Innovations in Collaborative Modeling
Michigan State University
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USING SYSTEM DYNAMICS MODELING TO IDENTIFY STRATEGIES THAT REDUCE COMMUNITY-LEVEL HIV VIRAL LOAD

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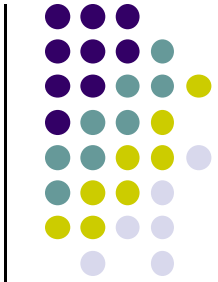
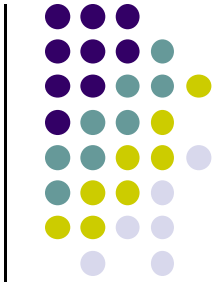
Introduction



- A 3-year in-depth study of the HIV Test & Treat (T&T) continuum of services in Greater Hartford, Connecticut, USA
- Purpose: To conduct an in-depth examination of T&T performance to better understand what contributes to HIV community viral load (CVL), in order to identify and plan community strategies to reduce it

Study Background



- ART can reduce viral load (VL) in PWH to undetectable within 6 months, which can reduce transmission by 95%
- This supports the concept of treatment as prevention
- This requires that all PWH in the community are found for testing, get linked quickly to care and treatment, and achieve and maintain viral suppression, or undetectable VL
- PWH who have not achieved viral suppression can transmit HIV, which adds to total virus in the community, or community viral load (CVL)

Study Aims

1. Identify inter-organizational network factors that facilitate people with HIV (PWH) moving efficiently and effectively across the T&T continuum
2. Examine the personal and community level factors that interact to generate system dynamics in the movement of PWH through the T&T continuum
3. Via participatory modeling, develop a conceptual system dynamics model of key structural factors and processes that impede progress toward reducing overall CVL

Study Timeline

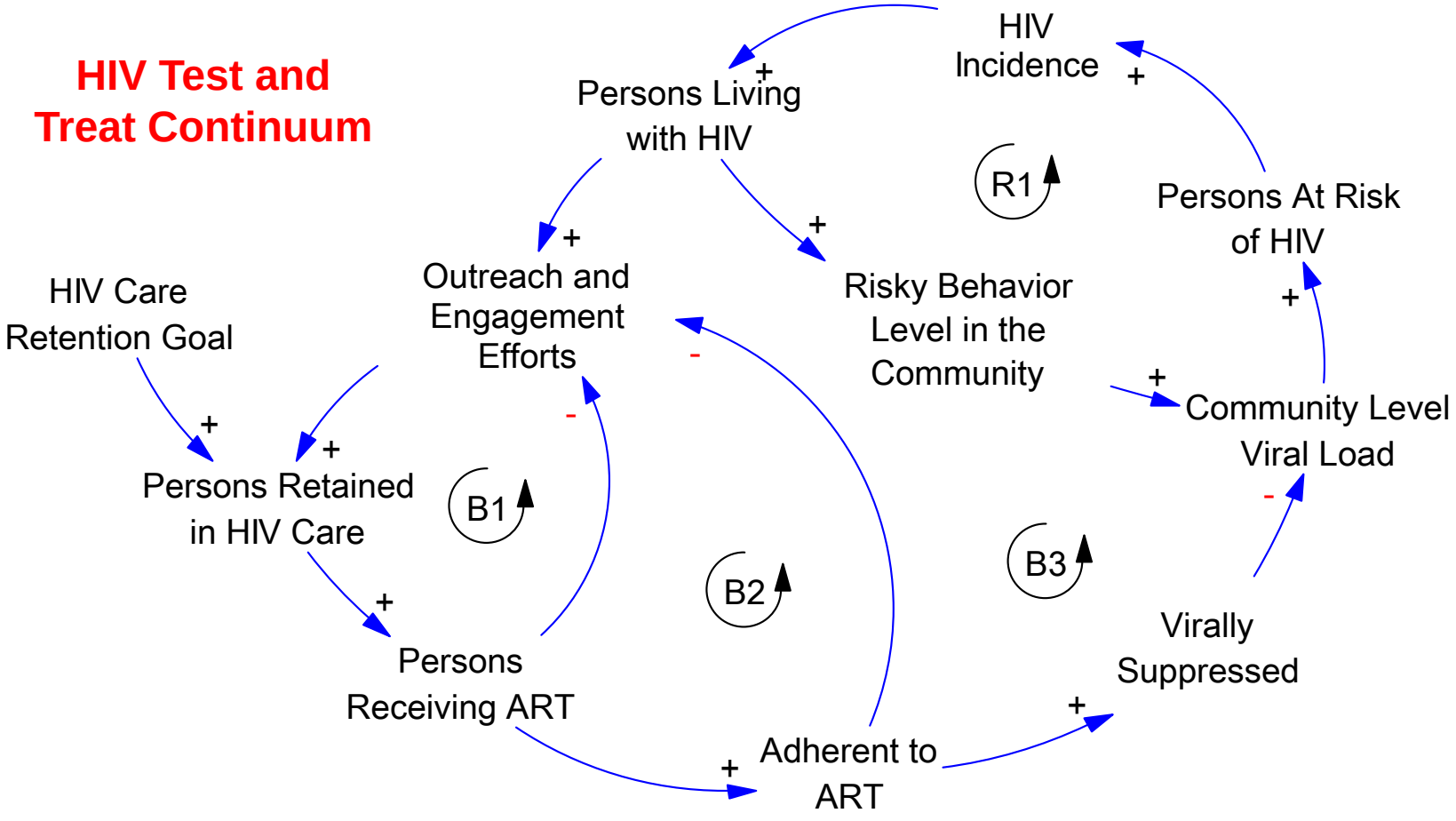
Year 1: Organizational network survey and group interviews with providers and PWH/at risk on the T&T system of services in Greater Hartford

