Accepting Test if Offered
   b. ~ People/Month

5. Number of Uninfected Population Tested =
   a. Fraction of Population Uninfected*Incremental Testing Capacity
   b. ~ People/Month

6. Incremental Testing Capacity =
   a. Fraction Not Recently Tested*Number of People Receiving Incremental Tests
   b. ~ People/Month

7. Number of People HIV Positive Unaware Newly Tested and Diagnosed =
   b. ~ People/Month

8. Testing Capacity =
   a. Max(0,Min(Not Recently Tested, Number of People Receiving Incremental Tests))
   b. ~ People/Month

9. New Diagnoses Through Background Testing =
   a. (Total New Diagnoses Through Background Testing + Number of People HIV Positive Unaware Newly Tested and Diagnosed)*Fraction Recently Tested
   b. ~ People/Month
10. New Diagnoses Through Background or Incremental Testing=
   a. Fraction Not Recently Tested*(Total New Diagnoses Through Background
      Testing + Number of People HIV Positive Unaware Newly Tested and
      Diagnosed)
   b. ~ People/Month

11. Moving to Recently Tested due to Negative Incremental Test Result=
   a. Number of Uninfected Population Tested
   b. ~ People/Month

12. Adjustment to Capture People Living Longer with Antiretroviral Therapy =
   a. 1*(1+RAMP(0.0075, 0, 60))
   b. ~ Dimensionless

13. Late Stage HIV Unaware Diagnosed Through Background Testing =
   a. "Late Stage HIV, Unaware of HIV Infection"*Fraction of Late Stage HIV
      Infected Getting Tested Per Month
   b. ~ People/Month

14. Mid Stage HIV Unaware Diagnosed Through Background Testing =
   a. Fraction of Mid Stage HIV Infected Getting Tested Per Month"Mid Stage HIV,
      Unaware of HIV Infection"
   b. ~ People/Month

15. Late Stage HIV Unaware Tested and Diagnosed =
   a. (Late Stage HIV Unaware Diagnosed Through Background Testing) + Number of
      Additional Late Stage Unaware Diagnosed Per Month
   b. ~ People/Month

16. Not Recently Tested = INTEG (Moving to Not Recently Tested After Waiting Period-"Deaths Among HIV
   Positive Unaware (R1) Not Recently Tested"-New Diagnoses Through
   Background or Incremental Testing-Moving to Recently Tested due to Negative
   Incremental Test Result, 1.37135e+07+"Initial Value for Acutely infected,
   unaware of HIV infection" + "Initial Value for Early stage HIV, unaware of HIV
   infection" + "Initial Value for Mid stage HIV, unaware of HIV infection" +
   "Initial Value for Late stage HIV, unaware of HIV infection")
   b. ~ People

17. Moving to Not Recently Tested After Waiting Period =
   a. Recently Tested/X Months Until Appropriate to Offer Subsequent Incremental
      Test
   b. ~ People/Month

18. "Deaths Among HIV Positive Unaware (R1) Not Recently Tested" =
a. (Non AIDS Mortality for Undiagnosed HIV Cases + AIDS Deaths Among Late Stage HIV Unaware)*Fraction Not Recently Tested
b. \(~\) People/Month

19. Acutely Infected Unaware Tested and Diagnosed =
   a. Base Case Acutely Infected Unaware Diagnosed Through Background Testing + Number of Additional Acutely Infected Unaware Diagnosed Per Month
   b. \(~\) People/Month

20. Base Case Acutely Infected Unaware Diagnosed Through Background Testing =
   a. Fraction Acutely Infected Unaware Getting Tested*Leaving Acutely Infected Unaware
   b. \(~\) People/Month

21. Early Stage HIV Unaware Tested and Diagnosed =
   a. (Early Stage HIV Unaware Tested and Diagnosed Through Background Testing)+Number of Additional Early Stage Unaware Diagnosed Per Month
   b. \(~\) People/Month

22. Mid Stage HIV Unaware Tested and Diagnosed =
   a. (Mid Stage HIV Unaware Diagnosed Through Background Testing)+Number of Additional Mid Stage Unaware Diagnosed Per Month
   b. \(~\) People/Month

23. Total Testing Pool =
   a. Not Recently Tested + Recently Tested
   b. \(~\) People

24. "Deaths Among HIV Positive Unaware (R1) Recently Tested" =
   a. (Non AIDS Mortality for Undiagnosed HIV Cases + AIDS Deaths Among Late Stage HIV Unaware)*Fraction Recently Tested
   b. \(~\) People/Month

25. Total New Diagnoses Through Background Testing =
   a. Base Case Acutely Infected Unaware Diagnosed Through Background Testing + Early Stage HIV Unaware Tested and Diagnosed Through Background Testing + Late Stage HIV Unaware Diagnosed Through Background Testing + Mid Stage HIV Unaware Diagnosed Through Background Testing
   b. \(~\) People/Month

26. Early Stage HIV Unaware Tested and Diagnosed Through Background Testing =
   a. "Early Stage HIV, Unaware of HIV Infection"*Fraction Early HIV Infected Getting Tested Per Month
   b. \(~\) People/Month

27. Recently Tested = INTEG (}
a. Moving to Recently Tested due to Negative Incremental Test Result: "Deaths Among HIV Positive Unaware (R1) Recently Tested" - Moving to Not Recently Tested After Waiting Period - New Diagnoses Through Background Testing, 0)

b. ~ People

28. Non AIDS Mortality for Undiagnosed HIV Cases =
a. Non AIDS Mortality for Mid Stage HIV Unaware + Non AIDS Mortality for Early Stage HIV Unaware + Non AIDS Mortality for Late Stage HIV Unaware
b. ~ People/Month

29. Fraction of Population HIV Positive Aware =
a. People Living with Diagnosed HIV Infection/Total Population
b. ~ Dimensionless

30. X Months Until Appropriate to Offer Subsequent Incremental Test =
a. 60
b. ~ Month

31. Deaths Among People Living with Diagnosed HIV Infection =
a. (AIDs Deaths + Non AIDS Mortality for Diagnosed HIV Cases)
b. ~ People/Month

32. Fraction Recently Tested =
a. Recently Tested/Total Testing Pool
b. ~ Dimensionless

33. Fraction Not Recently Tested =
a. Not Recently Tested/Total Testing Pool
b. ~ Dimensionless

34. "Diagnosed HIV Cases (R2, R3, R4)" = INTEG (a. New Diagnoses Through Background or Incremental Testing + New Diagnoses Through Background Testing - Deaths Among People Living with Diagnosed HIV Infection, 119653)
b. ~ People

35. Fraction of HIV Cases in Care Not Virally Suppressed =
a. Initial Fraction of HIV Cases in Care Not Virally Suppressed * Switch Function
b. ~ Dimensionless

36. Switch for Sensitivity Test of Perfect Viral Load Suppression =
a. 0
b. ~ Dimensionless

37. Switch Function =
a. IF THEN ELSE(Switch for Sensitivity Test of Perfect Viral Load Suppression=0 , 1 , (1+step(-1.57)))
b. ~ Dimensionless

38. Initial Fraction of HIV Cases in Care Not Virally Suppressed =
a. 0.25  
b. ~ Dimensionless

39. Number of Acute HIV Infection in Care Not Virally Suppressed =
a. "Acutely Infected, Engaged in HIV Care"*Fraction of HIV Cases in Care Not Virally Suppressed 
b. ~ People

40. Annual Increase in HIV Tests =
a. Months Per Year*Incremental Change in Number of HIV Tests 
b. ~ People/Year

41. Annual Newly Diagnosed AIDS Cases =
a. Months Per Year*Late Stage HIV Unaware Tested and Diagnosed  
b. ~ People/Year

42. Non AIDS Mortality for Diagnosed Late Stage HIV =
a. Non AIDS Mortality for Late Stage HIV Diagnosed + Non AIDS Mortality for Late Stage HIV in Care + Non AIDS Mortality for Late Stage HIV in Sporadic Care  
b. ~ People/Month

43. Contacts Per Acute HIV Infection HIV Acutely Infected Unaware =
a. 4  
b. ~ Dimensionless/Month

44. Current Infection Rate per Contact for Early Stage HIV Diagnosed =
a. Infection Rate per Contact for Early Stage HIV Diagnosed*Adjustment to Infection Rates to Capture Declining Infection Rate from 2006 to 2009  
b. ~ Dimensionless

45. Fraction Acutely Infected Unaware Getting Tested =
a. 0.04  
b. ~ Dimensionless

46. Fraction Acutely Infected Linked to Care =
a. 0.25  
b. ~ Dimensionless

47. Fraction Early HIV Infected Getting Tested Per Month =
a. 0.018
b. ~ Dimensionless/Month

48. Non AIDS Mortality for Diagnosed Mid Stage HIV =
   a. Non AIDS Mortality for Mid Stage HIV Diagnosed + Non AIDS Mortality for Mid Stage HIV in Care + Non AIDS Mortality for Mid Stage HIV in Sporadic Care
   b. ~ People/Month

49. Fraction of Late Stage HIV Diagnosed Initially Linked to Care Per Month =
   a. 0.5
   b. ~ Dimensionless/Month

50. Fraction of Mid Stage HIV Diagnosed Initially Linked to Care Per Month =
   a. 0.02
   b. ~ Dimensionless/Month

51. Fraction of Mid Stage HIV Infected Getting Tested Per Month =
   a. 0.032
   b. ~ Dimensionless/Month

52. Fraction of Late Stage HIV Infected Getting Tested Per Month =
   a. 0.99
   b. ~ Dimensionless/Month

53. Fraction of Early Stage HIV Diagnosed Initially Linked to Care Per Month =
   a. 0.015
   b. ~ Dimensionless/Month

54. Non AIDS Mortality for Diagnosed Early Stage HIV =
   a. "Non-AIDS Mortality for Sporadic in Care" + Non AIDS Mortality for Early Stage HIV Diagnosed + Non AIDS Mortality For Early Stage HIV in Care
   b. ~ People/Month

55. New Infections Lower CI =
   a. New Infections
   b. ~ People/Year

56. New Infections Upper CI =
   a. New Infections
   b. ~ People/Year

57. "Living HIV Non-AIDS Cases Diagnosed and Undiagnosed" =
   a. Living HIV Non AIDS Cases + "Living with HIV Non-AIDS Undiagnosed"
   b. ~ People
58. "Newly Diagnosed HIV (non-AIDS) Cases" =
   a. Acutely Infected Unaware Tested and Diagnosed + Early Stage HIV Unaware Tested and Diagnosed + Mid Stage HIV Unaware Tested and Diagnosed
   b. \(~\) People/Month

