A System Dynamics-Based Evaluation of the Mandatory Offer of HIV Testing in New York State

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Roadmap

- Motivation for system dynamics policy evaluation
- Research methods
  - System dynamics modeling approach
  - HIVSIM model of New York HIV testing and treatment system
- Results: baseline projections, in absence of the law
- Results: potential effects of the law
- Key model insights

New York State HIV testing law

- Effective September 1, 2010
- Aims to increase HIV testing and subsequent entry into care and treatment
- Key features:
  - HIV testing required in routine medical care (ages 13-64)
  - Simplified informed consent and pre-test counseling
  - Providers/facilities offering HIV tests must arrange follow-up care appointments
- Statutory requirement for Commissioner of Health to evaluate the number of HIV tests and number who access care and treatment; due September 1, 2012

Rationale for system dynamics modeling study

- Quantitative data (surveys, administrative data, surveillance system) may not address complexities in the system of HIV testing and care
- Qualitative research can examine nuances, but cannot generate quantitative predictions
- Empirical data from other evaluation studies limited to short time horizon and measurable outcomes
- Law implemented in context of multiple concurrent policies that may affect outcomes

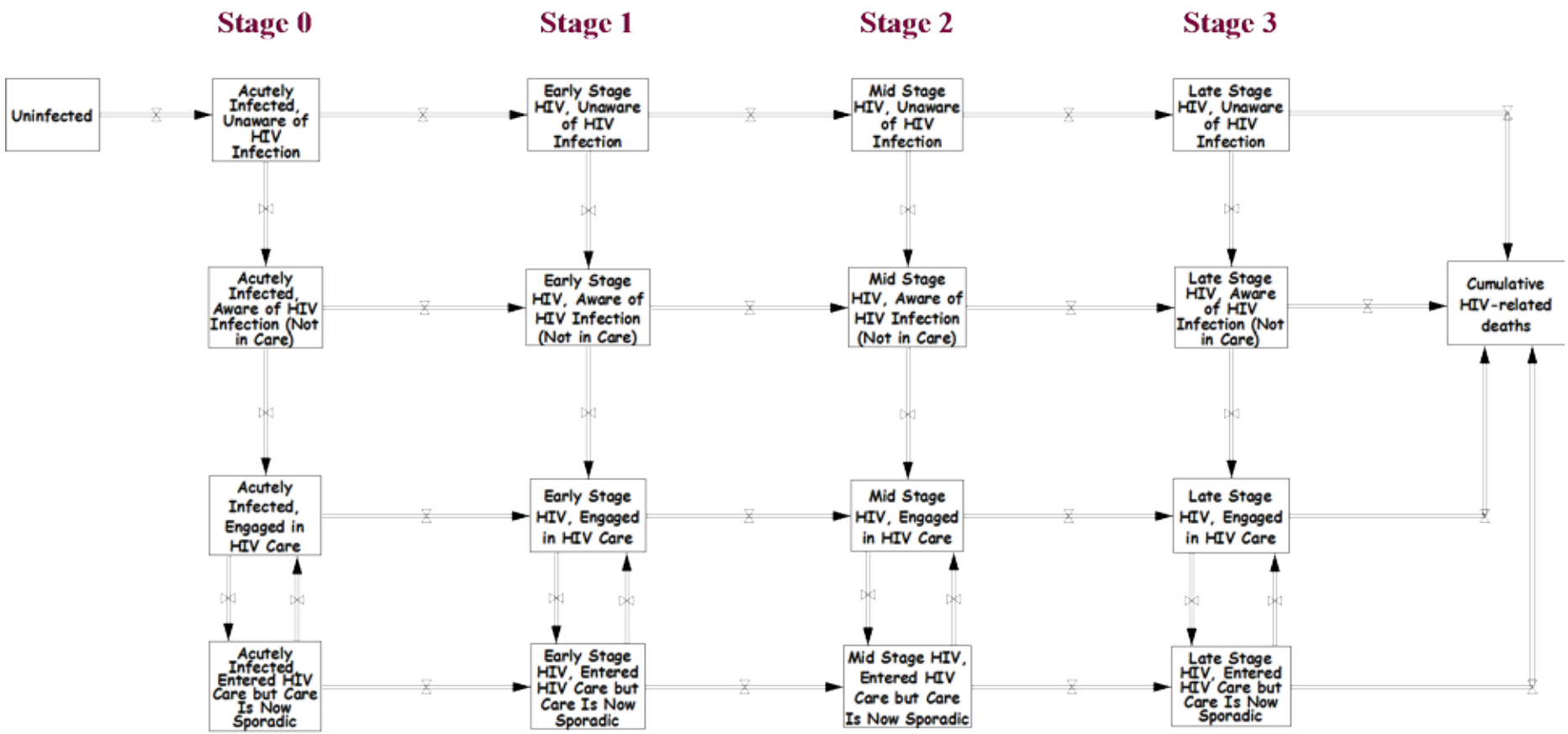
Features of system dynamics models

- Analyze problems in complex social, managerial, economic, or ecological systems, at the population level
- Work closely with stakeholders and experts to develop system structure and incorporate data
- Holistic view of the interaction of organizations and processes in system producing system-wide results
- Feedback loops to model dynamic system processes
- Nonlinearities in relationships among variables
- Dynamic implications of policies, *why* and *how* outcome will change, potential unintended consequences, areas where implementation may not lead to intended outcomes

Methods overview

- Computer simulation model of HIV testing and care in New York State (HIVSIM)
- Data sources used for HIVSIM parameters and calibration
  - HIV surveillance system (NYSDOH)
  - Medicaid claims (NYSDOH)
  - Incidence estimates (NYSDOH, using CDC methodology)
  - Expert opinion
  - Published literature
- Counterfactual analyses of short- and long-term outcomes under alternate implementation scenarios
- Results presented as graphs over time; % changes over time and across scenarios ("differences in differences")

HIVSIM stock and flow diagram



Stock and flow diagramming notation

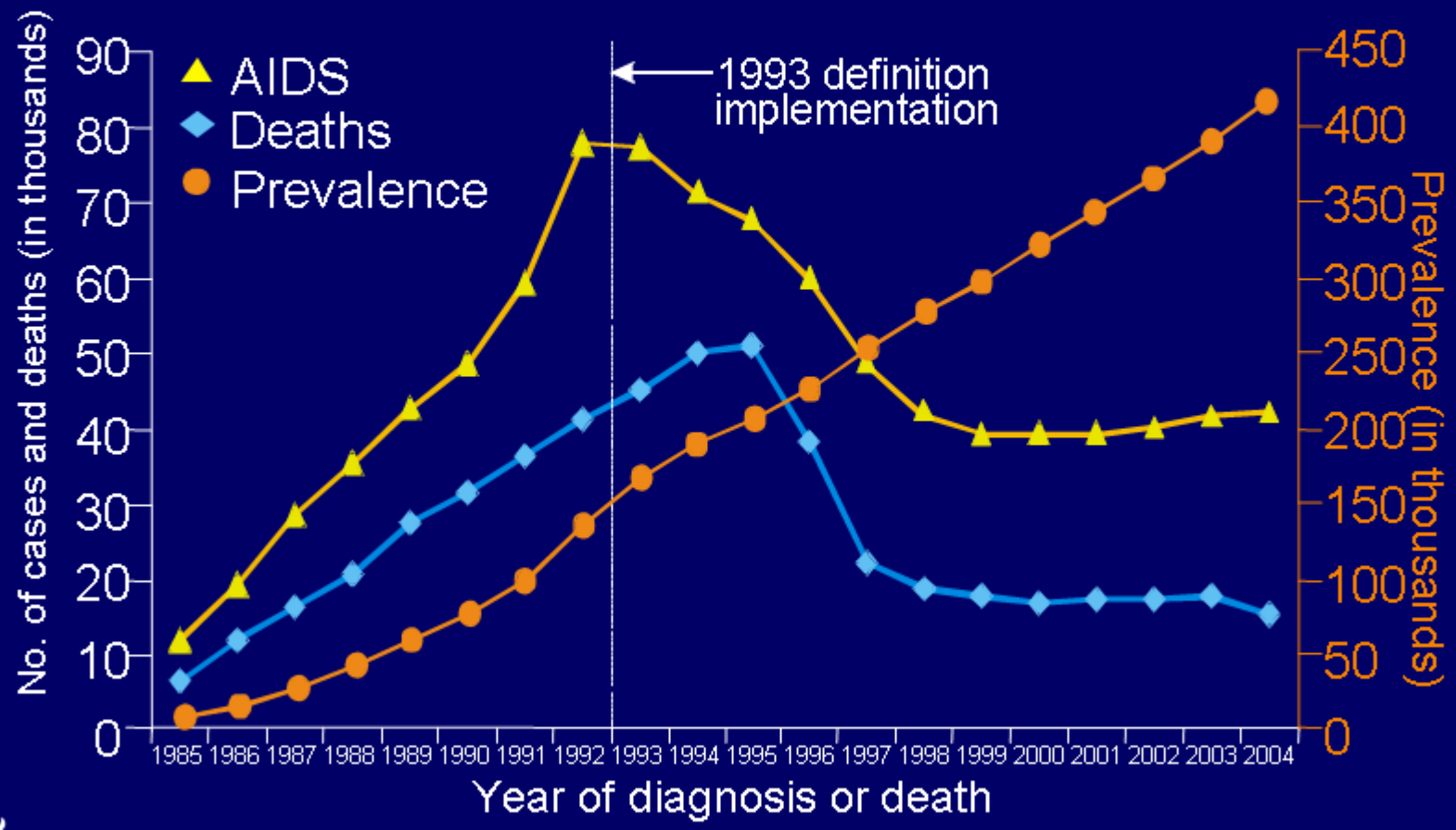
Stock

Flow

Valve (flow regulator)

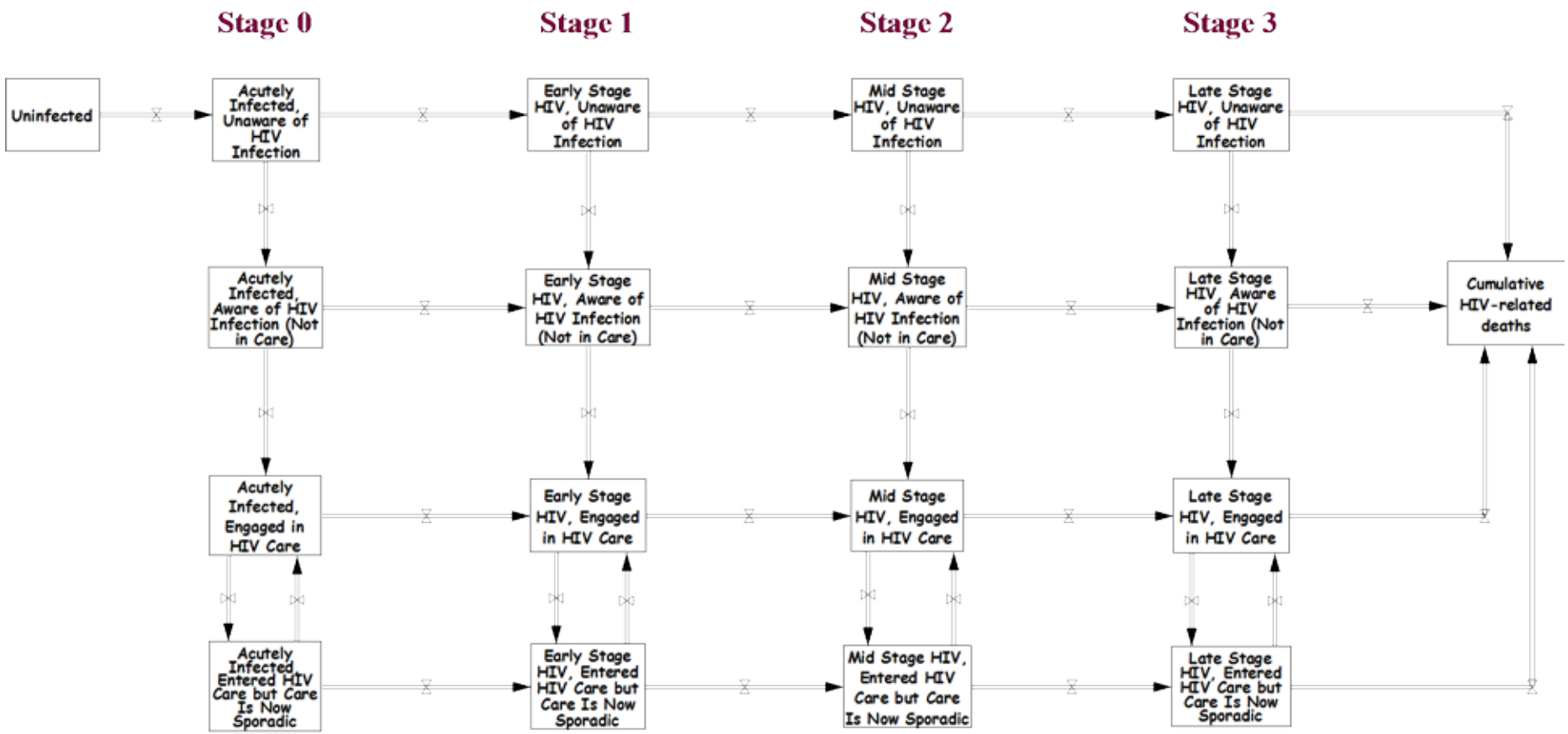
Source or Sink
(stocks outside the model boundary)