Years 1-2: Development of organizational network map and systems diagrams of T&T

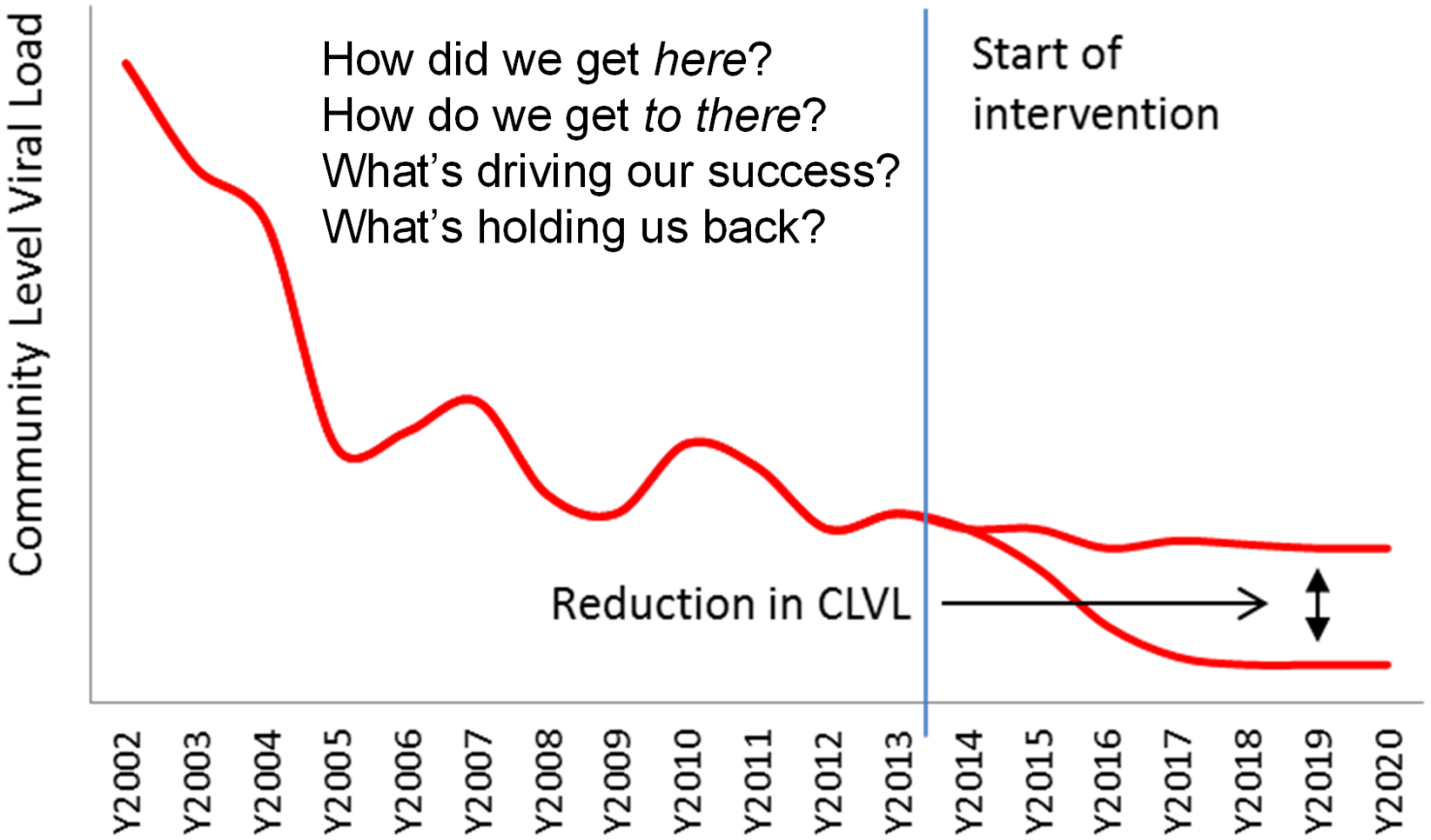
Years 1-3: Cohort study (repeated surveys) with 300 PWH/at risk (baseline, 6mo, 12mo) plus repeated interviews with subset of 40 every 3 months on transitions through the T&T system