59. "Living with HIV Non-AIDS Undiagnosed" =
   a. "Acutely infected, unaware of HIV infection" + "Early Stage HIV, Unaware of HIV Infection" + "Mid Stage HIV, Unaware of HIV Infection"
   b. \(~\) People

60. Total Number of HIV Cases Currently in Sporadic Care =
   a. "Acutely Infected, Entered HIV Care but Care Is Now Sporadic" + "Early Stage HIV, Entered HIV Care but Care Is Now Sporadic" + "Late Stage HIV, Entered HIV Care but Care Is Now Sporadic" + "Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic"
   b. \(~\) People

61. Current Average Time in Late Stage HIV in Care =
   a. Average Time in Late Stage HIV in Care*Adjustment to Capture People Living Longer with Antiretroviral Therapy
   b. \(~\) Month

62. Total Linked to Care Per Month =
   a. Acutely Infected Diagnosed Initially Linked to Care + Early Stage HIV Diagnosed Initially Linked to Care + Mid Stage HIV Diagnosed Initially Linked to Care + Late Stage HIV Diagnosed Initially Linked to Care
   b. \(~\) People/Month

63. Initial Average Time in Late Stage HIV in Sporadic Care =
   a. 310
   b. \(~\) Month

64. Average Time in Late Stage HIV in Care =
   a. 400
   b. \(~\) Month

65. Current Average Time Late Stage HIV in Sporadic Care =
   a. Initial Average Time in Late Stage HIV in Sporadic Care*Adjustment to Capture People Living Longer with Antiretroviral Therapy
   b. \(~\) Month

66. Infection Rate per Contact for Early Stage HIV Diagnosed =
   a. 0.0025
   b. \(~\) Dimensionless

67. Diagnosed HIV Cases Newly Linked to Care =
a. Acutely Infected Diagnosed Initially Linked to Care + Early Stage HIV Diagnosed Initially Linked to Care + Mid Stage HIV Diagnosed Initially Linked to Care + Late Stage HIV Diagnosed Initially Linked to Care
b. $\sim$ People/Month

68. Diagnosed HIV Cases Newly Linked to Care Annually =
   a. Months Per Year*Diagnosed HIV Cases Newly Linked to Care
   b. $\sim$ People/Year

69. Incremental Change in Number of HIV Tests =
   a. Number of Uninfected Population Tested + Number of People HIV Positive Unaware Newly Tested and Diagnosed + Number of Known Infected Tested
   b. $\sim$ People/Month

70. Testing Law Implementation Ramp =
   a. IF THEN ELSE( Switch to Turn on Testing Law Structure=0 , 0 , RAMP( Value for Ramp, Start Time Medical Professionals, End Time Medical Professionals) )
   b. $\sim$ Medical Professionals

71. Switch to Turn on Testing Law Structure =
   a. 0
   b. $\sim$ Dimensionless

72. Adjustment Time for Professional Awareness of Testing Law =
   a. 1
   b. $\sim$ Month

73. Number of Medical Professionals Aware of Testing Law =
   a. Smooth(Testing Law Implementation Ramp, Adjustment Time for Professional Awareness of Testing Law)
   b. $\sim$ Medical Professionals

74. Number of Additional Acutely Infected Unaware Diagnosed Per Month =
   a. Number of People HIV Positive Unaware Newly Tested and Diagnosed*Fraction Acutely Infected Unaware
   b. $\sim$ People/Month

75. Number of Additional Early Stage Unaware Diagnosed Per Month =
   a. Number of People HIV Positive Unaware Newly Tested and Diagnosed*Fraction Early Stage Unaware
   b. $\sim$ People/Month

76. Average Number of Unique Patients Seen Per Medical Professional Each Month =
   a. 126
   b. $\sim$ People/Month/Medical Professionals
77. Number of People Offered First Test =
   a. Number of Medical Professionals Aware of Testing Law*Fraction of Medical
      Professionals Offering Tests*Average Number of Unique Patients Seen Per
      Medical Professional Each Month
   b. ~ People/Month

78. Fraction of People Accepting Test if Offered =
   a. 0.6
   b. ~ Dimensionless

79. Number of Additional Mid Stage Unaware Diagnosed Per Month =
   a. Number of People HIV Positive Unaware Newly Tested and Diagnosed*Fraction
      Mid Stage Unaware
   b. ~ People/Month

80. Fraction of Medical Professionals Offering Tests =
   a. 0.5
   b. ~ Dimensionless

81. Number of Additional Late Stage Unaware Diagnosed Per Month =
   a. Fraction Late Stage Unaware*Number of People HIV Positive Unaware Newly
      Tested and Diagnosed
   b. ~ People/Month

82. Deaths Among Diagnosed HIV Cases =
   a. Estimated Annual Deaths + Annual Non AIDS Mortality for Diagnosed HIV
      Cases
   b. ~ People/Year

83. Average Time in Early Stage HIV in Care =
   a. 90
   b. ~ Month

84. Average Time in Mid Stage HIV in Care =
   a. 260
   b. ~ Month

85. AIDS Deaths =
   a. AIDS Deaths Among Late Stage HIV Diagnosed + AIDS Deaths Among Late
      Stage HIV in Care + AIDS Deaths for Late Stage HIV in Sporadic Care
   b. ~ People/Month

86. Estimated Annual Deaths =
   a. AIDS Deaths*Months Per Year
   b. ~ People/Year
87. Total Mid Stage HIV =  
   a. "Mid Stage HIV, Unaware of HIV Infection" + "Mid Stage HIV, Aware of HIV Infection (Not in Care)" + "Mid Stage HIV, Engaged in HIV Care" + "Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic"  
   b. ~ People

88. "People Living with HIV Infection (Diagnosed and Undiagnosed)" =  
   a. Total Acutely Infected + Total Early Stage HIV + Total Mid Stage HIV + Total Late Stage HIV  
   b. ~ People

89. Total Acutely Infected =  
   a. "Acutely infected, unaware of HIV infection" + "Acutely Infected, Aware of HIV Infection (Not in Care)" + "Acutely Infected, Engaged in HIV Care" + "Acutely Infected, Entered HIV Care but Care Is Now Sporadic"  
   b. ~ People

90. Total Early Stage HIV =  
   a. "Early Stage HIV, Unaware of HIV Infection" + "Early Stage HIV, Aware of HIV Infection (Not in Care)" + "Early Stage HIV, Engaged in HIV Care" + "Early Stage HIV, Entered HIV Care but Care Is Now Sporadic"  
   b. ~ People

91. Total Late Stage HIV =  
   a. "Late Stage HIV, Unaware of HIV Infection" + "Late Stage HIV, Aware of HIV Infection (Not in Care)" + "Late Stage HIV, Engaged in HIV Care" + "Late Stage HIV, Entered HIV Care but Care Is Now Sporadic"  
   b. ~ People

92. Fraction of Mid Stage HIV Currently Engaged in Care =  
   a. "Mid Stage HIV, Engaged in HIV Care"/Diagnosed HIV Cases Currently Engaged in Care  
   b. ~ Dimensionless

93. Fraction of Late Stage HIV Currently Engaged in Care =  
   a. "Late Stage HIV, Engaged in HIV Care"/Diagnosed HIV Cases Currently Engaged in Care  
   b. ~ Dimensionless

94. Fraction of Acutely Infected Currently Engaged in Care =  
   a. "Acutely Infected, Engaged in HIV Care"/Diagnosed HIV Cases Currently Engaged in Care  
   b. ~ Dimensionless

95. Fraction of Early Stage HIV Currently Engaged in Care =
a. "Early Stage HIV, Engaged in HIV Care"/Diagnosed HIV Cases Currently Engaged in Care
b. ~ Dimensionless

96. Living Acute HIV Cases =
   a. "Acutely Infected, Aware of HIV Infection (Not in Care)"+"Acutely Infected, Engaged in HIV Care" + "Acutely Infected, Entered HIV Care but Care Is Now Sporadic"
b. ~ People

97. Acutely Infected in Care Moving to Sporadic Care =
   a. Fraction of Acutely Infected in Care Moving to Sporadic Care Per Month*"Acutely Infected, Engaged in HIV Care"
b. ~ People/Month

98. People Living with Diagnosed Acute HIV Infection =
   a. "Acutely Infected, Aware of HIV Infection (Not in Care)"+"Acutely Infected, Engaged in HIV Care" + "Acutely Infected, Entered HIV Care but Care Is Now Sporadic"
b. ~ People

99. Total Acutely Infected Ever Linked to Care =
   a. "Acutely Infected, Engaged in HIV Care" + "Acutely Infected, Entered HIV Care but Care Is Now Sporadic"
b. ~ People

100. New Infections Generated by Mid Stage HIV in Care =
    a. Contacts per Mid Stage HIV in Care*Infection Rate per Contact for Mid Stage HIV in Care*Uninfected*Mid Stage HIV in Care Not Virally Suppressed/Total Population
    b. ~ People/Month

101. New Infections Generated by Acute HIV Infection in Care =
    a. Contacts Per Contacts Acute HIV Infection in Care*Infection Rate per Contact for Acute HIV Infection in Care*Uninfected*Number of Acute HIV Infection in Care Not Virally Suppressed/Total Population
    b. ~ People/Month

102. New Infections Generated by Early Stage HIV in Care =
    a. Contacts per Early Stage HIV in Care*Infection Rate per Contact for Early Stage HIV in Care*Uninfected*Early Stage HIV in Care Not Virally Suppressed/Total Population
    b. ~ People/Month

103. New Infections Generated by Late Stage HIV in Care =
a. Contacts per Late Stage HIV in Care*Infection Rate per Contact Late Stage HIV in Care*Uninfected*Late Stage HIV in Care Not Virally Suppressed/Total Population
b. ~ People/Month

104. Diagnosed HIV Cases Currently Engaged in Care =
   a. "Acutely Infected, Engaged in HIV Care" + "Early Stage HIV, Engaged in HIV Care" + "Mid Stage HIV, Engaged in HIV Care" + "Late Stage HIV, Engaged in HIV Care"
   b. ~ People

105. Mid Stage HIV in Care Not Virally Suppressed =
   a. Fraction of HIV Cases in Care Not Virally Suppressed*"Mid Stage HIV, Engaged in HIV Care"
   b. ~ People

106. Infection Rate per Contact for Early Stage HIV in Care =
   a. Current Infection Rate per Contact for Early Stage HIV Diagnosed
   b. ~ Dimensionless

107. Infection Rate per Contact for Acute HIV Infection in Care =
   a. Infection Rate per Acute HIV Infection Diagnosed
   b. ~ Dimensionless

108. Late Stage HIV in Care Not Virally Suppressed =
   a. "Late Stage HIV, Engaged in HIV Care"*Fraction of HIV Cases in Care Not Virally Suppressed
   b. ~ People