Estimated Number of AIDS Cases, Deaths, and Persons Living with AIDS,1985-2004, United States

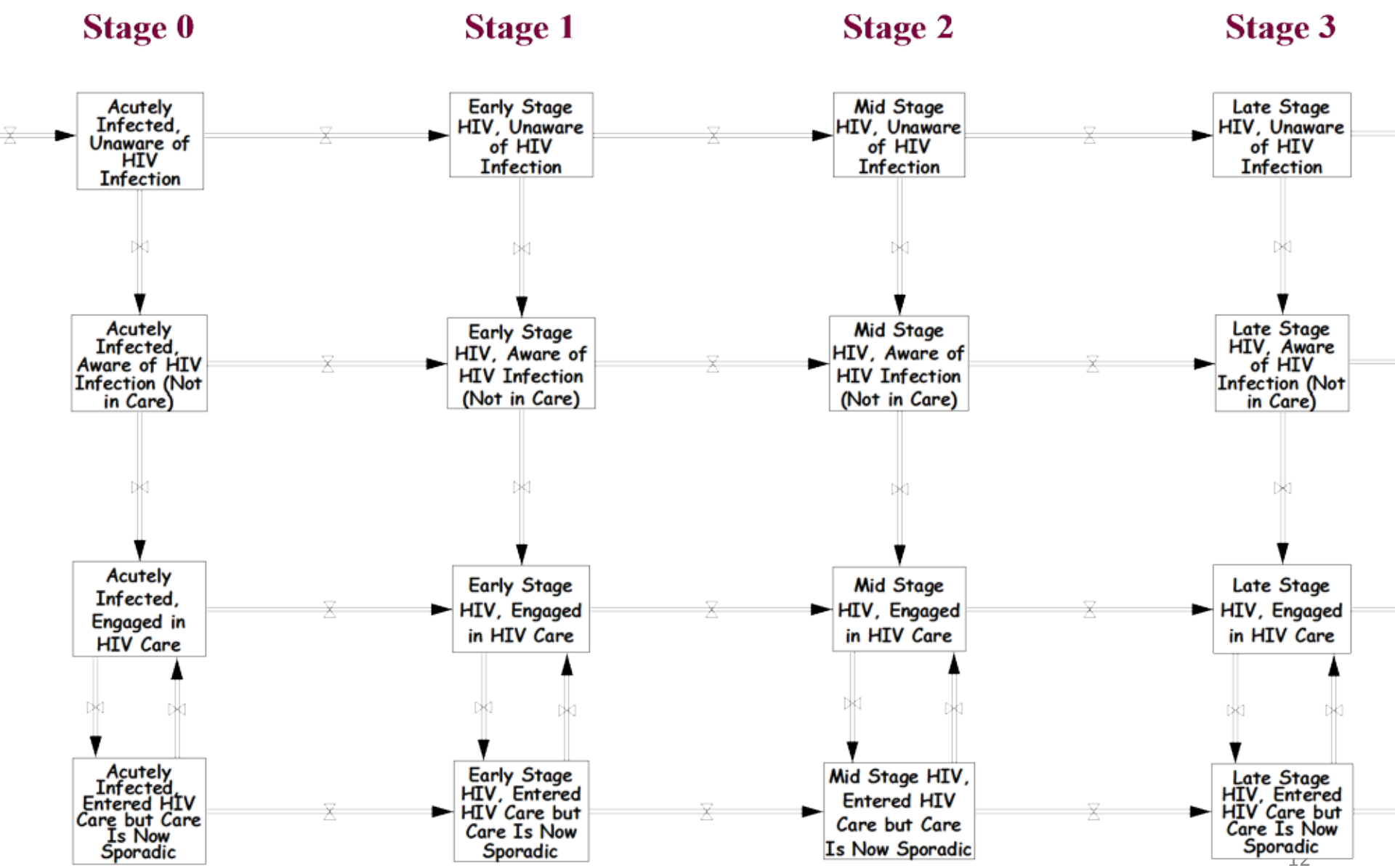


Note. Data adjusted for reporting delays.