Year 1-3: Group model development with providers and PWH on organizational network and system diagrams for use in planning new directions

Causal Loop Diagram Depicting Balancing and Reinforcing Feedback Loops



City of Hartford: Hypothetical Community Level Viral Load Over Time, 2002 – 2020



Epidemiologic Profile of HIV for the State of Connecticut and the City of Hartford, CT

Continuum of Care Description	State of CT N	State of CT %	Hartford[1] N	Hartford[1] %
TOTAL PWH 2011	11,985	100%	2,205	100%
TOTAL HIV incidence 2011	348	3%	64	3%
TOTAL HIV deaths 2011	164	1%	30	1%
Undiagnosed HIV positive[2]	1,837	18%	338	18%
Diagnosed	10,148		1,867	
Not in care	3,620	36%	666	36%
In care	6,528	64%	1,201	64%
Receiving ART	5,149	79%	947	79%
Achieving VS	4,866	75%	895	75%

Source: Ct Dept of Public Health; Epidemiologic Profile of HIV in CT, HIV Continuum of Care, Connecticut 2011 (data reported through 2012).

[1]City of Hartford accounted for 18% of the state's total HIV cases in 2011.

[2]Undiagnosed cases are estimated to be 18% of diagnosed casesin 2011.

Link to spreadsheet

Epidemiologic Profile of HIV in Connecticut

– 2013 –

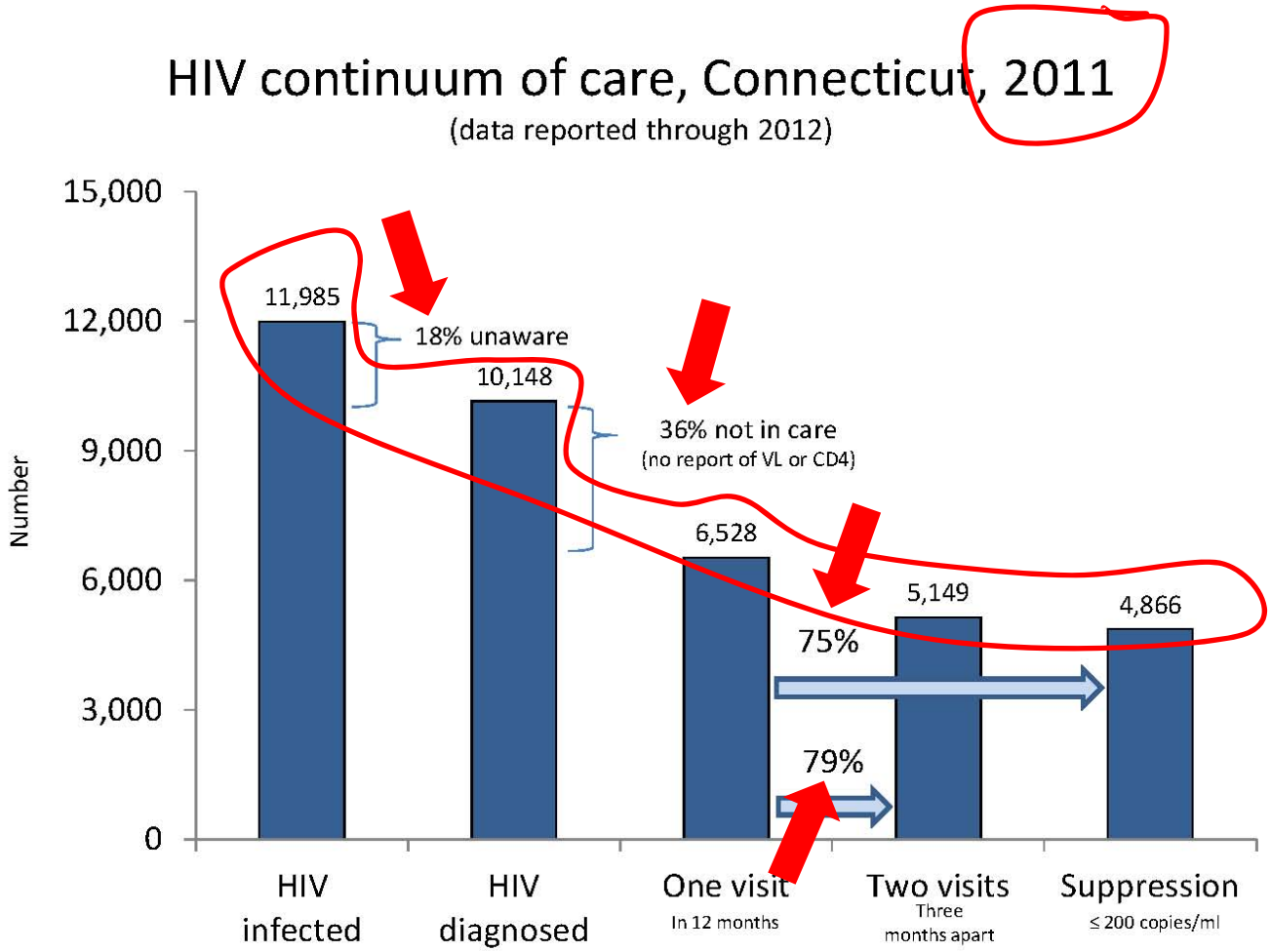


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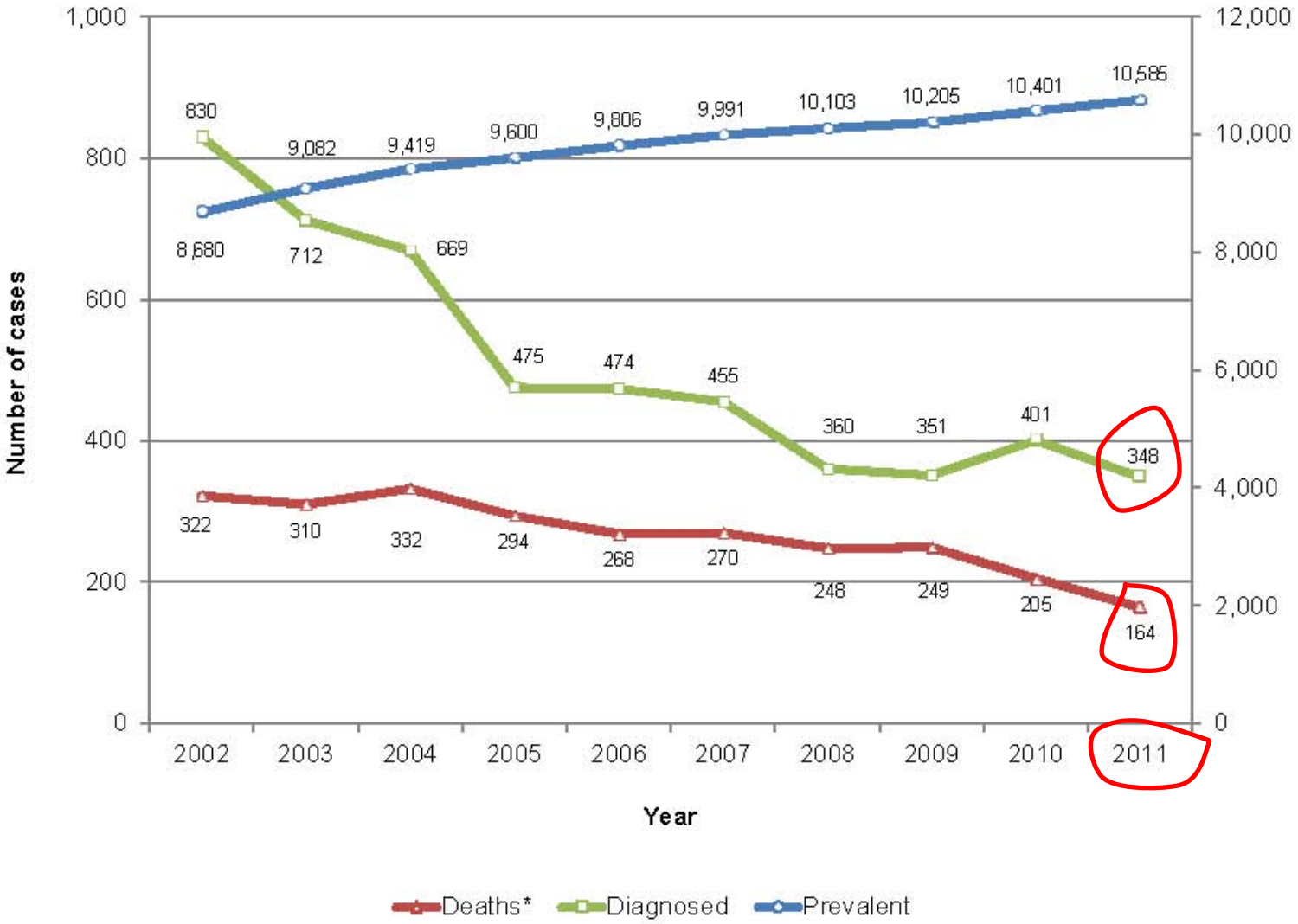
Table 2.5.3: PLWH by city of residence at diagnosis, sex, race/ethnicity, and risk, Connecticut, 2011