109. Early Stage HIV in Care Not Virally Suppressed =
   a. "Early Stage HIV, Engaged in HIV Care"*Fraction of HIV Cases in Care Not Virally Suppressed
   b. ~ People

110. Fraction of Population Uninfected =
   a. Uninfected/Total Population
   b. ~ Dimensionless

111. Fraction of Population HIV Positive Unaware =
   a. Total HIV Positive Unaware/Total Population
   b. ~ Dimensionless

112. AIDS Deaths Among Late Stage HIV in Care =
   a. "Late Stage HIV, Engaged in HIV Care"/Current Average Time in Late Stage HIV in Care
   b. ~ People/Month
113. Non AIDS Mortality for Diagnosed HIV Cases =
   a. Non AIDS Mortality for Diagnosed Early Stage HIV + Non AIDS Mortality for Diagnosed Late Stage HIV + Non AIDS Mortality for Diagnosed Mid Stage HIV
   b. \( \sim \) People/Month

114. Annual Non AIDS Mortality for Diagnosed HIV Cases =
   a. Months Per Year*Non AIDS Mortality for Diagnosed HIV Cases
   b. \( \sim \) People/Year

115. Fraction of New Infections from Acute Aware and Unaware =
   a. (New Infections Generated by Acute HIV Infection Unaware + New Infections Generated by Acute HIV Infection Diagnosed + New Infections Generated by Acute HIV Infection in Sporadic Care + New Infections Generated by Acute HIV Infection in Care)/New Infections Per Month
   b. \( \sim \) Dimensionless

116. Infection Rate per Contact for Late Stage HIV Diagnosed =
   a. Current Infection Rate per Contact for Early Stage HIV Diagnosed
   b. \( \sim \) Dimensionless

117. Infection Rate per Contact Late Stage HIV in Care =
   a. Infection Rate per Contact for Early Stage HIV in Care
   b. \( \sim \) Dimensionless

118. Infection Rate Per Contact for Late Stage HIV in Sporadic Care =
   a. Infection Rate per Contact for Early Stage HIV in Sporadic Care
   b. \( \sim \) Dimensionless

119. Infection Rate Per Contact for Mid Stage HIV Unaware =
   a. Infection Rate per Contact for Early Stage HIV Unaware
   b. \( \sim \) Dimensionless

120. Infection Rate per Contact for Mid Stage HIV in Sporadic Care =
   a. Infection Rate per Contact for Early Stage HIV in Sporadic Care
   b. \( \sim \) Dimensionless

121. Infection Rate per Contact for Acute HIV Infection in Sporadic Care =
   a. Infection Rate per Acute HIV Infection Diagnosed
   b. \( \sim \) Dimensionless

122. Infection Rate per Contact for Mid Stage HIV Diagnosed =
   a. Current Infection Rate per Contact for Early Stage HIV Diagnosed
   b. \( \sim \) Dimensionless

123. Infection Rate per Contact for Mid Stage HIV in Care =
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a. Infection Rate per Contact for Early Stage HIV in Care
b. ~ Dimensionless

124. Infection Rate per Contact for Late Stage HIV Unaware =
a. Infection Rate per Contact for Early Stage HIV Unaware
b. ~ Dimensionless

d. Contacts per Mid Stage HIV in Sporadic Care =
a. 2
b. ~ Dimensionless/Month

126. Infection Rate per Contact for Early Stage HIV in Sporadic Care =
a. Current Infection Rate per Contact for Early Stage HIV Diagnosed
b. ~ Dimensionless

127. Living Early Stage HIV Cases =
a. "Early Stage HIV, Aware of HIV Infection (Not in Care)"+"Early Stage HIV, Engaged in HIV Care" + "Early Stage HIV, Entered HIV Care but Care Is Now Sporadic"
b. ~ People

d. Living Diagnosed AIDS Cases =
a. ("Late Stage HIV, Aware of HIV Infection (Not in Care)"+"Late Stage HIV, Engaged in HIV Care" + "Late Stage HIV, Entered HIV Care but Care Is Now Sporadic")
b. ~ People

129. Living HIV Non AIDS Cases =
a. Living Acute HIV Cases + Living Early Stage HIV Cases + Living Mid Stage HIV Cases
b. ~ People

130. Living Mid Stage HIV Cases =
a. "Mid Stage HIV, Aware of HIV Infection (Not in Care)"+"Mid Stage HIV, Engaged in HIV Care" + "Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic"
b. ~ People

131. Total Not Engaged in Care =
a. "Acutely Infected, Aware of HIV Infection (Not in Care)"+"Early Stage HIV, Aware of HIV Infection (Not in Care)"+"Late Stage HIV, Aware of HIV Infection (Not in Care)"+"Mid Stage HIV, Aware of HIV Infection (Not in Care)"
b. ~ People

132. Total Aware of HIV Status =
a. Living Diagnosed AIDS Cases + Living HIV Non AIDS Cases
b. ~ People

133. Fraction Mid Stage Unaware =
   a. "Mid Stage HIV, Unaware of HIV Infection"/Total HIV Positive Unaware
   b. ~ Dimensionless

134. Fraction Late Stage Unaware =
   a. "Late Stage HIV, Unaware of HIV Infection"/Total HIV Positive Unaware
   b. ~ Dimensionless

135. Fraction Early Stage Unaware =
   a. "Early Stage HIV, Unaware of HIV Infection"/Total HIV Positive Unaware
   b. ~ Dimensionless

136. Total HIV Positive Unaware =
   a. "Acutely infected, unaware of HIV infection" + "Early Stage HIV, Unaware of HIV Infection" + "Late Stage HIV, Unaware of HIV Infection" + "Mid Stage HIV, Unaware of HIV Infection"
   b. ~ People

137. Fraction Acutely Infected Unaware =
   a. "Acutely infected, unaware of HIV infection"/Total HIV Positive Unaware
   b. ~ Dimensionless

138. Annual Newly Diagnosed HIV Cases =
   a. Months Per Year*Newly Diagnosed HIV Cases Per Month
   b. ~ People/Year

139. Total Mid Stage HIV Ever Linked to Care =
   a. "Mid Stage HIV, Engaged in HIV Care" + "Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic"
   b. ~ People

140. Total Early Stage HIV Ever Linked to Care =
   a. "Early Stage HIV, Engaged in HIV Care" + "Early Stage HIV, Entered HIV Care but Care Is Now Sporadic"
   b. ~ People

141. Fraction of Early Stage HIV Engaged in HIV Care =
   a. Total Early Stage HIV Ever Linked to Care/Diagnosed HIV Cases Ever Linked to Care
   b. ~ Dimensionless

142. Fraction of Acutely Infected Engaged in Care =
   a. Total Acutely Infected Ever Linked to Care/Diagnosed HIV Cases Ever Linked to Care
b. ~ Dimensionless

143. Fraction of Mid Stage HIV Engaged in Care =
   a. Total Mid Stage HIV Ever Linked to Care/Diagnosed HIV Cases Ever Linked to Care
   b. ~ Dimensionless

144. Diagnosed HIV Cases Ever Linked to Care =
   a. Total Acutely Infected Ever Linked to Care + Total Early Stage HIV Ever Linked to Care + Total Late Stage HIV Ever Linked to Care + Total Mid Stage HIV Ever Linked to Care
   b. ~ People

145. Fraction of New Diagnoses in Early Stage =
   a. Early Stage HIV Unaware Tested and Diagnosed/Newly Diagnosed HIV Cases Per Month
   b. ~ Dimensionless

146. Fraction of Late Stage HIV Engaged in HIV Care =
   a. Total Late Stage HIV Ever Linked to Care/Diagnosed HIV Cases Ever Linked to Care
   b. ~ Dimensionless

147. Total Late Stage HIV Ever Linked to Care =
   a. "Late Stage HIV, Engaged in HIV Care" + "Late Stage HIV, Entered HIV Care but Care Is Now Sporadic"
   b. ~ People

148. Fraction of New Diagnoses in Mid Stage =
   a. Mid Stage HIV Unaware Tested and Diagnosed/Newly Diagnosed HIV Cases Per Month
   b. ~ Dimensionless

149. New Infections Generated by Early Stage HIV in Sporadic Care =
   a. Contacts per Early Stage HIV in Sporadic Care*Infection Rate per Contact for Early Stage HIV in Sporadic Care*Uninfected*"Early Stage HIV, Entered HIV Care but Care Is Now Sporadic"/Total Population
   b. ~ People/Month

150. New Infections Generated by Late Stage HIV Unaware =
   a. Contacts Per Late Stage HIV Unaware*Infection Rate per Contact for Late Stage HIV Unaware*Uninfected*"Late Stage HIV, Unaware of HIV Infection"/Total Population
   b. ~ People/Month

151. New Infections Generated by Late Stage HIV Diagnosed =
152. New Infections Generated by Acute HIV Infection Unaware =
   a. Contacts Per Acute HIV Infection HIV Acutely Infected Unaware*Infection Rate Per Contact for Acute HIV Infection Unaware*Uninfected*"Acutely infected, unaware of HIV infection"/Total Population
   b. ~ People/Month

153. New Infections Generated by Acute HIV Infection Diagnosed =
   a. Contacts Per Acute HIV Infection Diagnosed*Infection Rate per Acute HIV Infection Diagnosed*Uninfected*"Acutely infected, Aware of HIV Infection (Not in Care)"/Total Population
   b. ~ People/Month

154. New Infections Generated by Acute HIV Infection in Sporadic Care =
   a. Contacts Per Acute HIV Infection in Sporadic Care*Infection Rate per Contact for Acute HIV Infection in Sporadic Care*Uninfected*"Acutely Infected, Entered HIV Care but Care Is Now Sporadic"/Total Population
   b. ~ People/Month

155. New Infections Generated by Early Stage HIV Unaware =
   a. Contacts Per Early Stage HIV Unaware*Infection Rate per Contact for Early Stage HIV Unaware*Uninfected*"Early Stage HIV, Unaware of HIV Infection"/Total Population
   b. ~ People/Month

156. New Infections Generated by Early Stage HIV Diagnosed =
   a. Contacts per Early Stage HIV Diagnosed*Current Infection Rate per Contact for Early Stage HIV Diagnosed*Uninfected*"Early Stage HIV, Aware of HIV Infection (Not in Care)"/Total Population
   b. ~ People/Month

157. New Infections Generated by Mid Stage HIV Unaware =
   a. Contacts Per Mid Stage HIV Unaware*Infection Rate Per Contact for Mid Stage HIV Unaware*Uninfected*"Mid Stage HIV, Unaware of HIV Infection"/Total Population
   b. ~ People/Month