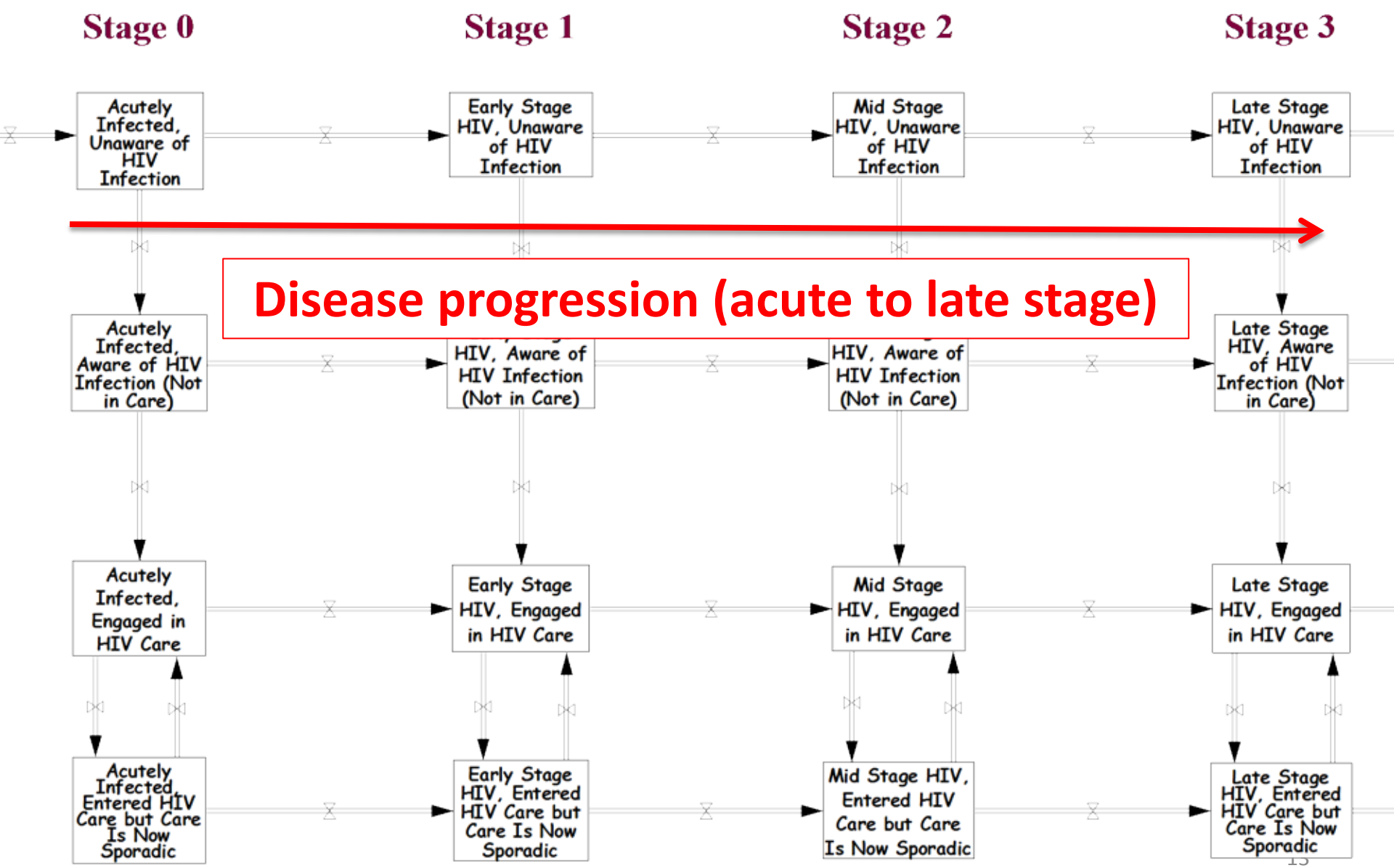
HIVSIM stock and flow diagram



Stock and flow diagram: zoomed in



Key features of HIVSIM



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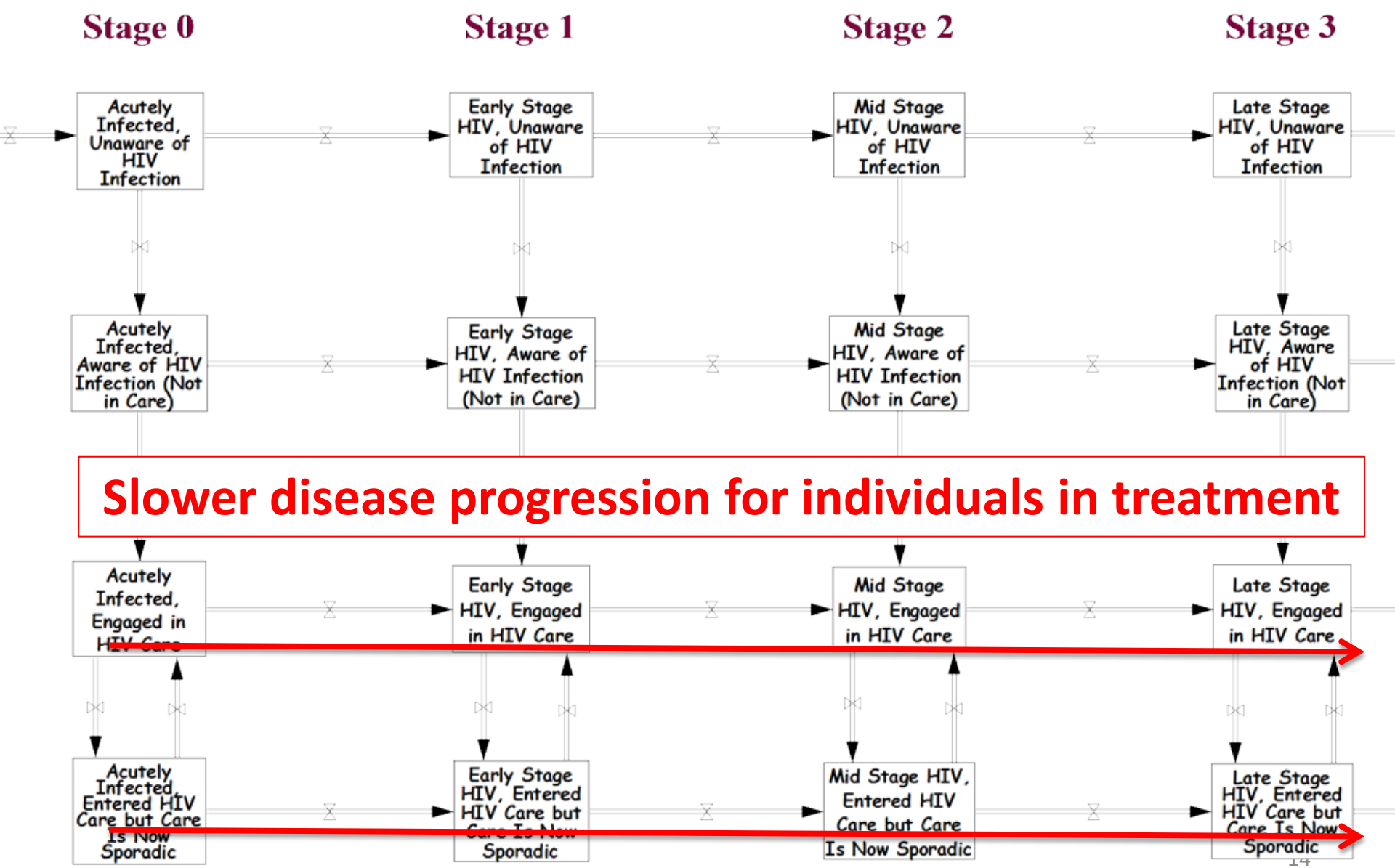
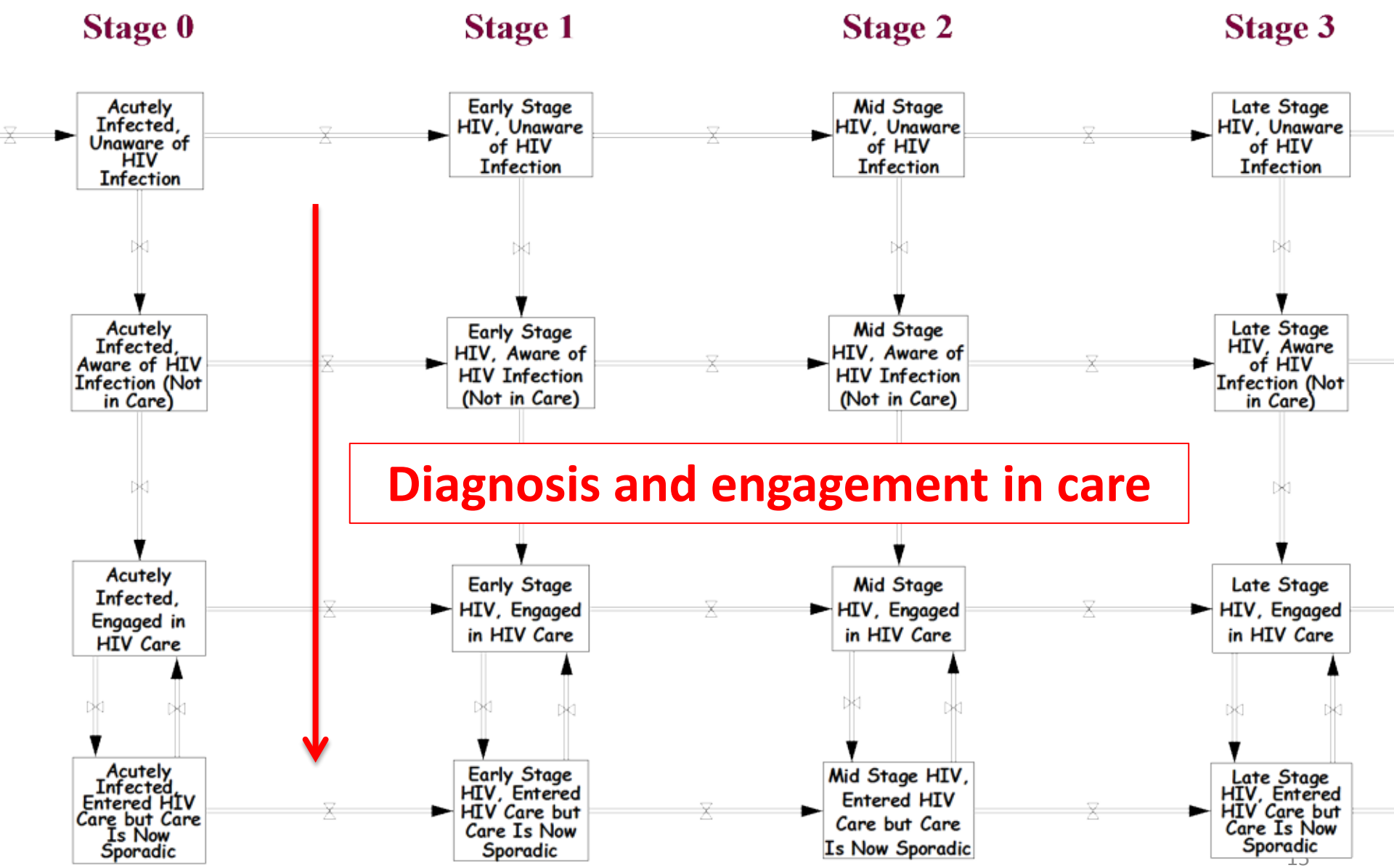


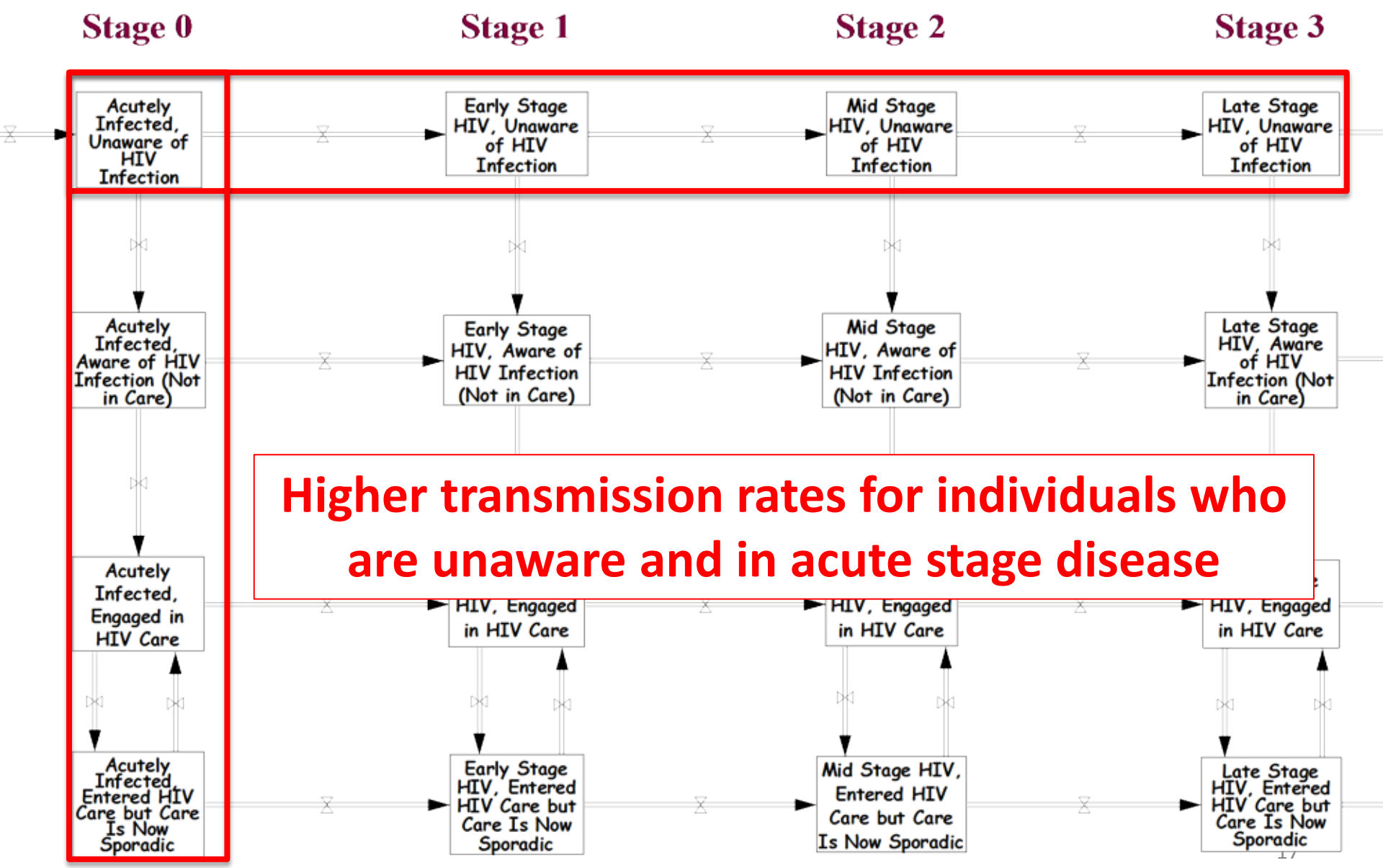
Key features of HIVSIM



Dynamics of different transmission rates

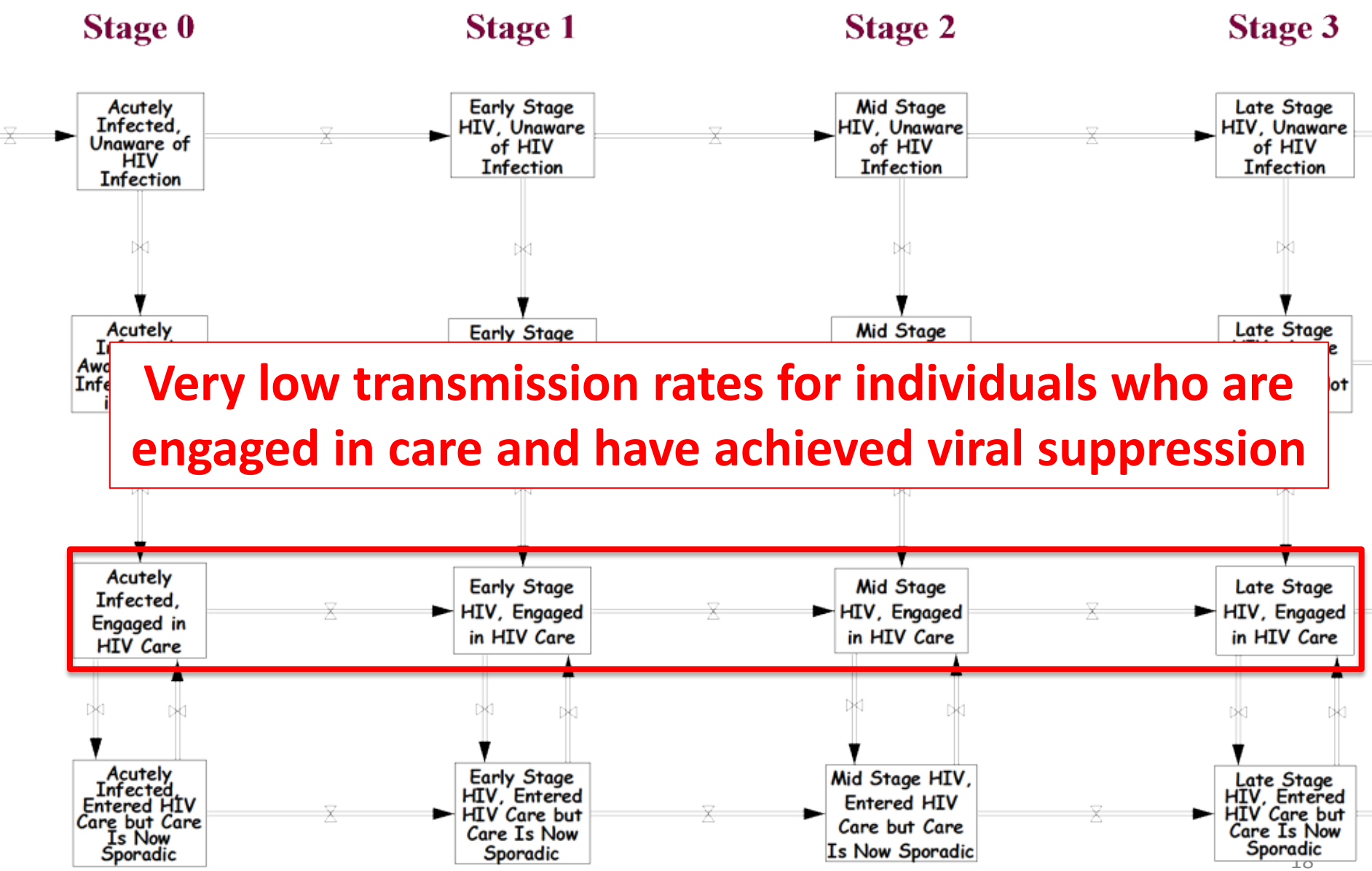
- Unaware individuals transmit 3.5 times more infections than diagnosed individuals (risk behaviors, viral load)
- 75% of New Yorkers engaged in care have a transmission rate of zero (complete viral suppression)
- 25% of new infections are attributable to acutely infected individuals
- Assumption that individuals in stages 1-3 (early, mid, late) have identical transmission rates