			Sex		Race/ethnicity				Risk					
		Total	Male	Female	White	Black	Hisp	Other	IDU	% MSM	MSM/IDU	Hetero	Pedi	Oth/unk
Residence	N	%	%	%	%	%	%	%	%	%	%	%	%	%
Hartford	1,946	18.4	65.3	34.7	14.7	34.1	50.0	1.2	47.6	14.7	2.4	20.9	1.9	12.5
New Haven	1,455	13.7	64.0	36.0	20.2	48.3	25.8	5.6	40.9	19.9	2.3	24.6	2.7	9.6
Bridgeport	1,315	12.4	60.5	39.5	16.2	44.3	38.9	0.6	34.1	16.3	1.7	28.7	1.4	17.8
Waterbury	704	6.7	61.9	38.1	28.6	27.1	43.3	1.0	42.8	18.2	1.6	21.3	2.4	13.8
Stamford	511	4.8	68.7	31.3	25.4	45.4	25.8	3.3	28.8	23.3	1.0	23.3	2.7	20.9
New Britain	397	3.8	65.0	35.0	24.7	17.1	57.7	0.5	38.0	20.4	1.3	23.2	2.0	15.1
Norwalk	329	3.1	63.8	36.2	36.8	38.3	21.6	3.3	28.0	26.1	1.2	22.8	2.7	19.1
Danbury	222	2.1	66.2	33.8	37.8	23.0	34.2	5.0	29.7	25.2	1.4	24.8	0.9	18.0
East Hartford	213	2.0	64.3	35.7	27.2	38.5	33.3	0.9	29.6	18.8	3.8	25.8	1.4	20.7
Meriden	212	2.0	60.8	39.2	35.4	16.5	47.6	0.5	30.2	24.1	0.9	28.3	0.5	16.0
West Haven	197	1.9	61.4	38.6	28.4	38.6	23.4	9.6	32.0	23.4	0.5	28.4	3.0	12.7
New London	182	1.7	58.2	41.8	29.1	36.3	32.4	2.2	34.6	19.2	2.7	30.8	2.7	9.9
Hamden	168	1.6	67.3	32.7	35.7	48.8	13.1	2.4	23.8	26.2	1.8	28.0	1.2	19.0
Middletown	157	1.5	66.2	33.8	48.4	29.9	21.0	0.6	37.6	26.1	1.9	20.4	--	14.0
Norwich	141	1.3	60.3	39.7	55.3	28.4	14.2	2.1	28.4	28.4	2.1	28.4	0.7	12.1
Windham	117	1.1	59.8	40.2	32.5	13.7	52.1	1.7	53.8	15.4	2.6	18.8	1.7	7.7
Manchester	108	1.0	58.3	41.7	53.7	22.2	21.3	2.8	27.8	26.9	--	21.3	--	24.1
Stratford	93	0.9	72.0	28.0	44.1	40.9	11.8	3.2	16.1	31.2	1.1	26.9	1.1	23.7
East Haven	88	0.8	71.6	28.4	38.6	14.8	37.5	9.1	35.2	28.4	1.1	19.3	--	15.9
Bristol	81	0.8	66.7	33.3	65.4	4.9	29.6	--	38.3	38.3	1.2	16.0	1.2	4.9
Bloomfield	75	0.7	73.3	26.7	17.3	69.3	10.7	2.7	28.0	29.3	1.3	24.0	--	17.3
West Hartford	75	0.7	72.0	28.0	61.3	12.0	25.3	1.3	18.7	48.0	--	16.0	1.3	16.0
Milford	71	0.7	77.5	22.5	67.6	15.5	14.1	2.8	14.1	47.9	1.4	12.7	--	23.9
Greenwich	69	0.7	76.8	23.2	75.4	8.7	10.1	5.8	17.4	46.4	4.3	14.5	1.4	15.9
Wallingford	62	0.6	85.5	14.5	71.0	12.9	14.5	1.6	16.1	48.4	3.2	12.9	3.2	16.1
Torrington	57	0.5	73.7	26.3	75.4	3.5	15.8	5.3	29.8	31.6	5.3	14.0	--	19.3
Groton	52	0.5	71.2	28.8	46.2	26.9	23.1	3.8	25	40.4	3.8	17.3	--	13.5
Fairfield	50	0.5	74.0	26.0	76.0	10.0	14.0	--	18.0	40.0	--	18.0	2.0	22.0
All other towns	1,438	13.6	78.4	21.6	74.2	11.7	11.4	2.7	20.7	43.3	1.9	14.6	1.2	18.3
Total	10,585	100.0	66.3	33.7	32.9	32.3	32.3	2.5	34.9	23.9	1.9	22.4	1.8	15.2