158. New Infections Generated by Mid Stage HIV Diagnosed =
   a. Contacts Per Mid Stage HIV Diagnosed*Infection Rate per Contact for Mid Stage HIV Diagnosed*Uninfected*"Mid Stage HIV, Aware of HIV Infection (Not in Care)"/Total Population
   b. ~ People/Month
159. New Infections Generated by Mid Stage HIV in Sporadic Care =
   a. Contacts per Mid Stage HIV in Sporadic Care * Infection Rate per Contact for Mid Stage HIV in Sporadic Care * Uninfected * "Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic"/Total Population
   b. ~ People/Month

160. New Infections Generated by Late Stage HIV in Sporadic Care =
   a. Contacts per Late Stage HIV in Sporadic Care * Infection Rate Per Contact for Late Stage HIV in Sporadic Care * Uninfected * "Late Stage HIV, Entered HIV Care but Care Is Now Sporadic"/Total Population
   b. ~ People/Month

161. Fraction of Diagnosed HIV Cases Ever Linked to Care =
   a. Diagnosed HIV Cases Ever Linked to Care/(Total Not Engaged in Care + Diagnosed HIV Cases Ever Linked to Care)
   b. ~ Dimensionless

162. Initial Value for Cumulative HIV Related Deaths = INITIAL(
   a. 65000)
   b. ~ People

163. Fraction of Newly Diagnosed Cases with AIDS =
   a. Late Stage HIV Unaware Tested and Diagnosed/Newly Diagnosed HIV Cases Per Month
   b. ~ Dimensionless

164. "Initial Value for Early stage HIV, unaware of HIV infection" =
   a. 10500
   b. ~ People

165. "Initial Value for Early stage HIV, entered HIV care but care is now sporadic" =
   a. 6163
   b. ~ People

166. "Initial Value for Mid stage HIV, entered HIV care but care is now sporadic" = INITIAL(
   a. 4237)
   b. ~ People

167. "Initial Value for Mid stage HIV, unaware of HIV infection" =
   a. 4400
   b. ~ People

168. "Initial Value for Acutely infected, unaware of HIV infection" =
   a. 861
   b. ~ People
169. "Initial Value for Mid stage HIV, aware of HIV infection (not in care)" = INITIAL(a.
   4188)
b. ~ People

170. "Initial Value for Mid stage HIV, Engaged in HIV care" = INITIAL(a.
   12158)
b. ~ People

   15
b. ~ People

172. "Initial Value for Acutely infected, engaged in HIV care" = INITIAL(a.
   5)
b. ~ People

173. "Initial Value for Acutely infected, entered HIV care but care is now sporadic" = INITIAL(a.
   0)
b. ~ People

174. "Initial Value for Early stage HIV, aware of HIV infection (not in care)" = a.
   4688
b. ~ People

175. "Initial Value for Early stage HIV, engaged in HIV care" = a.
   15929
b. ~ People

176. "Initial Value for Late stage HIV, engaged in HIV care" = INITIAL(a.
   63913)
b. ~ People

177. "Initial Value for Late stage HIV, entered HIV care but care is now sporadic" = INITIAL(a.
   7981)
b. ~ People

178. "Initial Value for Late stage HIV, unaware of HIV infection" = a.
   110
b. ~ People

179. "Initial Value for Late stage HIV, aware of HIV infection (not in care)" = INITIAL(a.
   376)
b. ~ People
180. Fraction of New Infections from Individuals Sporadically in Care =
   a. New Infections from Individuals Sporadically in Care/New Infections Per Month
   b. ~ Dimensionless

181. New Infections Per Month =
   a. New Infections from Individuals and in Care + New Infections from Non Acute Aware + New Infections from Unaware + New Infections from Individuals Sporadically in Care
   b. ~ People/Month

182. New Infections from Individuals Sporadically in Care =
   a. New Infections Generated by Acute HIV Infection in Sporadic Care + New Infections Generated by Early Stage HIV in Sporadic Care + New Infections Generated by Late Stage HIV in Sporadic Care + New Infections Generated by Mid Stage HIV in Sporadic Care
   b. ~ People/Month

183. Non AIDS Mortality for Late Stage HIV Diagnosed =
   a. "Fraction of Late Stage HIV with Non-AIDS Deaths Per Month"*"Late Stage HIV, Aware of HIV Infection (Not in Care)"
   b. ~ People/Month

184. Non AIDS Mortality for Mid Stage HIV Diagnosed =
   a. "Fraction of Mid Stage HIV with Non-AIDS Deaths Per Month"*"Mid Stage HIV, Aware of HIV Infection (Not in Care)"
   b. ~ People/Month

185. Late Stage HIV Diagnosed Initially Linked to Care =
   a. "Late Stage HIV, Aware of HIV Infection (Not in Care)"*Fraction of Late Stage HIV Diagnosed Initially Linked to Care Per Month
   b. ~ People/Month

186. "Mid Stage HIV, Engaged in HIV Care" = INTEG (a.
   Early Stage HIV in Care Progressing to Mid Stage HIV in Care + Mid Stage HIV Diagnosed Initially Linked to Care + "Mid Stage HIV Re-Engaging in Care"-Mid Stage HIV in Care Moving to Sporadic Care-Mid Stage HIV in Care Progressing to Late Stage HIV in Care-Non AIDS Mortality for Mid Stage HIV in Care, "Initial Value for Mid stage HI
   V, Engaged in HIV care")
   b. ~ People

187. "Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic" = INTEG (a.
   Early Stage HIV in Sporadic Care Progressing to Mid Stage HIV in Sporadic Care + Mid Stage HIV in Care Moving to Sporadic Care -"Mid Stage HIV Re-Engaging in Care"-Mid Stage HIV in Sporadic Care Progressing to Late Stage
HIV in Sporadic Care -Non AIDS Mortality for Mid Stage HIV in Sporadic Care, "Initial Value for Mid stage HIV, entered HIV care but care is now sporadic")

b. ~ People

188. "Late Stage HIV, Aware of HIV Infection (Not in Care)" = INTEG (a. Late Stage HIV Unaware Tested and Diagnosed + Mid Stage HIV Diagnosed Progressing to Late Stage HIV Diagnosed-AIDS Deaths Among Late Stage HIV Diagnosed-Late Stage HIV Diagnosed Initially Linked to Care-Non AIDS Mortality for Late Stage HIV Diagnosed, "Initial Value for Late stage HIV, aware of HIV infection (not in care")

b. ~ People

189. "Late Stage HIV, Engaged in HIV Care" = INTEG (a. Late Stage HIV Diagnosed Initially Linked to Care + "Late Stage HIV Re-Engaging in Care" + Mid Stage HIV in Care Progressing to Late Stage HIV in Care-AIDS Deaths Among Late Stage HIV in Care-Late Stage HIV In Care Moving to Sporadic Care-Non AIDS Mortality for Late Stage HIV in Care, "Initial Value for Late stage HIV, engaged in HIV care")

b. ~ People

190. "Late Stage HIV, Entered HIV Care but Care Is Now Sporadic"= INTEG (a. Late Stage HIV In Care Moving to Sporadic Care + Mid Stage HIV in Sporadic Care Progressing to Late Stage HIV in Sporadic Care-AIDS Deaths Among Late Stage HIV in Sporadic Care-Late Stage HIV In Care-"Late Stage HIV Re-Engaging in Care"-Non AIDS Mortality for Late Stage HIV in Sporadic Care, "Initial Value for Late stage HIV, entered HIV care but care is now sporadic")

b. ~ People

191. "Late Stage HIV, Unaware of HIV Infection" = INTEG (a. Mid Stage HIV Unaware Progressing to Late Stage HIV Unaware-AIDS Deaths Among Late Stage HIV Unaware-Late Stage HIV Unaware Tested and Diagnosed-Non AIDS Mortality for Late Stage HIV Unaware, "Initial Value for Late stage HIV, unaware of HIV infection")

b. ~ People

192. Newly Diagnosed HIV Cases Per Month =

a. Acutely Infected Unaware Tested and Diagnosed + Early Stage HIV Unaware Tested and Diagnosed + Late Stage HIV Unaware Tested and Diagnosed + Mid Stage HIV Unaware Tested and Diagnosed

b. ~ People/Month

193. "Fraction of Late Stage HIV with Non-AIDS Deaths Per Month" =

a. 0.0003

b. ~ Dimensionless/Month

194. Non AIDS Mortality for Early Stage HIV Diagnosed =
a. Fraction of Early Stage HIV with Non AIDS Deaths Per Month*"Early Stage HIV, Aware of HIV Infection (Not in Care)"

b. ~ People/Month

195. Non AIDS Mortality For Early Stage HIV in Care =
   a. "Early Stage HIV, Engaged in HIV Care"*Fraction of Early Stage HIV with Non AIDS Deaths Per Month
   b. ~ People/Month

196. "Early Stage HIV, Engaged in HIV Care" = INTEG ( 
   a. Acutely Infected in Care Progressing to Early Stage HIV in Care + Early Stage HIV Diagnosed Initially Linked to Care + "Early Stage HIV Re-Engaging in Care"-Early Stage HIV in Care Moving to Sporadic Care - Early Stage HIV in Care Progressing to Mid Stage HIV in Care-Non AIDS Mortality For Early Stage HIV in Care, "Initial Value for Early stage HIV, engaged in HIV care")
   b. ~ People

197. "Early Stage HIV, Entered HIV Care but Care Is Now Sporadic" = INTEG ( 
   a. Acutely Infected in Sporadic Care Progressing to Early Stage HIV in Sporadic Care + Early Stage HIV in Care Moving to Sporadic Care-"Early Stage HIV Re-Engaging in Care"-Early Stage HIV in Sporadic Care Progressing to Mid Stage HIV in Sporadic Care-"Non-AIDS Mortality for Sporadic in Care", "Initial Value for Early stage HIV, entered HIV care but care is now sporadic")
   b. ~ People

198. "Early Stage HIV, Unaware of HIV Infection" = INTEG ( 
   a. Acutely Infected Unaware Progressing to Early Stage HIV Unaware-Early Stage HIV Unaware Progressing to Mid Stage HIV Unaware-Early Stage HIV Unaware Tested and Diagnosed-Non AIDS Mortality for Early Stage HIV Unaware, "Initial Value for Early stage HIV, unaware of HIV infection")
   b. ~ People

199. Non AIDS Mortality for Late Stage HIV Unaware =
   a. "Fraction of Late Stage HIV with Non-AIDS Deaths Per Month"*"Late Stage HIV, Unaware of HIV Infection"
   b. ~ People/Month

200. Non AIDS Mortality for Mid Stage HIV in Care =
   a. "Fraction of Mid Stage HIV with Non-AIDS Deaths Per Month"*"Mid Stage HIV, Engaged in HIV Care"
   b. ~ People/Month