Different transmission rates in HIVSIM



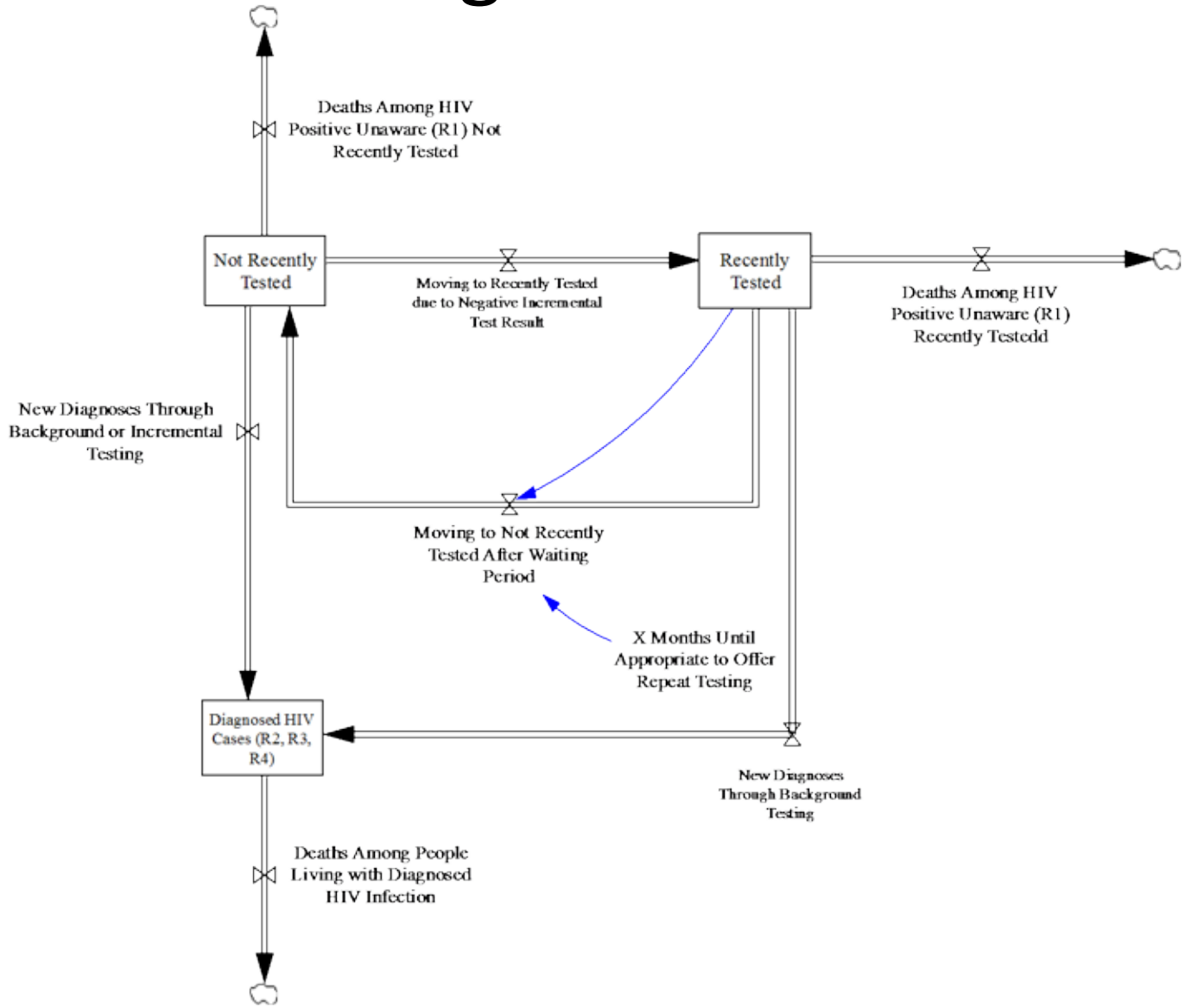
Higher transmission rates for individuals who are unaware and in acute stage disease

Different transmission rates in HIVSIM



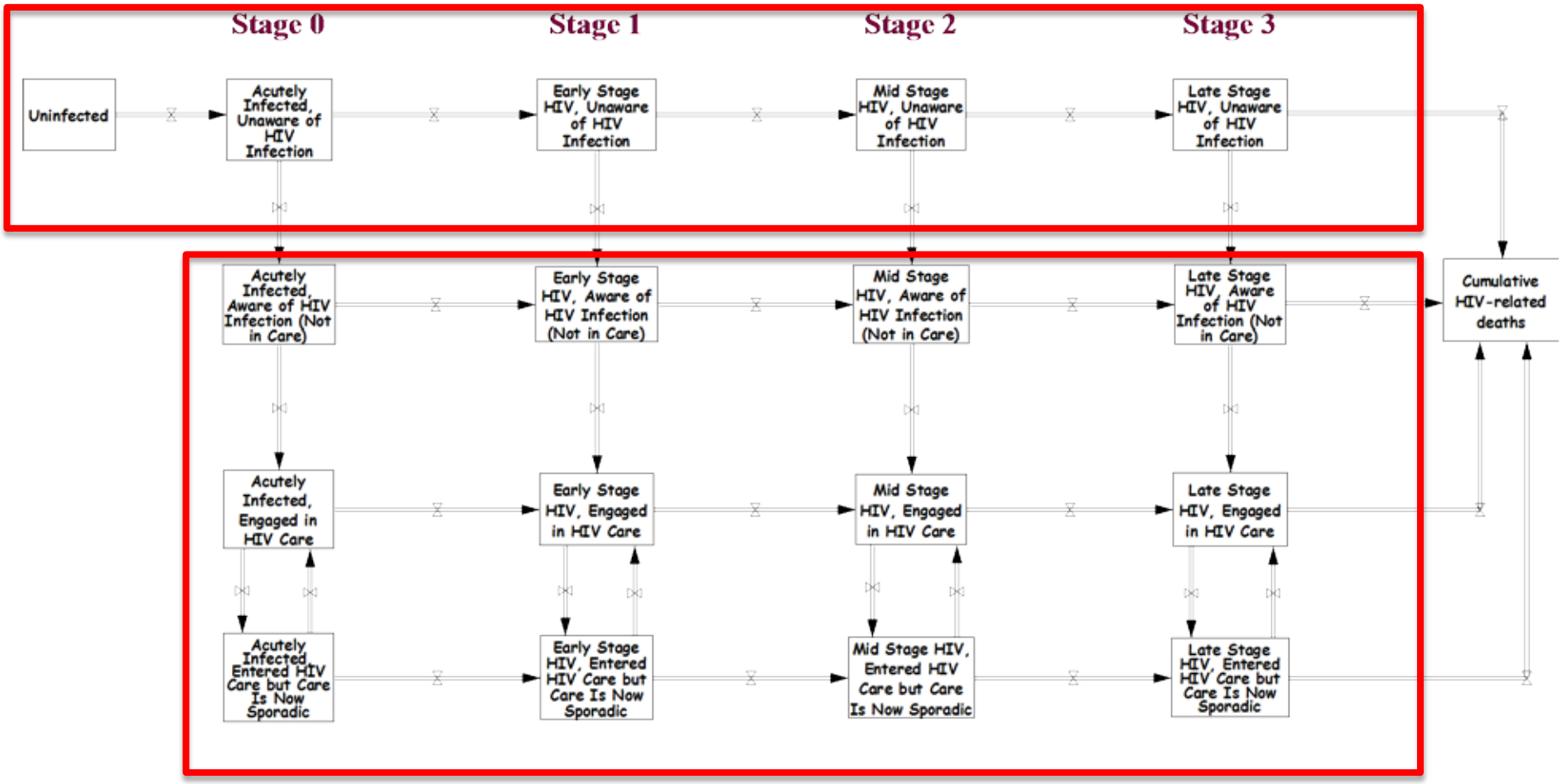
Very low transmission rates for individuals who are engaged in care and have achieved viral suppression