Figure 2.1.1: Cases of HIV disease: diagnosed, deaths, and prevalent cases, Connecticut, 2002-2011



*Deaths in the most recent year are preliminary

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Additional Parameterization: Community Viral Load

Diagnosed not in care = (666 * (35,000 * .80)) = 18,648,000

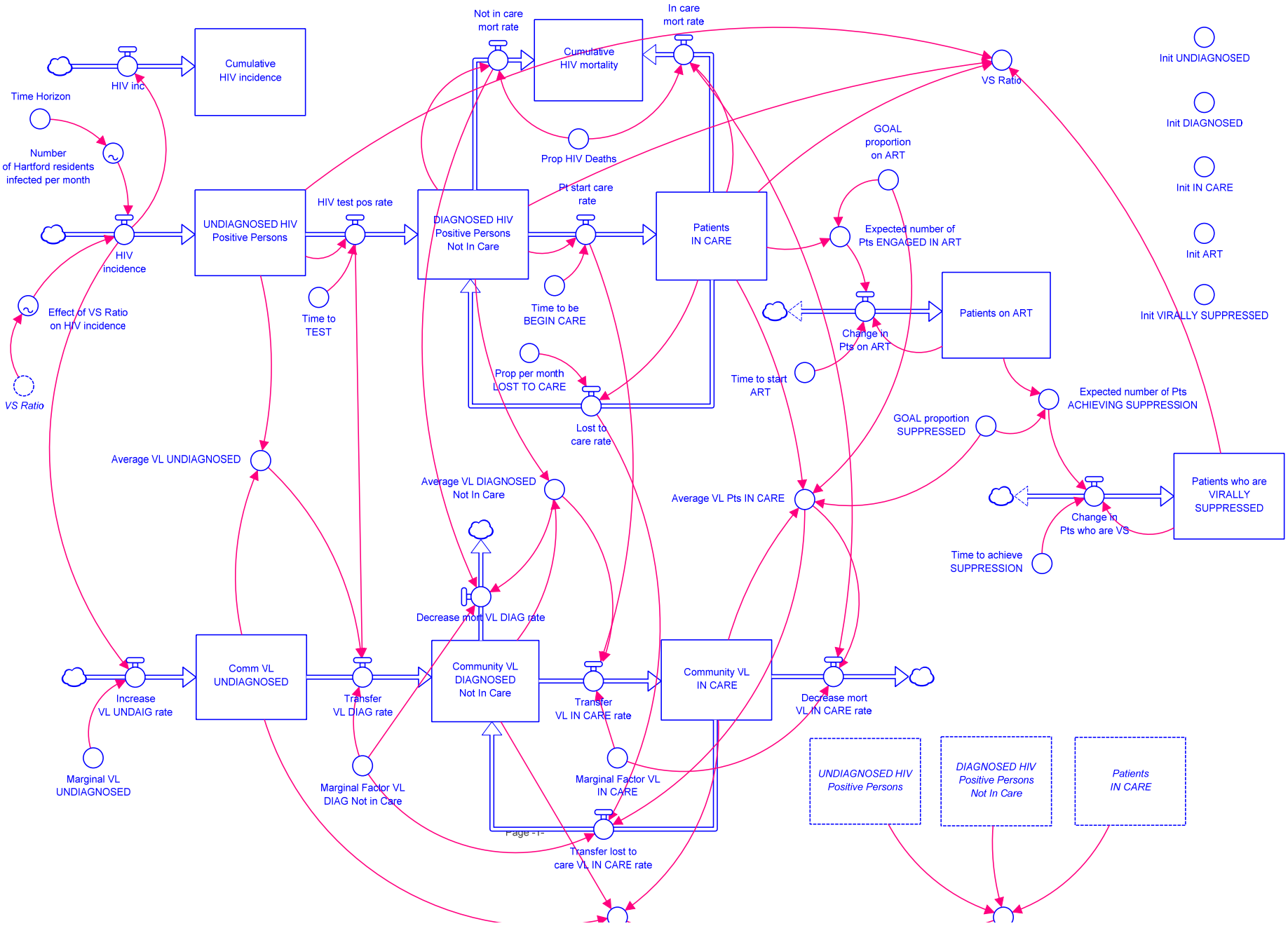
In care = (1201 * .79 * .75 * 35,000 * .10) = 2,490,514