201. "Mid Stage HIV, Aware of HIV Infection (Not in Care)"= INTEG ( 
   a. Early Stage HIV Diagnosed Progressing to Mid Stage HIV Diagnosed + Mid Stage HIV Unaware Tested and Diagnosed-Mid Stage HIV Diagnosed Progressing to Late Stage HIV Diagnosed-Mid Stage HIV Diagnosed Initially
Linked to Care-Non AIDS Mortality for Mid Stage HIV Diagnosed, "Initial Value for Mid stage HIV, aware of HIV infection (not in care)"

b. ~ People

202. Non AIDS Mortality for Mid Stage HIV in Sporadic Care =
a. "Fraction of Mid Stage HIV with Non-AIDS Deaths Per Month"*"Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic"
b. ~ People/Month

203. Non AIDS Mortality for Mid Stage HIV Unaware =
a. "Fraction of Mid Stage HIV with Non-AIDS Deaths Per Month"*"Mid Stage HIV, Unaware of HIV Infection"
b. ~ People/Month

204. "Mid Stage HIV, Unaware of HIV Infection" = INTEG (a. Early Stage HIV Unaware Progressing to Mid Stage HIV Unaware-Mid Stage HIV Unaware Progressing to Late Stage HIV Unaware-Mid Stage HIV Unaware Tested and Diagnosed-Non AIDS Mortality for Mid Stage HIV Unaware, "Initial Value for Mid stage HIV, unaware of HIV infection")
b. ~ People

205. Fraction of Early Stage HIV with Non AIDS Deaths Per Month =
a. 0.0003
b. ~ Dimensionless/Month

206. "Fraction of Mid Stage HIV with Non-AIDS Deaths Per Month" =
a. 0.0003
b. ~ Dimensionless/Month

207. "Early Stage HIV, Aware of HIV Infection (Not in care)" = INTEG (a. Acutely Infected Diagnosed Progressing to Early Stage HIV Diagnosed + Early Stage HIV Unaware Tested and Diagnosed-Early Stage HIV Diagnosed Progressing to Mid Stage HIV Diagnosed-Early Stage HIV Diagnosed Initially Linked to Care-Non AIDS Mortality for Early Stage HIV Diagnosed, "Initial Value for Early stage HIV, aware of HIV infection (not in care)"

b. ~ People

208. Non AIDS Mortality for Late Stage HIV in Sporadic Care =
a. "Fraction of Late Stage HIV with Non-AIDS Deaths Per Month"*"Late Stage HIV, Entered HIV Care but Care Is Now Sporadic"
b. ~ People/Month

209. Non AIDS Mortality for Early Stage HIV Unaware =
a. "Early Stage HIV, Unaware of HIV Infection"*Fraction of Early Stage HIV with Non AIDS Deaths Per Month
b. ~ People/Month
210. "Non-AIDS Mortality for Sporadic in Care" =
   a. "Early Stage HIV, Entered HIV Care but Care Is Now Sporadic"*Fraction of
      Early Stage HIV with Non AIDS Deaths Per Month
   b. ∼ People/Month

211. Fraction New Infections Generated by Acutely Infected =
   a. Total Infections Generated by Acutely Infected/Total New Infections Test
   b. ∼ Dimensionless

212. Fraction New Infections Generated by Early Stage HIV =
   a. Total Infections Generated by Early Stage HIV/Total New Infections Test
   b. ∼ Dimensionless

213. Total New Infections Test =
   a. Total Infections Generated by Acutely Infected + Total Infections Generated by
      Early Stage HIV + Total Infections Generated by Mid Stage HIV + Total
      Infections Generated by Late Stage HIV
   b. ∼ People/Month

214. Fraction New Infections Generated by Acutely Infected and Early Stage =
   a. Fraction New Infections Generated by Acutely Infected + Fraction New
      Infections Generated by Early Stage HIV
   b. ∼ Dimensionless

215. Total Infections Generated by Mid Stage HIV =
   a. New Infections Generated by Mid Stage HIV Unaware + New Infections
      Generated by Mid Stage HIV Diagnosed + New Infections Generated by Mid
      Stage HIV in Care + New Infections Generated by Mid Stage HIV in Sporadic
      Care
   b. ∼ People/Month

216. Fraction New Infections Generated by Late Stage HIV =
   a. Total Infections Generated by Late Stage HIV/Total New Infections Test
   b. ∼ Dimensionless

217. Total Infections Generated by Early Stage HIV =
   a. New Infections Generated by Early Stage HIV Unaware + New Infections
      Generated by Early Stage HIV Diagnosed + New Infections Generated by Early
      Stage HIV in Sporadic Care + New Infections Generated by Late Stage HIV in
      Care
   b. ∼ People/Month

218. Total Infections Generated by Late Stage HIV =
   a. New Infections Generated by Late Stage HIV Unaware + New Infections
      Generated by Late Stage HIV Diagnosed + New Infections Generated by Late
Stage HIV in Sporadic Care + New Infections Generated by Mid Stage HIV in Care
b. ~ People/Month

219. Total Infections Generated by Acutely Infected =
   a. New Infections Generated by Acute HIV Infection Unaware + New Infections Generated by Acute HIV Infection Diagnosed + New Infections Generated by Acute HIV Infection in Sporadic Care + New Infections Generated by Acute HIV Infection in Care
b. ~ People/Month

220. Fraction New Infections Generated by Mid Stage HIV =
   a. Total Infections Generated by Mid Stage HIV/Total New Infections Test
b. ~ Dimensionless

221. New Infections =
   a. New Infections Per Month*Months Per Year
   b. ~ People/Year

222. AIDS Deaths Among Late Stage HIV Unaware =
   a. "Late Stage HIV, Unaware of HIV Infection"/Average Time in Late Stage HIV Unaware
   b. ~ People/Month

223. AIDS Deaths Among Late Stage HIV Diagnosed =
   a. "Late Stage HIV, Aware of HIV Infection (Not in Care)"/Average Time in Late Stage HIV Diagnosed
   b. ~ People/Month

224. Mid Stage HIV Diagnosed Progressing to Late Stage HIV Diagnosed =
   a. "Mid Stage HIV, Aware of HIV Infection (Not in Care)"/Average Time in Mid Stage HIV Diagnosed
   b. ~ People/Month

225. Mid Stage HIV Unaware Progressing to Late Stage HIV Unaware =
   a. "Mid Stage HIV, Unaware of HIV Infection"/Average Time in Mid Stage HIV Unaware
   b. ~ People/Month

226. Mid Stage HIV Diagnosed Initially Linked to Care =
   a. "Mid Stage HIV, Aware of HIV Infection (Not in Care)"*Fraction of Mid Stage HIV Diagnosed Initially Linked to Care Per Month
   b. ~ People/Month

227. Early Stage HIV Unaware Progressing to Mid Stage HIV Unaware =
a. "Early Stage HIV, Unaware of HIV Infection"/Average Time in Early HIV Unaware
   b. ~ People/Month

228. Early Stage HIV Diagnosed Initially Linked to Care =
   a. "Early Stage HIV, Aware of HIV Infection (Not in Care)"*Fraction of Early Stage HIV Diagnosed Initially Linked to Care Per Month
   b. ~ People/Month

229. Early Stage HIV Diagnosed Progressing to Mid Stage HIV Diagnosed =
   a. "Early Stage HIV, Aware of HIV Infection (Not in Care)"/Average Time in Early Stage HIV Diagnosed
   b. ~ People/Month

230. People Living with Diagnosed Mid Stage HIV =
   a. "Mid Stage HIV, Aware of HIV Infection (Not in Care)"+"Mid Stage HIV, Engaged in HIV Care" + "Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic"
   b. ~ People

231. People Living with Diagnosed Early Stage HIV =
   a. "Early Stage HIV, Aware of HIV Infection (Not in Care)" + "Early Stage HIV, Engaged in HIV Care" + "Early Stage HIV, Entered HIV Care but Care Is Now Sporadic"
   b. ~ People

232. People Living with Diagnosed Late Stage HIV =
   a. "Late Stage HIV, Aware of HIV Infection (Not in Care)" + "Late Stage HIV, Engaged in HIV Care" + "Late Stage HIV, Entered HIV Care but Care Is Now Sporadic"
   b. ~ People

233. Contacts per Late Stage HIV in Sporadic Care =
   a. 2
   b. ~ Dimensionless/Month

234. Contacts per Early Stage HIV in Sporadic Care =
   a. 2
   b. ~ Dimensionless/Month

235. Contacts Per Acute HIV Infection in Sporadic Care =
   a. 2
   b. ~ Dimensionless/Month

236. Newly Diagnosed AIDS Cases Per Month =
\[ \text{a. Mid Stage HIV Diagnosed Progressing to Late Stage HIV Diagnosed} + \text{ Mid Stage HIV in Care Progressing to Late Stage HIV in Care} + \text{ Mid Stage HIV Unaware Progressing to Late Stage HIV Unaware} + \text{ Mid Stage HIV in Sporadic Care Progressing to Late Stage HIV in Sporadic Care} \]

\[ \text{b. } \sim \text{ People/Month} \]

237. Average Time Early Stage HIV in Sporadic Care =
\[ \text{a. } 68 \]
\[ \text{b. } \sim \text{ Month} \]

238. "Acutely Infected, Aware of HIV Infection (Not in Care)" = \text{INTEG (}
\[ \text{a. Acutely Infected Unaware Tested and Diagnosed-Acutely Infected Diagnosed Progressing to Early Stage HIV Diagnosed-Acutely Infected Diagnosed Initially Linked to Care, } \text{"Initial Value for Acutely infected, aware of HIV infection (not in care)"} \]
\[ \text{b. } \sim \text{ People} \]

239. "Acutely Infected, Engaged in HIV Care" = \text{INTEG (}
\[ \text{a. Acutely Infected Diagnosed Initially Linked to Care + } \text{"Acutely Infected Re-Engaging in Care"-Acutely Infected in Care Moving to Sporadic Care-Acutely Infected in Care Progressing to Early Stage HIV in Care, } \text{"Initial Value for Acutely infected, engaged in HIV care"} \]
\[ \text{b. } \sim \text{ People} \]

240. "Mid Stage HIV Re-Engaging in Care" =
\[ \text{a. } \text{"Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic"} \times \text{"Fraction of Mid Stage HIV in Sporadic Care Re-Engaged in Care Per Month"} \]
\[ \text{b. } \sim \text{ People/Month} \]

241. "Acutely Infected, Entered HIV Care but Care Is Now Sporadic" = \text{INTEG (}
\[ \text{a. Acutely Infected in Care Moving to Sporadic Care-Acutely Infected Re-Engaging in Care-Acutely Infected in Sporadic Care Progressing to Early Stage HIV in Sporadic Care, } \text{"Initial Value for Acutely infected, entered HIV care but care is now sporadic"} \]
\[ \text{b. } \sim \text{ People} \]