HIVSIM stock and flow diagram: HIV testing structure



Mapping between the diagrams

Population eligible for testing

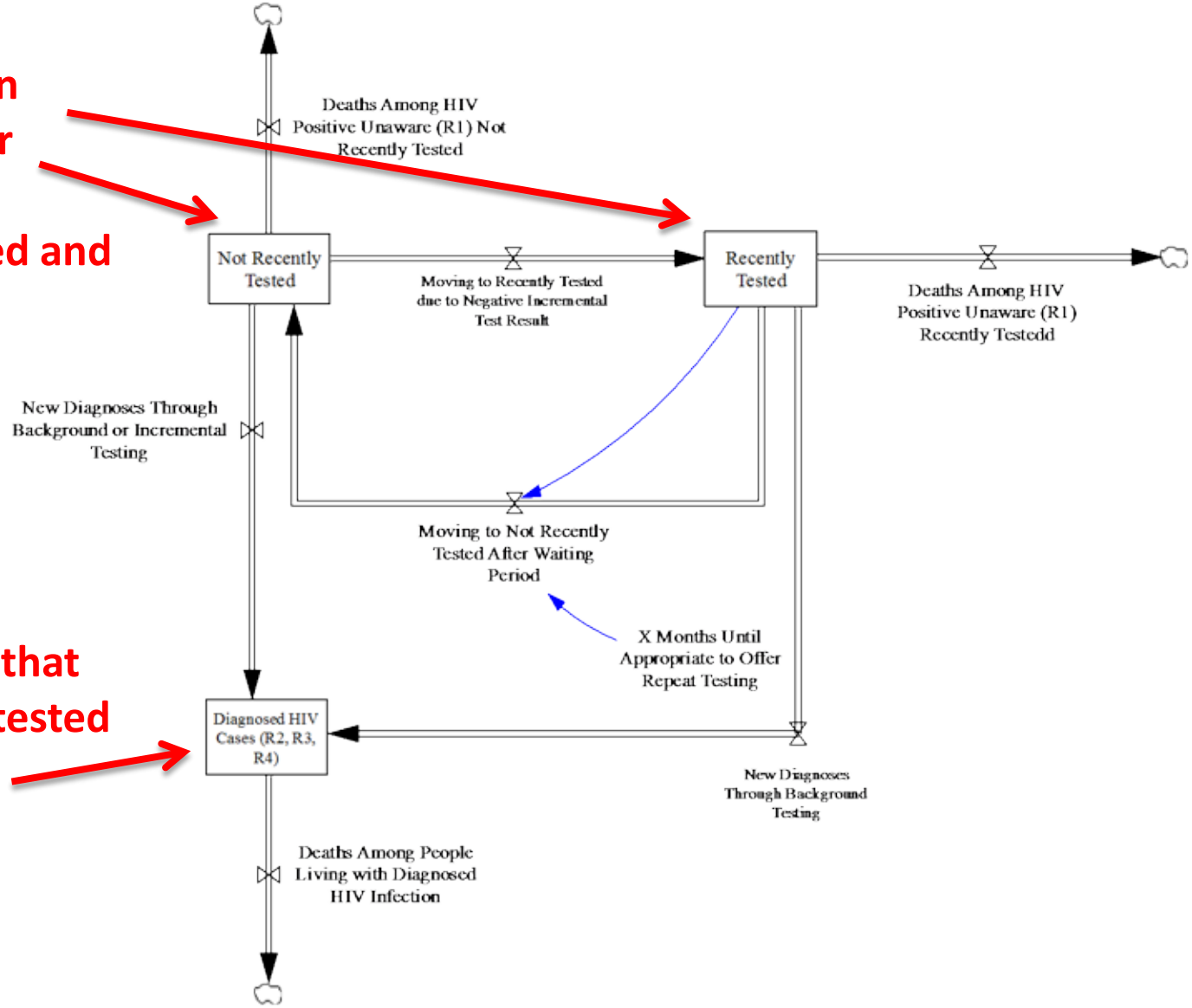


Population that previously tested positive

Mapping between the diagrams

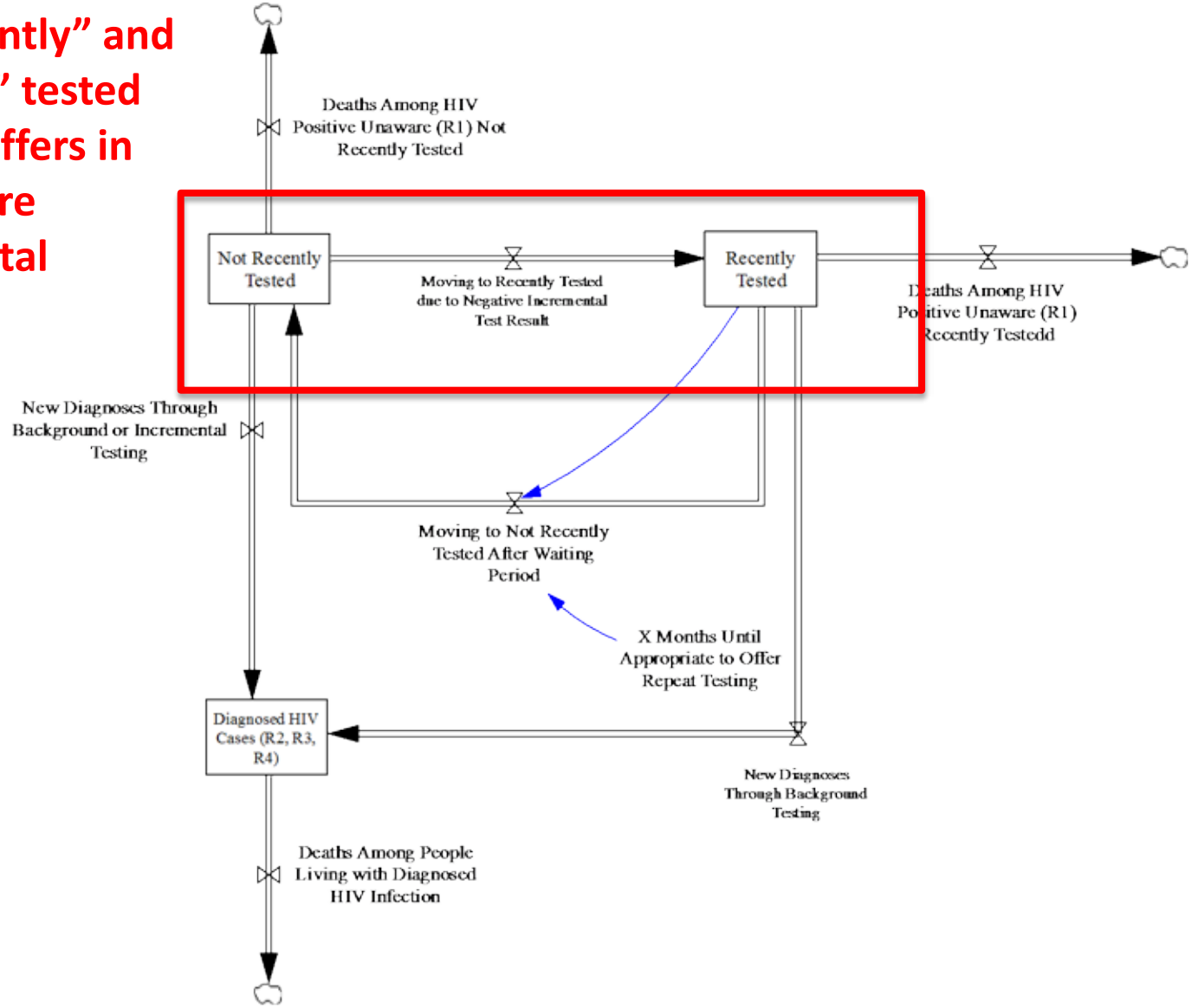
Population eligible for testing (uninfected and unaware)

Population that previously tested positive



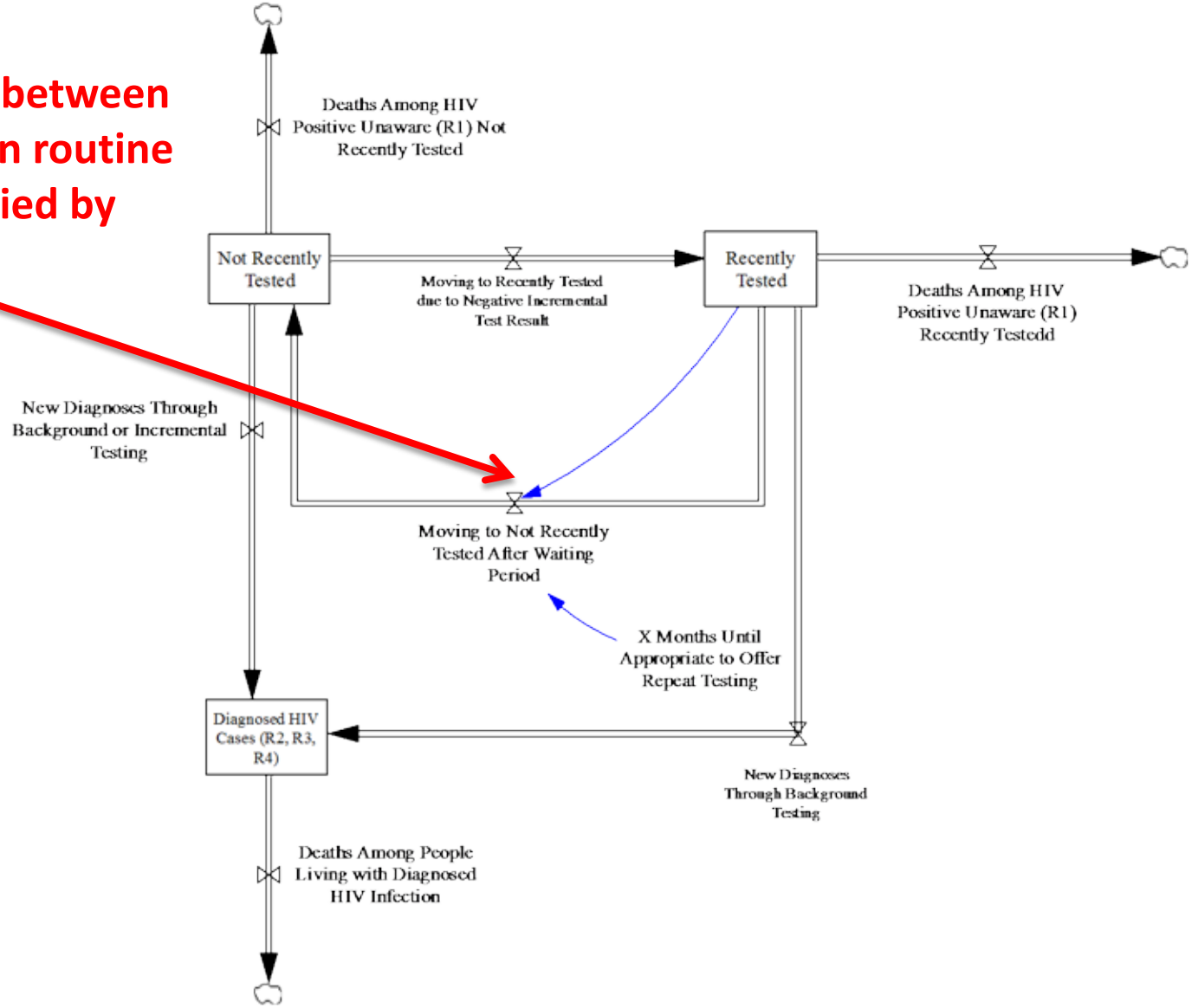
HIVSIM stock and flow diagram: HIV testing structure

"Not Recently" and "Recently" tested refers to offers in routine care (incremental testing)



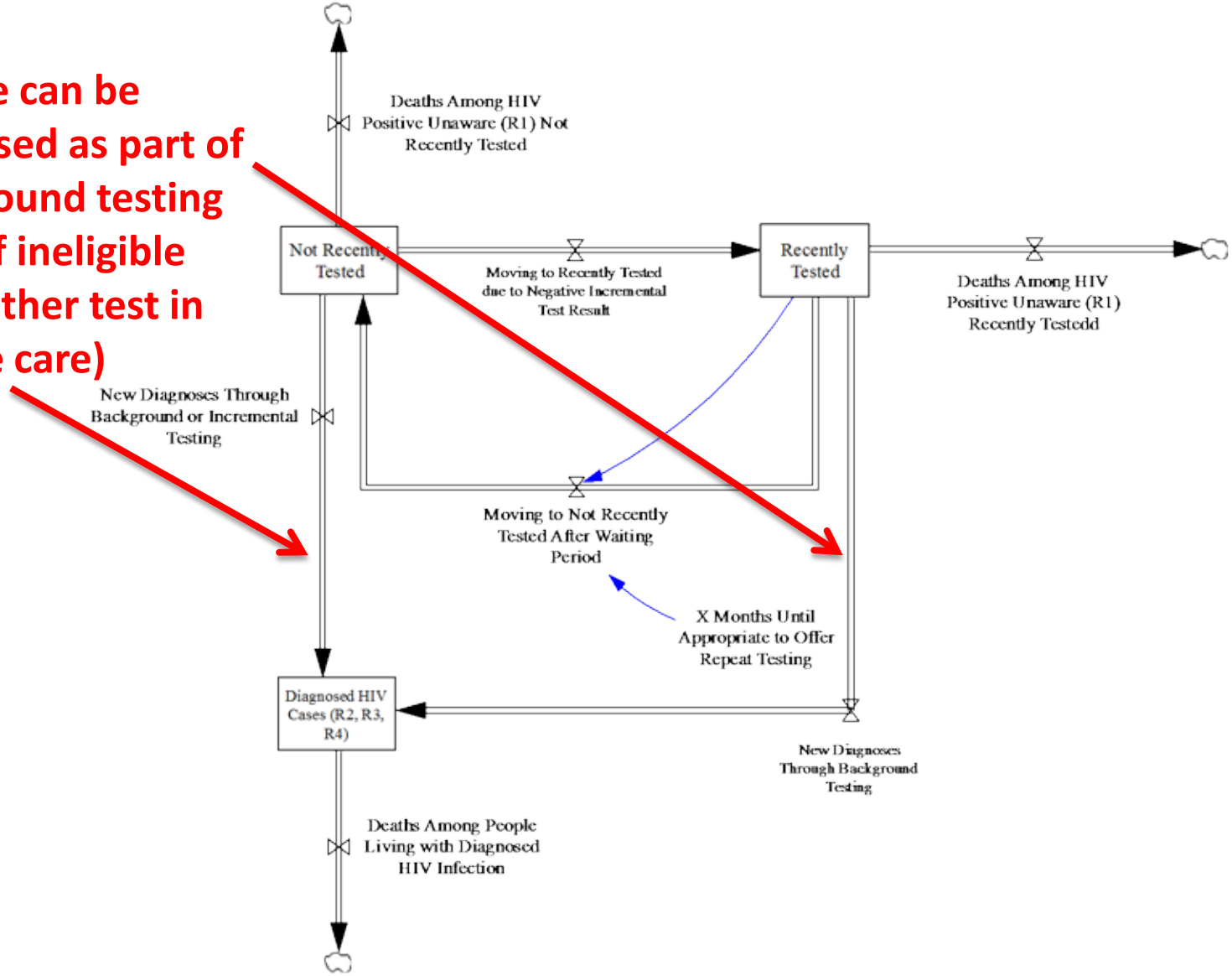
HIVSIM stock and flow diagram: HIV testing structure

Time delay between test offers in routine care (specified by modelers)



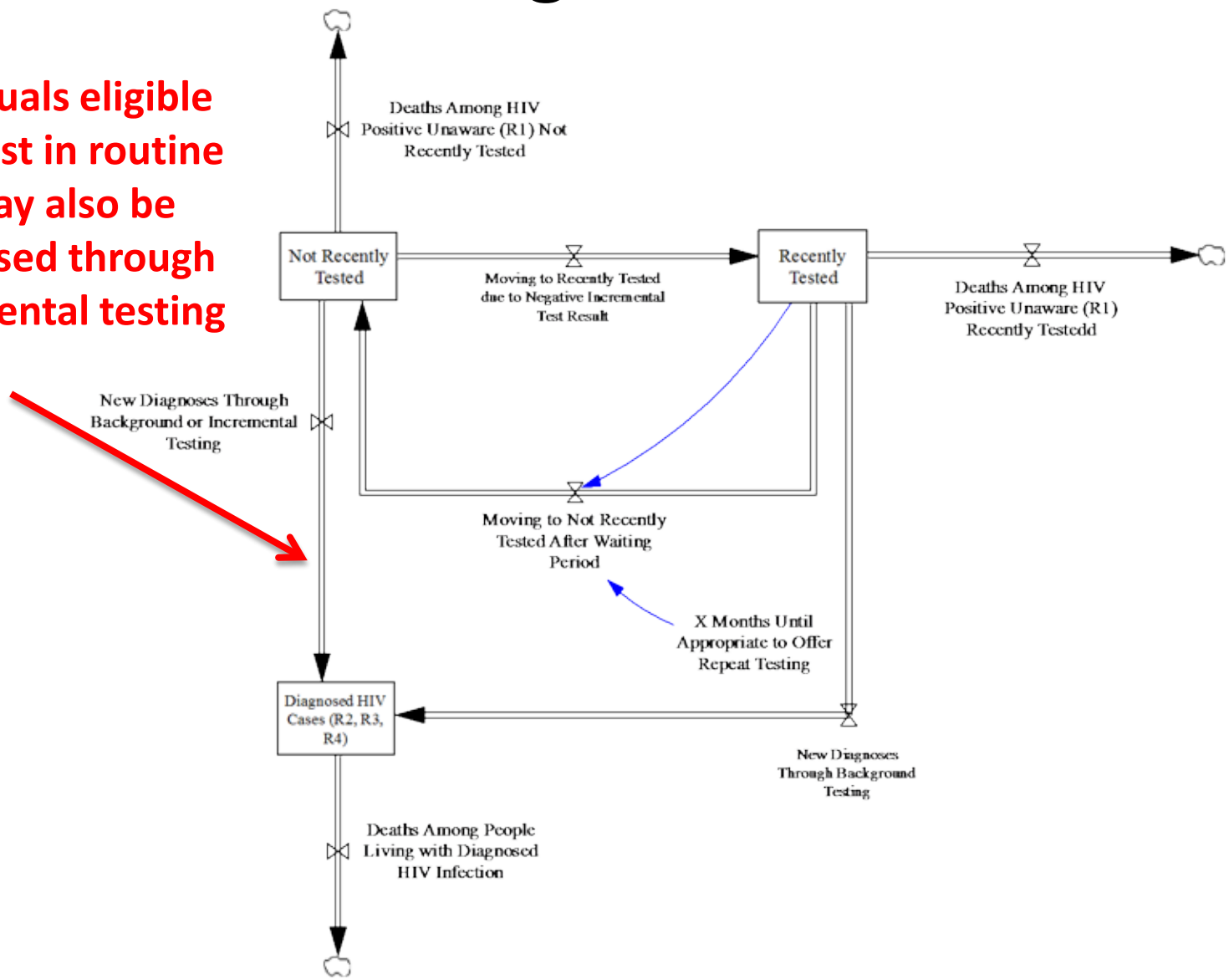
HIVSIM stock and flow diagram: HIV testing structure