Undiagnosed = (338 * 35,000) = 11,830,000

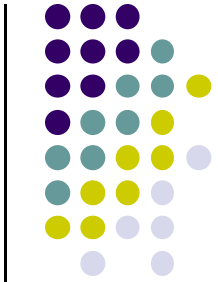
		copies/ml
10	6	1,000,000
10	5	100,000
10	4.5	31,623
10	4	10,000
10	3	1,000
10	2	100
10	1	10

Miller et al. 2010

Hartford Test and Treat (T&T) System Dynamics Scoping Model: Stock and Flow Diagram

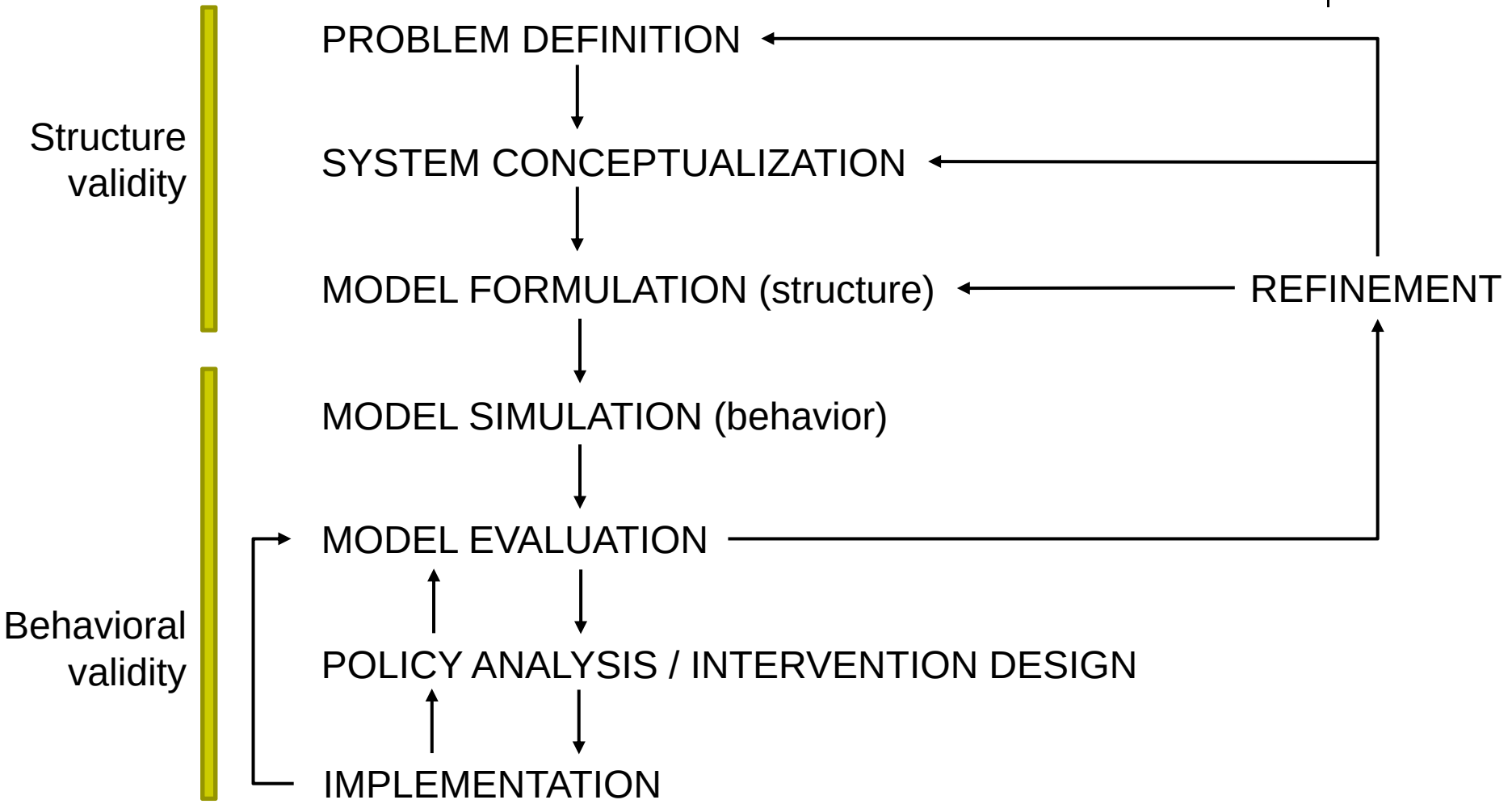


Common Data Dilemmas in Simulation Model Development



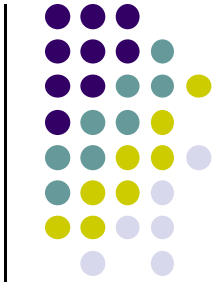
- What data are available?
- What is the quality of the data? (What is the fallibility of the data?)
- Generally, there are limited data about rates of change for key variables
- Challenges regarding how to appropriately ‘quantify’ (as opposed to ‘measure’) soft variables (e.g., anxiety, depression, satisfaction)

The Iterative Nature of SD Model Development and Validation



Adapted from Roberts et al. (1983) and Barlas (1996)

Formal SD Model Validation



Direct structure tests
- Empirical tests
- Structure-confirmation test
- Parameter- confirmation test]

Theoretical tests
- Structure-confirmation
- Parameter-confirmation
- Direct extreme-condition
- Dimensional consistency

Implementation methods
- Formal inspections/reviews/evals
- Walkthroughs
- Semantic analysis

Structure-oriented behavior tests
- Extreme-condition test
- Behavior sensitivity test
- Modified-behavior prediction
- Boundary adequacy test
- Phase relationship test
- Qualitative features analysis