242. "Acutely Infected Re-Engaging in Care" =
\[ \text{a. } \text{"Acutely Infected, Entered HIV Care but Care Is Now Sporadic"} \times \text{"Fraction of Acutely Infected in Sporadic Care Re-Engaged in Care Per Month"} \]
\[ \text{b. } \sim \text{ People/Month} \]

243. Acutely Infected in Sporadic Care Progressing to Early Stage HIV in Sporadic Care =
\[ \text{a. } \text{"Acutely Infected, Entered HIV Care but Care Is Now Sporadic"}/\text{Average Time in Acutely Infected in Sporadic Care} \]
\[ \text{b. } \sim \text{ People/Month} \]
244. Average Time in Mid Stage HIV in Sporadic Care =
   a. 100
   b. \sim \text{Month}

245. Late Stage HIV In Care Moving to Sporadic Care =
   a. "Late Stage HIV, Engaged in HIV Care" \times \text{Fraction of Late Stage HIV in Care Moving to Sporadic Care Per Month}
   b. \sim \text{People/Month}

246. "Late Stage HIV Re-Engaging in Care" =
   a. "Late Stage HIV, Entered HIV Care but Care Is Now Sporadic" \times \text{Fraction of Late Stage HIV in Sporadic Care Re-Engaged in Care Per Month}
   b. \sim \text{People/Month}

247. Early Stage HIV in Care Moving to Sporadic Care =
   a. "Early Stage HIV, Engaged in HIV Care" \times \text{Fraction of Early Stage HIV in Moving to Sporadic Care Per Month}
   b. \sim \text{People/Month}

248. "Early Stage HIV Re-Engaging in Care" =
   a. "Early Stage HIV, Entered HIV Care but Care Is Now Sporadic" \times \text{Fraction of Early Stage HIV in Sporadic Care Re-Engaged in Care Per Month}
   b. \sim \text{People/Month}

249. Early Stage HIV in Sporadic Care Progressing to Mid Stage HIV in Sporadic Care =
   a. "Early Stage HIV, Entered HIV Care but Care Is Now Sporadic" / \text{Average Time Early Stage HIV in Sporadic Care}
   b. \sim \text{People/Month}

250. "Fraction of Early Stage HIV in Sporadic Care Re-Engaged in Care Per Month" =
   a. 0.005
   b. \sim \text{Dimensionless/Month}

251. Average Time in Acutely Infected in Sporadic Care =
   a. 2
   b. \sim \text{Month}

252. "Fraction of Late Stage HIV in Sporadic Care Re-Engaged in Care Per Month" =
   a. 0.025
   b. \sim \text{Dimensionless/Month}

253. Mid Stage HIV in Care Moving to Sporadic Care =
   a. \text{Fraction of Mid Stage HIV in Care Moving to Sporadic Care Per Month} \times \text{Mid Stage HIV, Engaged in HIV Care}
   b. \sim \text{People/Month}
   c. \sim \text{|}
254. Mid Stage HIV in Sporadic Care Progressing to Late Stage HIV in Sporadic Care =
   a. "Mid Stage HIV, Entered HIV Care but Care Is Now Sporadic"/Average Time in
      Mid Stage HIV in Sporadic Care
   b. ~ People/Month

255. "Fraction of Acutely Infected in Sporadic Care Re-Engaged in Care Per Month" =
   a. 0.001
   b. ~ Dimensionless/Month

256. "Fraction of Mid Stage HIV in Sporadic Care Re-Engaged in Care Per Month" =
   a. 0.005
   b. ~ Dimensionless/Month

257. AIDS Deaths for Late Stage HIV in Sporadic Care =
   a. "Late Stage HIV, Entered HIV Care but Care Is Now Sporadic"/Current Average
      Time Late Stage HIV in Sporadic Care
   b. ~ People/Month

258. "Cumulative HIV-related deaths"= INTEG (  
   a. AIDS Deaths Among Late Stage HIV Unaware + AIDS Deaths Among Late
      Stage HIV Diagnosed + AIDS Deaths Among Late Stage HIV in Care + AIDS
      Deaths for Late Stage HIV in Sporadic Care, Initial Value for Cumulative HIV
      Related Deaths)
   b. ~ People

259. Date that Infection Rate Changes =
   a. 1
   b. ~ Month

260. Adjustment to Infection Rates to Capture Declining Infection Rate from 2006 to 2009 =
   a. Slope Starting Point + RAMP( Slope of Infection Rate from 2006 to 2009, Date
      that Infection Rate Changes, Date That Infection Rates Becomes Constant )
   b. ~ Dimensionless

261. Slope of Infection Rate from 2006 to 2009 =
   a. (Current Infection Rate-Slope Starting Point)/(Date That Infection Rates Becomes
      Constant-Date that Infection Rate Changes)
   b. ~ Dimensionless/Month

262. Slope Starting Point =
   a. 1
   b. ~ Dimensionless

263. Current Infection Rate =
a. 0.25 
b. ~ Dimensionless

264. Infection Rate Per Contact for Acute HIV Infection Unaware =
   a. 0.031 
b. ~ Dimensionless

265. Date That Infection Rates Becomes Constant =
   a. 60 
b. ~ Month

266. Uninfected = INTEG ( 
   a. -New Infections Per Month, 1.37135e+07) 
b. ~ People

267. Contacts per Late Stage HIV in Care =
   a. 2 
b. ~ Dimensionless/Month

268. Contacts per Mid Stage HIV in Care =
   a. 2 
b. ~ Dimensionless/Month

269. New Infections from Unaware =
   a. New Infections Generated by Acute HIV Infection Unaware + New Infections Generated by Early Stage HIV Unaware + New Infections Generated by Late Stage HIV Unaware + New Infections Generated by Mid Stage HIV Unaware 
b. ~ People/Month

270. Contacts Per Contacts Acute HIV Infection in Care =
   a. 2 
b. ~ Dimensionless/Month

271. Fraction of New Infections from Individuals in Care =
   a. New Infections from Individuals and in Care/New Infections Per Month 
b. ~ Dimensionless

272. Fraction of New HIV Infections from Non Acute Aware =
   a. New Infections from Non Acute Aware/New Infections Per Month 
b. ~ Dimensionless

273. Fraction of New Infections from Unaware =
   a. New Infections from Unaware/New Infections Per Month 
b. ~ Dimensionless
274. Contacts per Late Stage HIV Diagnosed =
   a. 2
   b. ~ Dimensionless/Month

275. New Infections from Individuals and in Care =
   a. New Infections Generated by Acute HIV Infection in Care + New Infections
      Generated by Early Stage HIV in Care + New Infections Generated by Late Stage
      HIV in Care + New Infections Generated by Mid Stage HIV in Care
   b. ~ People/Month

276. New Infections from Non Acute Aware=
   a. New Infections Generated by Acute HIV Infection Diagnosed + New Infections
      Generated by Early Stage HIV Diagnosed + New Infections Generated by Late
      Stage HIV Diagnosed + New Infections Generated by Mid Stage HIV Diagnosed
   b. ~ People/Month

277. Contacts per Early Stage HIV in Care=
   a. 2
   b. ~ Dimensionless/Month

278. Contacts per Early Stage HIV Diagnosed =
   a. 2
   b. ~ Dimensionless/Month

279. Contacts Per Late Stage HIV Unaware =
   a. 4
   b. ~ Dimensionless/Month

280. Contacts Per Mid Stage HIV Unaware =
   a. 4
   b. ~ Dimensionless/Month

281. Contacts Per Mid Stage HIV Diagnosed =
   a. 2
   b. ~ Dimensionless/Month

282. Contacts Per Acute HIV Infection Diagnosed =
   a. 2
   b. ~ Dimensionless/Month

283. Contacts Per Early Stage HIV Unaware =
   a. 4
   b. ~ Dimensionless/Month

284. Infection Rate per Acute HIV Infection Diagnosed =
a. 0.00999757
b. ~ Dimensionless

285. Infection Rate per Contact for Early Stage HIV Unaware =
a. 0.0019
b. ~ Dimensionless

286. Total Population =
a. "People Living with HIV Infection (Diagnosed and Undiagnosed)"+Uninfected
b. ~ People

287. Fraction of HIV Cases Who Are Diagnosed =
a. People Living with Diagnosed HIV Infection/"People Living with HIV Infection (Diagnosed and Undiagnosed)"
b. ~ Dimensionless

288. Fraction of HIV Cases Who Are Undiagnosed =
a. 1-Fraction of HIV Cases Who Are Diagnosed
b. ~ Dimensionless

289. People Living with Diagnosed HIV Infection =
a. People Living with Diagnosed Acute HIV Infection + People Living with Diagnosed Early Stage HIV + People Living with Diagnosed Late Stage HIV + People Living with Diagnosed Mid Stage HIV
b. ~ People

290. Total Late Stage HIV Not in Care =
a. "Late Stage HIV, Unaware of HIV Infection" + "Late Stage HIV, Aware of HIV Infection (Not in Care)"
b. ~ People

291. Months Per Year =
a. 12
b. ~ Month/Year

292. Fraction of Late Stage HIV in Care Moving to Sporadic Care Per Month=
a. 0.005
b. ~ Dimensionless/Month

293. Fraction of Mid Stage HIV in Care Moving to Sporadic Care Per Month=
a. 0.005
b. ~ Dimensionless/Month

294. Average Time in Late Stage HIV Unaware=
a. 24
b. ~ Month

295. Average Time in Late Stage HIV Diagnosed =
   a. 24
   b. ~ Month

296. Average Time in Mid Stage HIV Diagnosed =
   a. 47
   b. ~ Month

297. Average Time in Mid Stage HIV Unaware =
   a. 47
   b. ~ Month

298. Mid Stage HIV in Care Progressing to Late Stage HIV in Care =
   a. "Mid Stage HIV, Engaged in HIV Care"/Average Time in Mid Stage HIV in Care
   b. ~ People/Month

299. "Acutely infected, unaware of HIV infection" = INTEG ( 
   a. New Infections Per Month-Acutely Infected Unaware Progressing to Early Stage HIV Unaware - Acutely Infected Unaware Tested and Diagnosed, "Initial Value for Acutely infected, unaware of HIV infection")
   b. ~ People

300. Acutely Infected Diagnosed Initially Linked to Care =
   a. Leaving Acutely Infected Diagnosed*Fraction Acutely Infected Linked to Care
   b. ~ People/Month

301. Acutely Infected Diagnosed Progressing to Early Stage HIV Diagnosed =
   a. Leaving Acutely Infected Diagnosed*(1-Fraction Acutely Infected Linked to Care)
   b. ~ People/Month