Anyone can be diagnosed as part of background testing (even if ineligible for another test in routine care)



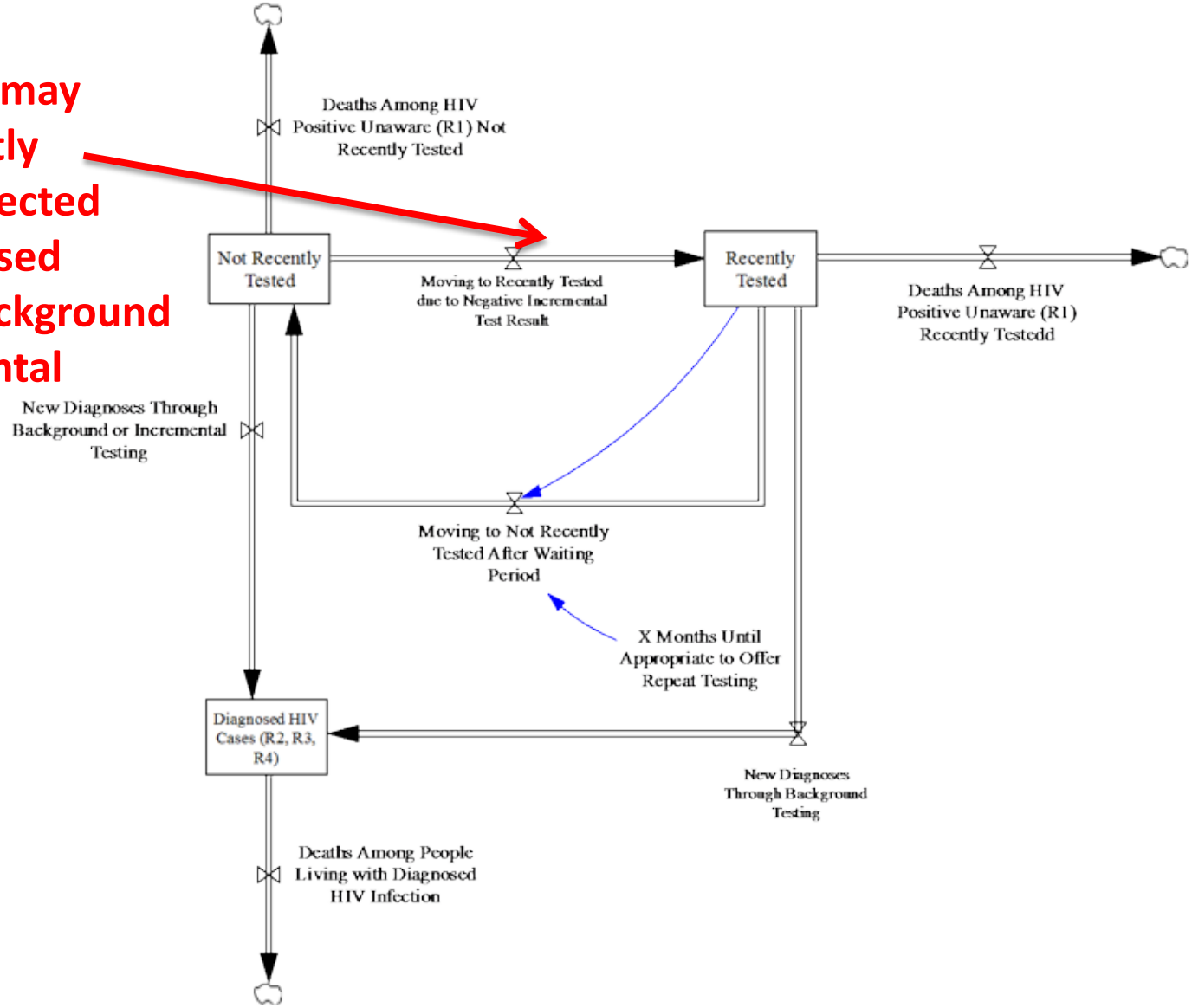
HIVSIM stock and flow diagram: HIV testing structure

Individuals eligible for a test in routine care may also be diagnosed through incremental testing



HIVSIM stock and flow diagram: HIV testing structure

Uninfected individuals may subsequently become infected and diagnosed through background or incremental testing



Recap of dynamic model features

- HIVSIM aggregates individual trajectories (disease progression, engagement in care) at the population level

- Dynamic feedback:
  - Existing cases generate new infections
  - Infectiousness and health outcomes (survival, mortality) change depending on disease stage and level of engagement in care

- Nonlinear feedback:
  - Continued testing of the whole population will result in a lower yield

Policy scenarios

- No law
- Level of implementation (perfect, high, and low)
- Frequency of repeat testing in routine care (annual, five-year, and one-time)
- Perfect viral suppression among individuals in care
- Range of implementation times (18 months to five years)

- *All scenarios represent implementation of <u>incremental</u> testing in routine care settings, and assume New Yorkers also continue to be diagnosed as part of <u>background</u> testing*

Outcome variables

- Increase in HIV tests*
- New infections
- Newly diagnosed HIV cases; newly diagnosed AIDS cases; fraction of newly diagnosed cases with concurrent 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 (diagnosed and undiagnosed)
- Fraction of HIV cases who are undiagnosed

* Law requires that the NYSDOH evaluate impact of statute with respect to "number of persons tested for HIV infection" and "number of persons who access care and treatment"

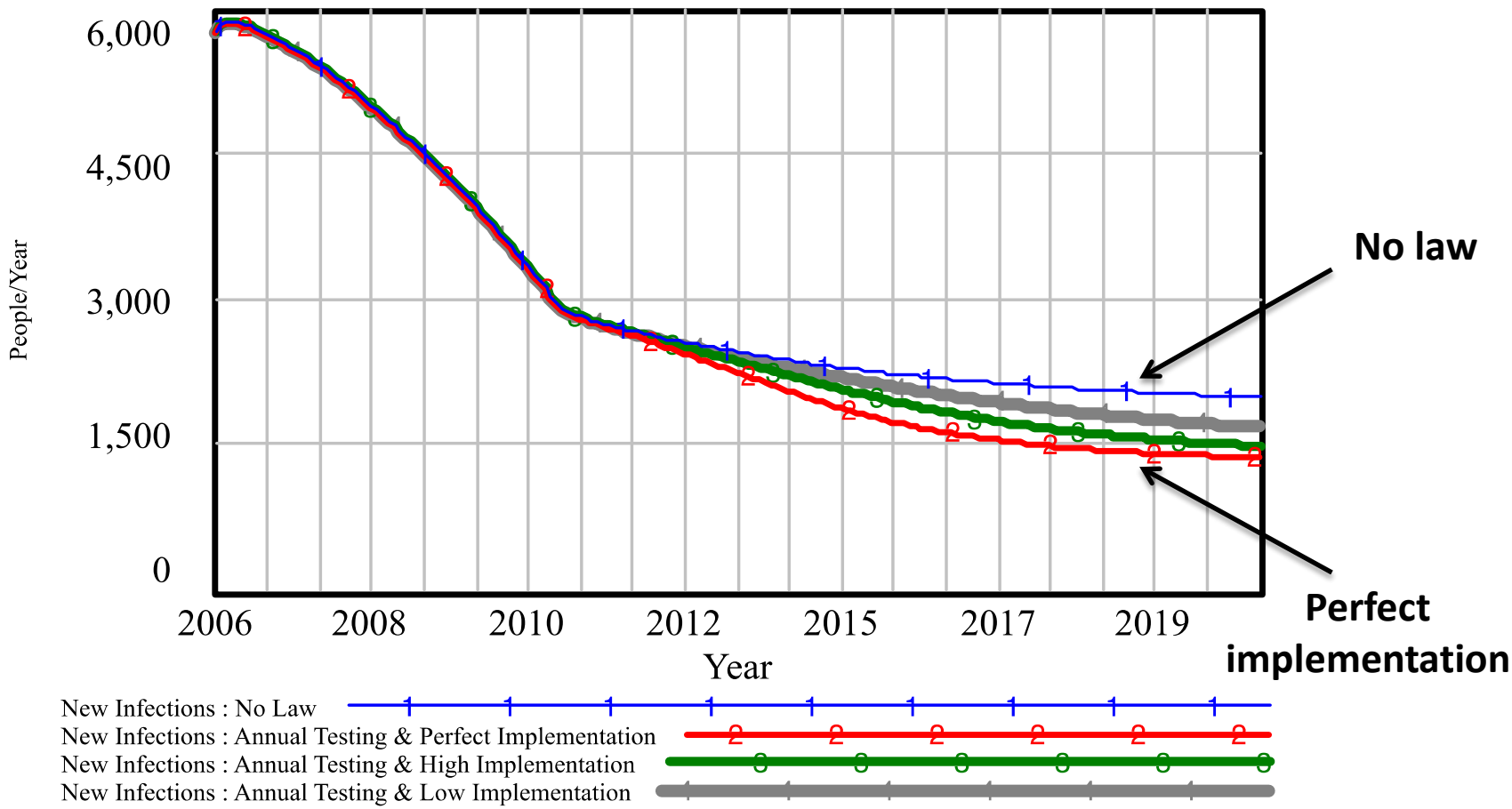
Baseline projections, in absence of law

- Continuing decline in annual new infections, annual new diagnoses, and fraction of undiagnosed cases
- Slight increase in people living with diagnosed HIV infection and diagnosed HIV cases currently in care
- *Explanations: current HIV prevention efforts, system delays, survival and transmission benefits of antiretroviral therapy*