- Turing test

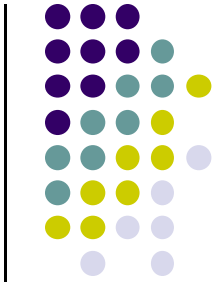
Behavior pattern tests

STRUCTURE VALIDITY

BEHAVIOR VALIDITY

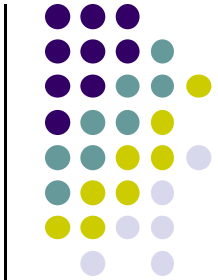
Yamas Barlas (1996)

Types of Insights from System Dynamics Models

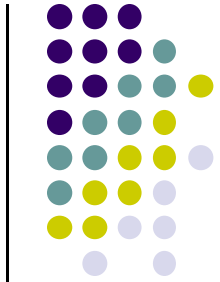


- Understanding of long-term behavior of a system
  - Eventual outcome(s)
  - Impact of parameter values on outcome(s)
  - Robustness of these outcomes to disturbance (i.e., change in parameter values)
- Identification of key causal processes (loop dominance), and high leverage parameters within the system
- Informed planning
  - Research questions/designs
  - Intervention implementation/monitoring strategies
  - Outreach campaigns (information dissemination and teaching)

Practical Considerations for Effective SD Modeling



- VERY model building project is different; participatory process will help shape effective engagement
- Need to consider
  - Time and resources (to build, test, and implement)
  - Modeler's skill/training and awareness of substantive topic
  - Data access and data quality (fallibility)
- Need to build effective rapport with target audience
  - Build trust; Achieve 'small wins' in model development
  - Appreciate differing philosophies of science
  - Present model and model output with clarity and purpose



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THANK YOU!