302. Acutely Infected Unaware Progressing to Early Stage HIV Unaware =
   a. (1-Fraction Acutely Infected Unaware Getting Tested)*Leaving Acutely Infected Unaware
   b. ~ People/Month

303. Average Time in Acutely Infected in Care =
   a. 2
   b. ~ Month

304. Average Time in Acutely Infected Unaware =
   a. 2
   b. ~ Month
305. Average Time in Acutely Infected Diagnosed =
   a. 2
   b. ~ Month

306. Average Time in Early HIV Unaware =
   a. 47
   b. ~ Month

307. Average Time in Early Stage HIV Diagnosed =
   a. 47
   b. ~ Month

308. Early Stage HIV in Care Progressing to Mid Stage HIV in Care =
   a. "Early Stage HIV, Engaged in HIV Care"/Average Time in Early Stage HIV in Care
   b. ~ People/Month

309. Fraction of Acutely Infected in Care Moving to Sporadic Care Per Month =
   a. 0.002
   b. ~ Dimensionless/Month

310. Fraction of Early Stage HIV in Moving to Sporadic Care Per Month =
   a. 0.005
   b. ~ Dimensionless/Month

311. Leaving Acutely Infected Diagnosed =
   a. "Acutely Infected, Aware of HIV Infection (Not in Care)"/Average Time in Acutely Infected Diagnosed
   b. ~ People/Month

312. Leaving Acutely Infected Unaware =
   a. "Acutely infected, unaware of HIV infection"/Average Time in Acutely Infected Unaware
   b. ~ People/Month

313. Number of Medical Professionals in NYS =
   a. 15,000
   b. ~ Medical Professionals

314. Value of Ramp =
   a. Number of Medical Professionals in NYS / (End Time Medical Professionals – Start Time Medical Professionals)
   b. ~ Medical Professionals

315. Start Time Medical Professionals =
a. 57
b. ~ Month

316. End Time Medical Professionals in NYS =
   a. Initial End Time for Medical Professionals in NYS * Sensitivity Test One
   b. ~ Month

317. Initial End Time for Medical Professionals in NYS =
   a. 93
   b. ~ Month

318. ************************************************************************
   a. Control

319. ************************************************************************
   i. Simulation Control Parameters
   b. |

320. FINAL TIME = 180
   a. ~ Month
   b. ~ The final time for the simulation.
   c. |

321. INITIAL TIME = 0
   a. ~ Month
   b. ~ The initial time for the simulation.
   c. |

322. TIME STEP = 0.0625
   a. ~ Month [0,?] 
   b. ~ The time step for the simulation.
   c. |
### Appendix 4: Data Sources for Fixed Parameters and Initial Conditions

This table displays the values, units, and sources for all constants in the model. The first column lists the equation number from Appendix 3.