Potential impact of law, if implemented as designed

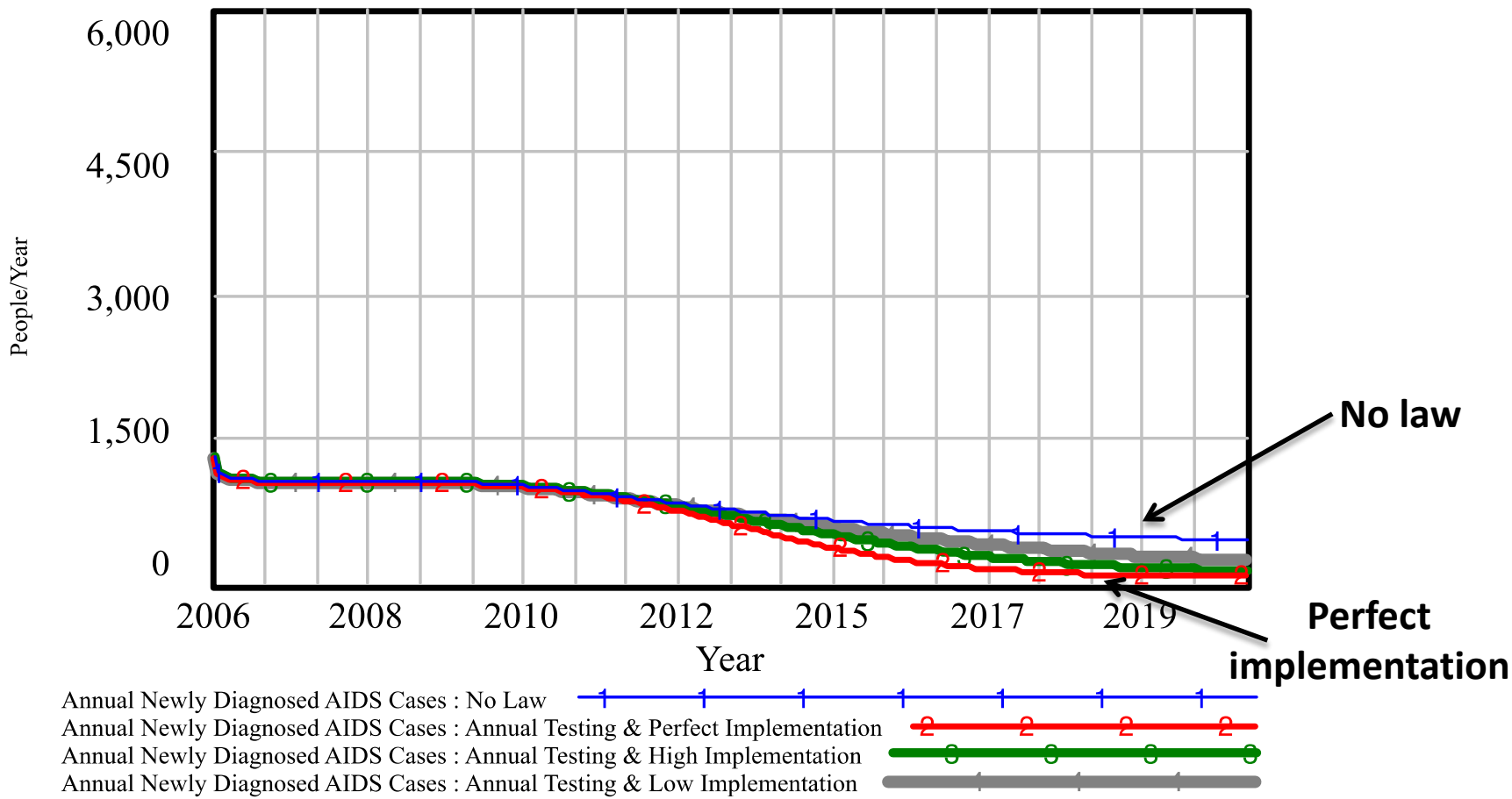
- Reductions in annual new infections and fraction of undiagnosed cases
- Initial surge then decline in newly diagnosed HIV cases per year
- Steady decline in newly diagnosed AIDS cases per year
- *Explanations: rapid identification of unaware individuals, individuals diagnosed earlier before progressing to late stage disease*

If implemented as designed, the HIV testing law will lead to fewer new infections.



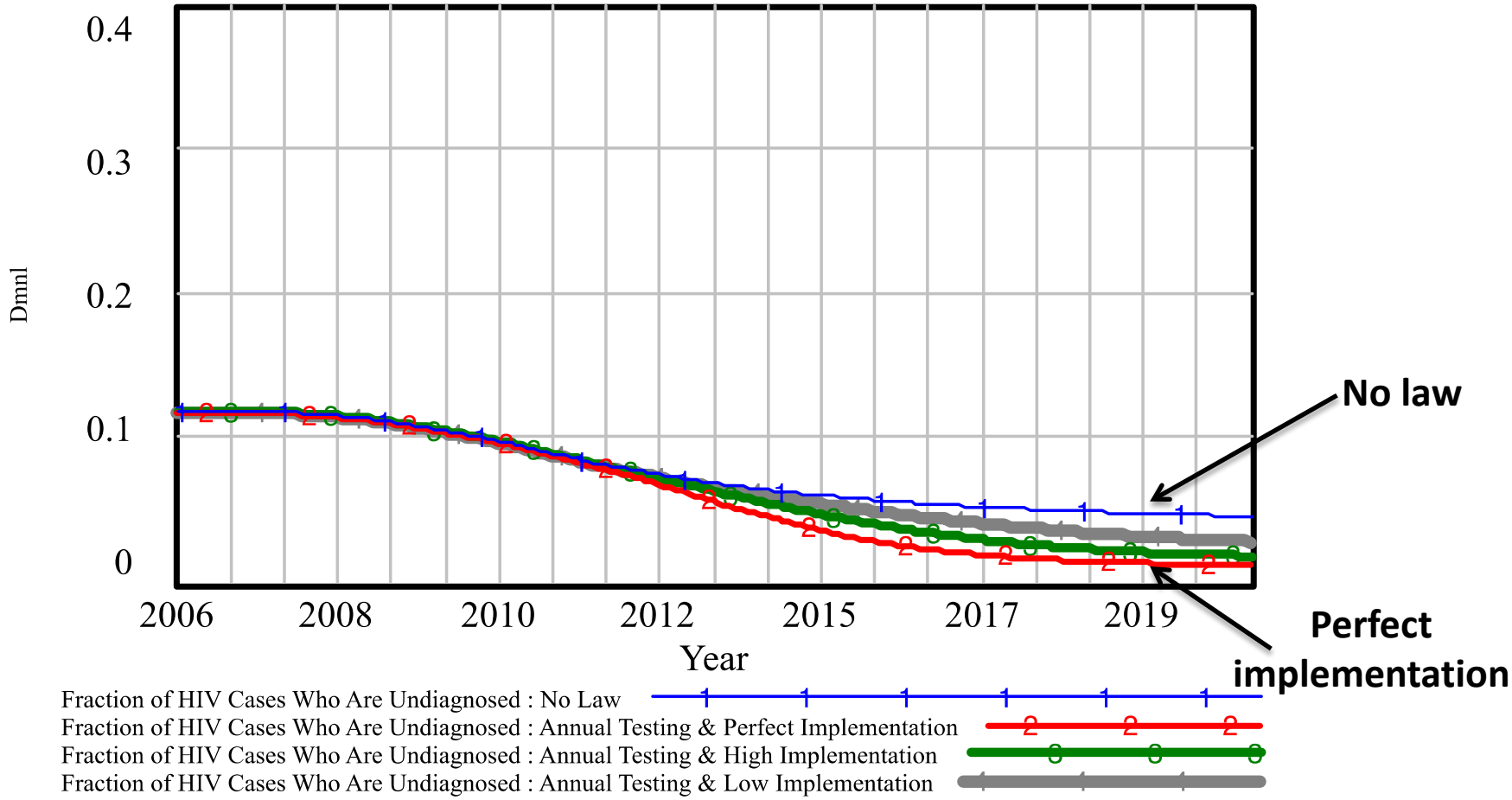
Results for scenarios of annual repeat testing in routine care (in addition to continued targeted risk-based testing), and three levels of implementation

If implemented as designed, the HIV testing law will lead to fewer newly diagnosed AIDS cases.



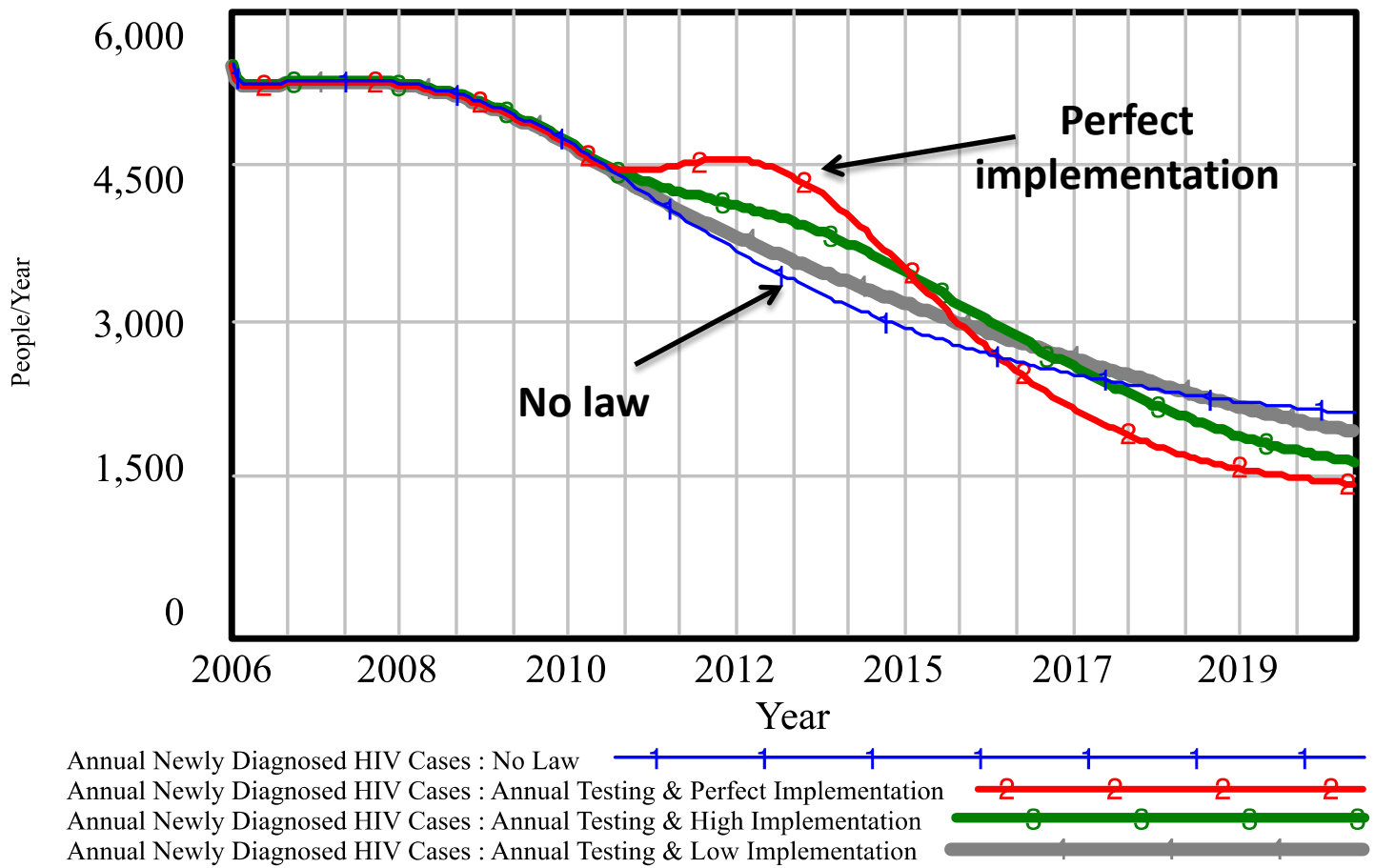
Results for scenarios of annual repeat testing in routine care (in addition to continued targeted risk-based testing), and three levels of implementation

If implemented as designed, the HIV testing law will reduce the fraction of undiagnosed cases.



Results for scenarios of annual repeat testing in routine care (in addition to continued targeted risk-based testing), and three levels of implementation

If implemented as designed, the HIV testing law will lead to an initial surge then decline in newly diagnosed HIV cases.

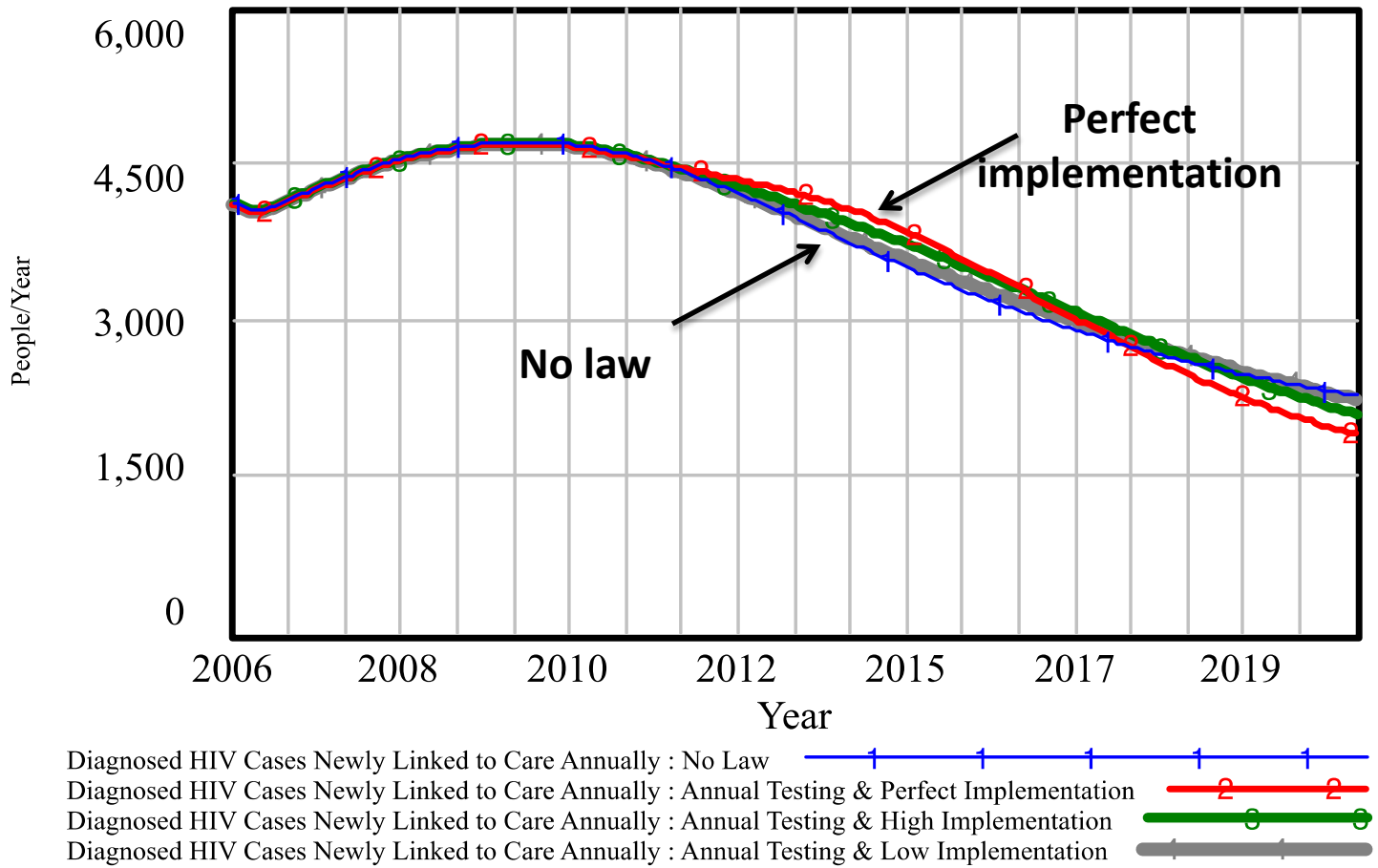


Results for scenarios of annual repeat testing in routine care (in addition to continued targeted risk-based testing), and three levels of implementation

Potential impact of law, if implemented as designed

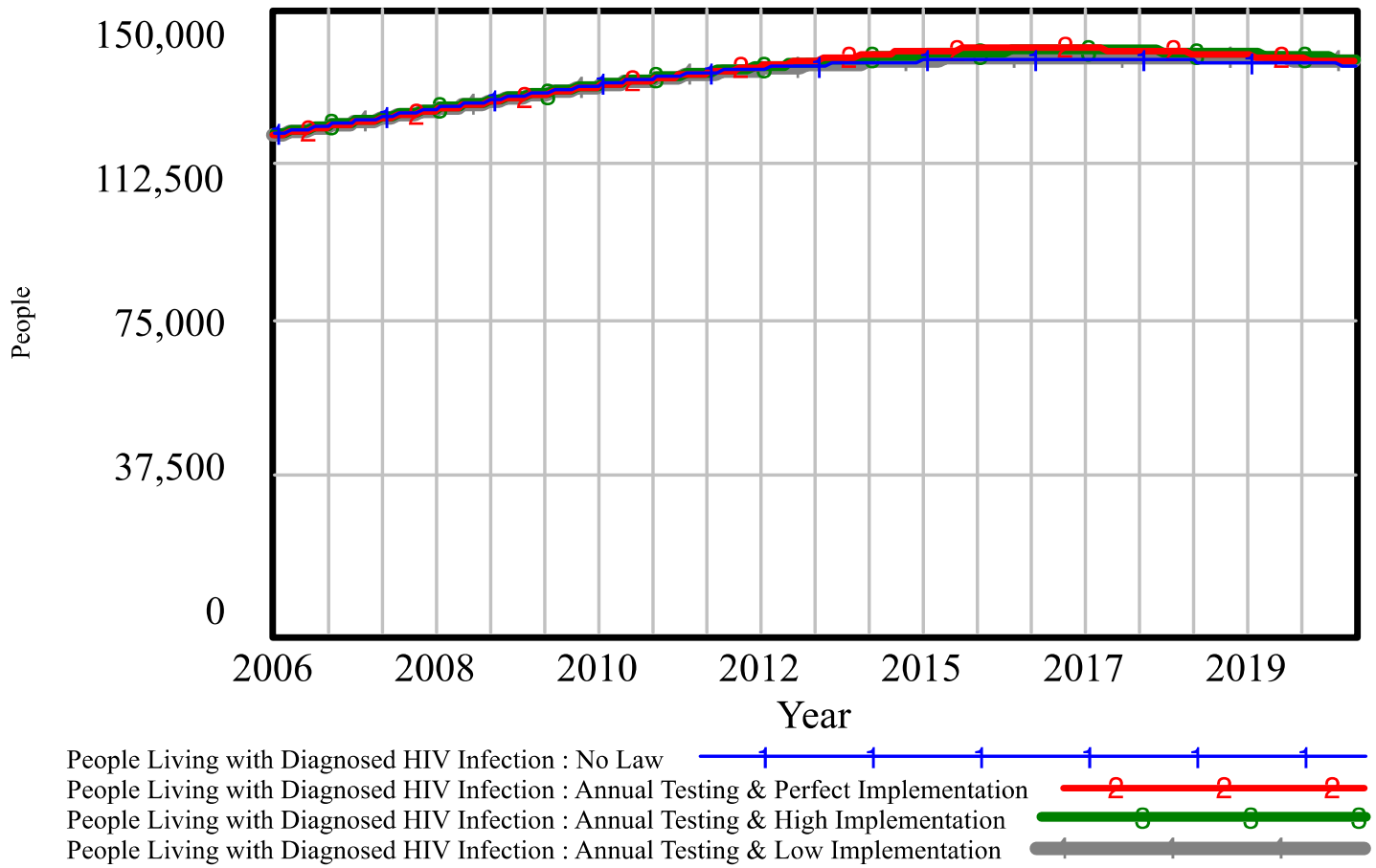
- No surge in individuals newly linked to care annually (relative increase, not absolute increase)
- Minimal changes in people living with diagnosed HIV infection and number of cases in care
- Number of annual new infections and fraction of undiagnosed cases do not approach zero
- *Explanations: declining trend in individuals newly linked to care, people stay in care for long time due to system delays, ongoing transmissions from individuals unaware and diagnosed cases not virally suppressed*

Even under perfect implementation, there will not be a large surge in diagnosed cases newly linked to care.



Results for scenarios of annual repeat testing in routine care (in addition to continued targeted risk-based testing), and three levels of implementation

Even under perfect implementation, there will be minimal differences in people living with diagnosed HIV infection.



Results for scenarios of annual repeat testing in routine care (in addition to continued targeted risk-based testing), and three levels of implementation

Comparison of level of implementation vs. testing frequency

- Frequency of testing in routine care (annual, five-year, and one-time)
  - Overall minimal differences in outcomes
  - Largest difference is number of tests performed per year

- Level of implementation (perfect, high, low)
  - Increasing level of implementation improves new infections, newly diagnosed cases, fraction of newly diagnosed cases with concurrent AIDS, and fraction of undiagnosed cases

Sensitivity analysis on time to implementation

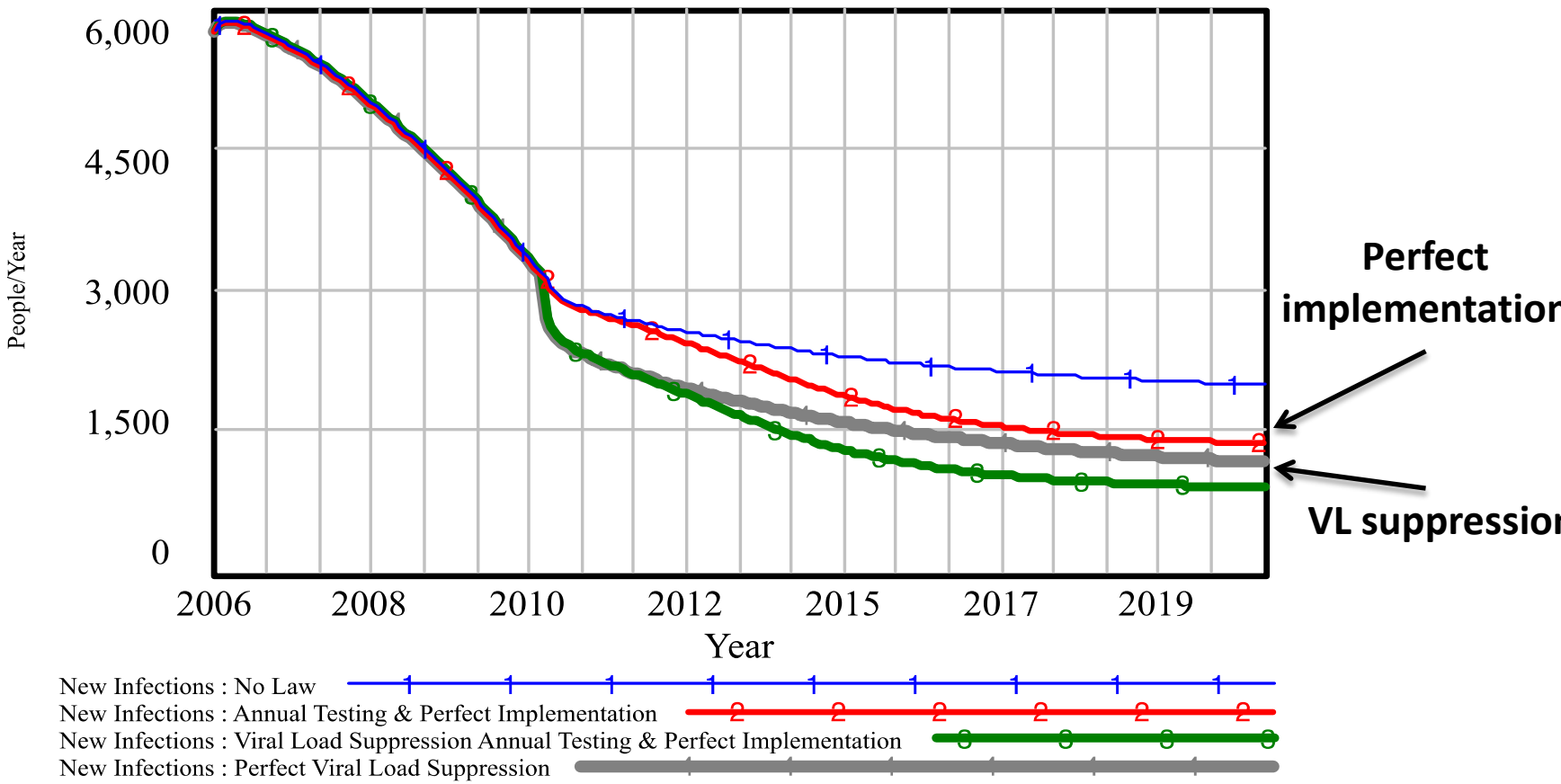
- No substantial changes if implementation time is varied
- Surges in new diagnoses and individuals newly linked to care appear larger, but outcomes are similar by the end of the period
- *Explanations: unaware individuals are identified more quickly; because the unaware population relatively small, diagnosing them a few years earlier does not have dramatic changes on new infections*

Perfect viral suppression

- Perfect viral suppression among individuals in care yields similar improvements in annual new infections, compared to perfect implementation

- Largest impact on new infections is from perfect viral suppression among individuals in care *and* perfect implementation of the testing law

Perfect viral suppression among individuals in care yields similar reductions to new infections.



Limitations

- All models are imperfect representations of reality
- No empirical data for some parameters
- True “level of implementation” unknown

Key model insights

- Continue to invest resources in programs that provide HIV medical care, improve retention in care, encourage reductions in risky behaviors

- Temporary increases in new HIV diagnoses under the law will be offset by an anticipated decline in new infections and new diagnoses under baseline projections

- Continue to use broad policy approach with wide range of HIV prevention interventions, in addition to HIV testing law

Key model insights

- One-time testing in routine care (in addition to continued targeted testing) is most efficient use of resources

- Useful indicators of the law's success are newly diagnosed HIV cases and newly diagnosed AIDS cases per year

Thank you!

- Feel free to contact me at:

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