<table>
<thead>
<tr>
<th>Eq #</th>
<th>Variable Name</th>
<th>Value</th>
<th>Units</th>
<th>Source</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Adjustment to Capture People Living Longer with Antiretroviral Therapy</td>
<td>$1 \times (1 + \text{Ramp}(0.0075, 0.60))$</td>
<td>Dimensionless</td>
<td>Calibration based on number of people living with HIV and deaths from BHAЕ surveillance data (see Tables 3.1 and 3.2), and a published estimate that life expectancy for people living with HIV is 75 years (67).</td>
<td>Empirical data show that deaths rates are declining over time as individuals live longer as a result of antiretroviral therapies.</td>
</tr>
<tr>
<td>30</td>
<td>X Months Until Appropriate to Offer Subsequent Incremental Test</td>
<td>12, 60, or 1e9</td>
<td>Month</td>
<td>Scenario</td>
<td>Used to test scenarios that vary the period of time until individuals are retested under incremental testing.</td>
</tr>
<tr>
<td>36</td>
<td>Switch for Sensitivity Test of Perfect Viral Load Suppression</td>
<td>0</td>
<td>Dimensionless</td>
<td>Scenario</td>
<td>This allows all individuals in care to have perfect viral load suppression, which corresponds with one of the sensitivity analyses.</td>
</tr>
<tr>
<td>38</td>
<td>Initial Fraction of HIV Cases in Care Not Virally Suppressed</td>
<td>0.25</td>
<td>Dimensionless</td>
<td>(33)</td>
<td>Among HIV-infected New Yorkers in care, 25% do not have viral suppression and may transmit HIV.</td>
</tr>
<tr>
<td>43</td>
<td>Contacts Per Acute HIV Infection HIV Acutely Infected Unaware</td>
<td>4</td>
<td>Dimensionless/ Month</td>
<td>Calibration based on published literature on relative contribution of infections from individuals in each category, combined with number of individuals in each stock.</td>
<td>See section 3c, viii. The actual contact rate is unknown for all groups, and the infection rate (product of contact rate, probability of infection per contact, and size of uninfected population) was estimated via calibration. The true contact rate is unknown and the absolute value is not meaningful. However, the relative differences across categories (e.g. unaware individuals have 2 times the number of contacts as aware individuals) is meaningful and incorporated into the estimate.</td>
</tr>
<tr>
<td>Eq #</td>
<td>Variable Name</td>
<td>Value</td>
<td>Units</td>
<td>Source</td>
<td>Comments</td>
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</tr>
<tr>
<td>46</td>
<td>Fraction Acutely Infected Initially Linked to Care</td>
<td>0.25</td>
<td>Dimensionless</td>
<td>BHAE unpublished surveillance data of diagnosis and linkage to care by stage (see section 3c, iii).</td>
<td>This may seem high, but people are only in the S0R1 stock for 2 months due to natural disease progression.</td>
</tr>
<tr>
<td>47</td>
<td>Fraction Early HIV Infected Getting Tested Per Month</td>
<td>0.018</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>This is the background testing rate in the absence of the law, and assumed to be continue throughout the period.</td>
</tr>
<tr>
<td>49</td>
<td>Fraction of Late Stage HIV Diagnosed Initially Linked to Care Per Month</td>
<td>0.5</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>This is high as people diagnosed with concurrent AIDS are sick and almost all of them will go into care.</td>
</tr>
<tr>
<td>50</td>
<td>Fraction of Mid Stage HIV Diagnosed Initially Linked to Care Per Month</td>
<td>0.02</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>This fraction may seem low, but people are in S1R1 for 47 months as part of the natural disease progression.</td>
</tr>
<tr>
<td>51</td>
<td>Fraction of Mid Stage HIV Infected Getting Tested Per Month</td>
<td>0.032</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>This is the background testing rate in the absence of the law, and assumed to be continue throughout the period.</td>
</tr>
<tr>
<td>52</td>
<td>Fraction of Late Stage HIV Infected Getting Tested Per Month</td>
<td>0.99</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>53</td>
<td>Fraction of Early Stage HIV Diagnosed Initially Linked to Care Per Month</td>
<td>0.015</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>This fraction may seem low, but people are in S1R1 for 47 months as part of the natural disease progression.</td>
</tr>
<tr>
<td>63</td>
<td>Initial Average Time in Late Stage HIV in Sporadic Care</td>
<td>310</td>
<td>Month</td>
<td>Calibration based on number of people living with HIV and deaths from BHAE surveillance data (see Tables 3.1 and 3.2), and a published estimate that life expectancy for people living with HIV is 75 years (67).</td>
<td>Assumption that gains in life expectancy are 75% of gains among individuals engaged in care. (See section 3c, vii.)</td>
</tr>
<tr>
<td>Eq #</td>
<td>Variable Name</td>
<td>Value</td>
<td>Units</td>
<td>Source</td>
<td>Comments</td>
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<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>66</td>
<td>Infection Rate per Contact for Early Stage HIV Diagnosed</td>
<td>0.0025</td>
<td>Dimensionless</td>
<td>Model calibration, described in Section 3c, viii.</td>
<td>Time for medical professionals to gradually become aware of the law, and therefore start offering tests to patients.</td>
</tr>
<tr>
<td>70</td>
<td>Testing Law Implementation Ramp</td>
<td>IF THEN ELSE( Switch to Turn on Testing Law Structure=0 , 0 , RAMP( Value for Ramp, Start Time Medical Professionals , End Time Medical Professionals ) )</td>
<td>Medical Professionals</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>Switch to Turn on Testing Law Structure</td>
<td>0</td>
<td>Dimensionless</td>
<td>N/A</td>
<td>Turns policy off (=0) and on (=1).</td>
</tr>
<tr>
<td>72</td>
<td>Adjustment Time for Professional Awareness of Testing Law</td>
<td>36</td>
<td>Month</td>
<td>Expert opinion about length of time to implement Bronx Knows.</td>
<td>Assumption vetted with steering committee.</td>
</tr>
<tr>
<td>76</td>
<td>Average Number of Unique Patients Seen Per Medical Professional Each Month</td>
<td>126</td>
<td>People / Month / Medical Professionals</td>
<td>(68)</td>
<td>Unique people seen per provider in a month.</td>
</tr>
<tr>
<td>78</td>
<td>Fraction of People Accepting Test if Offered</td>
<td>0.6, 1.0</td>
<td>Dimensionless</td>
<td>Scenarios; unpublished data from NYS module of the BRFSS; see table 4.1.</td>
<td>Value set to 0.6 for high and low implementation scenarios, and 1.0 for perfect implementation.</td>
</tr>
<tr>
<td>80</td>
<td>Fraction of Medical Professionals Offering Tests</td>
<td>0.25, 0.75, 1.0</td>
<td>Dimensionless</td>
<td>Scenarios; unpublished data from NYS module of the BRFSS; see table 4.1.</td>
<td>Value set to 1.0 for perfect implementation scenario, 0.75 for high implementation, and 0.25 for low implementation. Values discussed by steering committee.</td>
</tr>
<tr>
<td>83</td>
<td>Average Time in Early Stage HIV in Care</td>
<td>90</td>
<td>Month</td>
<td>Calibration based on number of people living with HIV and deaths from BHAE surveillance data (see Tables 3.1 and 3.2), and a published estimate that life expectancy for people living with HIV is 75 years (67).</td>
<td>Equations 83 and 84 were set to accumulate people in various disease stage categories to match historical data.</td>
</tr>
<tr>
<td>84</td>
<td>Average Time in Mid Stage HIV in Care</td>
<td>175</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>Eq #</td>
<td>Variable Name</td>
<td>Value</td>
<td>Units</td>
<td>Source</td>
<td>Comments</td>
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<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>162</td>
<td>Initial Value for Cumulative HIV Related Deaths</td>
<td>59,624</td>
<td>People</td>
<td>(2)</td>
<td>Individuals were allocated to the four stages (0, 1, 2, and 3) and rows (1, 2, 3, 4). The initial stage for unaware cases was based on the natural history of disease. The initial stage for diagnosed cases and individuals linked to care was based on surveillance data on linkage to care by stage. The allocation across rows (unaware, diagnosed, in regular or sporadic care) was based on internal data and expert opinion.</td>
</tr>
<tr>
<td>164</td>
<td>Initial Value for Early stage HIV, unaware of HIV infection</td>
<td>10,500</td>
<td>People</td>
<td>Published surveillance data on living cases (2); disease progression (34-37); Medicaid data on individuals in care (see section 3c, v); BHAE unpublished surveillance data of diagnosis and linkage to care by stage (see section 3c, iii); expert opinion on fraction of unaware cases (see section 3c, iv).</td>
<td>Individuals were allocated to the four stages (0, 1, 2, and 3) and rows (1, 2, 3, 4). The initial stage for unaware cases was based on the natural history of disease. The initial stage for diagnosed cases and individuals linked to care was based on surveillance data on linkage to care by stage. The allocation across rows (unaware, diagnosed, in regular or sporadic care) was based on internal data and expert opinion.</td>
</tr>
<tr>
<td>165</td>
<td>Initial Value for Early stage HIV, entered HIV care but care is now sporadic</td>
<td>6,163</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>166</td>
<td>Initial Value for Mid stage HIV, entered HIV care but care is now sporadic</td>
<td>4,237</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>167</td>
<td>Initial Value for Mid stage HIV, unaware of HIV infection</td>
<td>4,400</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>168</td>
<td>Initial Value for Acutely infected, unaware of HIV infection</td>
<td>861</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>169</td>
<td>Initial Value for Mid stage HIV, aware of HIV infection (not in care)</td>
<td>4,188</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>170</td>
<td>Initial Value for Mid stage HIV, Engaged in HIV care</td>
<td>12,158</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>Eq #</td>
<td>Variable Name</td>
<td>Value</td>
<td>Units</td>
<td>Source</td>
<td>Comments</td>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td>172</td>
<td>Initial Value for Acutely infected, engaged in HIV care</td>
<td>5</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>173</td>
<td>Initial Value for Acutely infected, entered HIV care but care is now sporadic</td>
<td>0</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>174</td>
<td>Initial Value for Early stage HIV, aware of HIV infection (not in care)</td>
<td>4,688</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>175</td>
<td>Initial Value for Early stage HIV, engaged in HIV care</td>
<td>15,929</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>176</td>
<td>Initial Value for Late stage HIV, engaged in HIV care</td>
<td>63,913</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>177</td>
<td>Initial Value for Late stage HIV, entered HIV care but care is now sporadic</td>
<td>7,981</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>178</td>
<td>Initial Value for Late stage HIV, unaware of HIV infection</td>
<td>110</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>179</td>
<td>Initial Value for Late stage HIV, aware of HIV infection (not in care)</td>
<td>376</td>
<td>People</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>193</td>
<td>Fraction of Late Stage HIV with Non-AIDS Deaths Per Month</td>
<td>0.0003</td>
<td>Dimensionless / Month</td>
<td>BHA surveillance data (see Table 3.2).</td>
<td>Fraction calculated based on the people living with HIV/AIDS.</td>
</tr>
<tr>
<td>205</td>
<td>Fraction of Early Stage HIV with Non AIDS Deaths Per Month</td>
<td>0.0003</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>206</td>
<td>Fraction of Mid Stage HIV with Non-AIDS Deaths Per Month</td>
<td>0.0003</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>Eq #</td>
<td>Variable Name</td>
<td>Value</td>
<td>Units</td>
<td>Source</td>
<td>Comments</td>
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<td>---------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>234</td>
<td>Contacts per Early Stage HIV in Sporadic Care</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>235</td>
<td>Contacts Per Acute HIV Infection in Sporadic Care</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>237</td>
<td>Average Time Early Stage HIV in Sporadic Care</td>
<td>68</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>244</td>
<td>Average Time in Mid Stage HIV in Sporadic Care</td>
<td>100</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>250</td>
<td>Fraction of Early Stage HIV in Sporadic Care Re-Engaged in Care Per Month</td>
<td>0.005</td>
<td>Dimensionless / Month</td>
<td>Medicaid data, see section 3c, v.</td>
<td>Captures the movement of people from care (R3) into sporadic care (R4).</td>
</tr>
<tr>
<td>251</td>
<td>Average Time in Acutely Infected in Sporadic Care</td>
<td>2</td>
<td>Month</td>
<td>Literature (34-37); see section 3c, vii</td>
<td></td>
</tr>
<tr>
<td>255</td>
<td>Fraction of Acutely Infected in Sporadic Care Re-Engaged in Care Per Month</td>
<td>0.001</td>
<td>Dimensionless / Month</td>
<td>Medicaid data, see section 3c, v.</td>
<td>Captures the movement of people from sporadic care (R4) into care (R3).</td>
</tr>
<tr>
<td>256</td>
<td>Fraction of Mid Stage HIV in Sporadic Care Re-Engaged in Care Per Month</td>
<td>0.005</td>
<td>Dimensionless / Month</td>
<td>Medicaid data, see section 3c, v.</td>
<td>Captures the movement of people from care (R4) into sporadic care (R3).</td>
</tr>
<tr>
<td>259</td>
<td>Date that Infection Rate Changes</td>
<td>1</td>
<td>Month</td>
<td>N/A</td>
<td>Part of the structure that captures the historical decline in new infections from 2006 to 2009.</td>
</tr>
<tr>
<td>262</td>
<td>Slope Starting Point</td>
<td>1</td>
<td>Month</td>
<td>N/A</td>
<td>See above.</td>
</tr>
<tr>
<td>263</td>
<td>Current Infection Rate</td>
<td>0.25</td>
<td>Dimensionless</td>
<td>N/A</td>
<td>See above.</td>
</tr>
<tr>
<td>264</td>
<td>Infection Rate Per Contact for Acute HIV Infection Unaware</td>
<td>0.031</td>
<td>Dimensionless</td>
<td>Model calibration, described in Section 3c, viii.</td>
<td></td>
</tr>
<tr>
<td>Eq #</td>
<td>Variable Name</td>
<td>Value</td>
<td>Units</td>
<td>Source</td>
<td>Comments</td>
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<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>267</td>
<td>Contacts per Late Stage HIV in Care</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>Calibration based on published literature on relative contribution of infections from individuals in each category, combined with number of individuals in each stock.</td>
<td>See section 3c, viii. The actual contact rate is unknown for all groups, and this number was estimated via calibration.</td>
</tr>
<tr>
<td>268</td>
<td>Contacts per Mid Stage HIV in Care</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>270</td>
<td>Contacts per Contacts Acute HIV Infection in Care</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>274</td>
<td>Contacts per Late Stage HIV Diagnosed</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>277</td>
<td>Contacts per Early Stage HIV in Care</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>278</td>
<td>Contacts per Early Stage HIV Diagnosed</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>279</td>
<td>Contacts Per Late Stage HIV Unaware</td>
<td>4</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>280</td>
<td>Contacts Per Mid Stage HIV Unaware</td>
<td>4</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>281</td>
<td>Contacts Per Mid Stage HIV Diagnosed</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>282</td>
<td>Contacts Per Acute HIV Infection Diagnosed</td>
<td>2</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>283</td>
<td>Contacts Per Early Stage HIV Unaware</td>
<td>4</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>284</td>
<td>Infection Rate per Acute HIV Infection Diagnosed</td>
<td>0.00999757</td>
<td>Dimensionless</td>
<td>Model calibration, described in Section 3c, viii.</td>
<td>Many significant digits because value determined through calibration.</td>
</tr>
<tr>
<td>285</td>
<td>Infection Rate per Contact for Early Stage HIV Unaware</td>
<td>0.0019</td>
<td>Dimensionless</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>291</td>
<td>Months Per Year</td>
<td>12</td>
<td>Month</td>
<td>Common knowledge.</td>
<td>Used to convert monthly data into annual data.</td>
</tr>
<tr>
<td>Eq #</td>
<td>Variable Name</td>
<td>Value</td>
<td>Units</td>
<td>Source</td>
<td>Comments</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------------------------------------------</td>
<td>-------</td>
<td>------------------------</td>
<td>---------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>293</td>
<td>Fraction of Mid Stage HIV in Care Moving to Sporadic Care Per Month</td>
<td>0.005</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>Captures the movement of people from care (R4) into sporadic care (R3).</td>
</tr>
<tr>
<td>294</td>
<td>Average Time in Late Stage HIV Unaware</td>
<td>24</td>
<td>Month</td>
<td>Literature; see section 3c, vii (34-37)</td>
<td>Based on natural history of HIV disease, in absence of antiretroviral therapy. This includes 2 months in acute stage, 94 months (up to 10 years) in latent stages (assumed to be split evenly across stages 1 and 2), and 24 months in late stage.</td>
</tr>
<tr>
<td>295</td>
<td>Average Time in Late Stage HIV Diagnosed</td>
<td>24</td>
<td>Month</td>
<td>See above.</td>
<td>See above. Being diagnosed, but not in treatment, does not affect disease progression.</td>
</tr>
<tr>
<td>296</td>
<td>Average Time in Mid Stage HIV Diagnosed</td>
<td>47</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>297</td>
<td>Average Time in Mid Stage HIV Unaware</td>
<td>47</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>303</td>
<td>Average Time in Acutely Infected in Care</td>
<td>2</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>304</td>
<td>Average Time in Acutely Infected Unaware</td>
<td>2</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>305</td>
<td>Average Time in Acutely Infected Diagnosed</td>
<td>2</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>306</td>
<td>Average Time in Early HIV Unaware</td>
<td>47</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>307</td>
<td>Average Time in Early Stage HIV Diagnosed</td>
<td>47</td>
<td>Month</td>
<td>See above.</td>
<td>See above.</td>
</tr>
<tr>
<td>309</td>
<td>Fraction of Acutely Infected in Care Moving to Sporadic Care Per Month</td>
<td>0.002</td>
<td>Dimensionless / Month</td>
<td>Medicaid data, see section 3c, v.</td>
<td>Captures the movement of people from sporadic care (R4) into care (R4).</td>
</tr>
<tr>
<td>310</td>
<td>Fraction of Early Stage HIV in Moving to Sporadic Care Per Month</td>
<td>0.005</td>
<td>Dimensionless / Month</td>
<td>See above.</td>
<td>Captures the movement of people from care (R3) into sporadic care (R4).</td>
</tr>
</tbody>
</table>
References


Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines on the Use of Antiretroviral Agents in HIV-1 Infected Adults and Adolescents.: Department of Health and Human Services 2012.


